

Development of Prices During the BSE Crisis

Some Empirical and Theoretical Results

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Abstract: This paper analyzes the market failure on the beef market caused by information that there is a severe BSE risk and shows the recovery of the market due to the BSE test. In the empirical part we use break robust cointegration tests and find that producer and consumer prices of beef in Germany are cointegrated with a joint co-break in the BSE crisis.

Key words: BSE, market failure, price transmission, cointegration, structural break

JEL classification: Q11, I18, C22, C32

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1. Introduction

The information about the first BSE case in Germany caused a collapse of the beef market. A recovery was observed only when a BSE test became available. In this paper we analyze the price reactions on BSE information from a theoretical and empirical point of view.

The BSE epidemic caused huge economic costs and a pronounced human mortality risk. These and other facts shall be recalled at first within a short story about BSE in Europe. In what follows we draw a simple model to explain the developments on the consumer market for beef. We start by describing the situation before the first BSE case was detected, using partial analysis of a competitive equilibrium. To explain the BSE crisis, we develop the demand shortfall within the framework of the expected utility hypothesis and quality dependent valuation. Whether we find a complete market collapse or an equilibrium on a low level depends on the position of the new demand and supply curves. Market recovery is modeled by gain of reputation due to the existence of a test on BSE.

In the empirical part of the paper we analyze price reactions before and during the BSE crisis. Using weekly data about producer and consumer prices we show the following results: Time series are integrated of order one with a structural break in the level. A cointegration relation can be shown clearly until the day before the first BSE case was detected in Germany. Estimations with data during the crisis indicate that the stationary relationship between producer and consumer prices disappears. Producer prices decrease as expected, but consumer prices raise. This could be explained by additional costs due to the test and conditions on waste disposal and last but not least by the consumer's preference for good quality. Having eliminated the level breaks, we find that the adjusted consumer and producer prices reveal a cointegration relationship for the whole period of examination.

2. The BSE Story: United Kingdom, Europe and Germany

First indicators for bovine spongiform encephalopathy (BSE) were found in the nineteen seventies. The first BSE case was diagnosed 1986. BSE is a disease of the brain characterised by the presence of an abnormal form of a protein called prion. The origins are not clear, but it is probably acquired by eating feed containing contaminated meat and bonemeal and by maternal transmission.

In 1996 the causal relationship between BSE and the new variant Creutzfeldt-Jakob Disease (vCJD), a fatal degenerative disease in human brain, is considered as highly probable. At that time it was already impossible to contain the disease by selective slaughtering. Instead it only

remained possible to slaughter all 13 million bovines or to hope the disease would pass by without severe consequences for human beings. The Thatcherian policy of leaving free way to business and at the same time rigorously cutting public expenses favored the second alternative.

In 1998 the Ministry of Agriculture, Fisheries and Food (MAFF) was given the information monopoly about the new epidemic. Critical researchers were assigned no more money. The role of the MAFF is analyzed critically by Dressel (2000). She points out:

1. "...that scientists weren't free to report to other scientists or to publish until all writings and so on had been exhaustively reviewed by all sorts of administrators..."
2. "Instead, when the new cattle disease, BSE, loomed, MAFF did not inform the Department of Health about the outbreak of the disease, or about any crucial scientific research that might have a bearing on its potential transmission to humans."
3. "And it was only with a delay of about six months after MAFF's awareness that BSE might have implications for public health, that the DoH [Department of Health] was informed about BSE."

The European Union banned the feeding of ruminant derived meat and bonemeal in the United Kingdom in July 1988 but not the export of this risk material. The exports were significantly increased. Ten months later, Germany stopped the imports for meat and bonemeal. Only in 1996, the European Union stopped the BSE contaminated meat and bonemeal exports from United Kingdom and 14 months later feeding was forbidden in the European Union.

Estimations suggest that there were about 1.9 million infected animals, about 1.6 of which were slaughtered and consumed before showing any clinical sign of the disease (Donnelly et al., 2002). The insufficient control of the feeding ban caused 36.000 additional BSE infections (Court of Auditors, 1998). In the last year (2002), there were still more than one thousand new reported BSE cases in United Kingdom.

The Court of Auditors (2001) reports that the costs of the BSE crisis borne by the EU were 4.7 billion Euro. The largest recipient was the United Kingdom with 2,058 million Euro followed by France and Germany with 741 and 720 million Euro, respectively. The main expenditure were direct income support payments, public interventions and the so called "over thirty months scheme (UK)". The last one was introduced in 1996 to eliminate cattle aged more than 30 months from the human food and animal feed chains.

The exact mechanism of transmission of the BSE agent to the human population has not been identified by now, but dietary exposure to BSE contaminated beef products remains the most likely hypothesis.

As a result of the BSE epidemic, there are by now 143 victims in Great Britain, 101 neuropathological confirmed deaths from the vCJD and an additional 36 deaths with the diagnose of vCJD. The number of definite or probable vCJD cases still alive is 6 (The UK Creutzfeldt-Jakob Disease Surveillance Unit, 2003). Estimations from Andrews (2003) suggest that the epidemic is no longer increasing exponentially but has reached a peak or a plateau. Ferguson et. al. (2002) estimate the 95% confidence interval for future vCJD mortality to be 50 to 50,000 human deaths considering exposure to bovine BSE alone. If they include exposure from the worst-case scenario, i. e., BSE entering the sheep population as well, the upper bound lies by 150,000 human deaths.

On November 24, 2000, Germany had it's first own diagnosed BSE case. 12 days later chancellor Schröder proclaimed a reform of the agriculture sector. BSE tests for all bovines over 30 months were introduced at December 6. Some days later, BSE risk material was found in sausage. On January 31, 2001, the slaughtering of 400,000 bovines for price intervention was announced. The price offered for one animal was 1,000 DM. From March to June the slaughtering was carried out.

In Germany, there is a high probability that cases of BSE have gone undetected, because the monitoring and testing programs were inadequate. The Court of Auditors (2001) criticized that in Germany the feed ban has not been applied effectively and some meat and bonemeal material was processed in a too low standard.

There are substantial regional differences in the occurrence of the German BSE cases. In table 1, we compare the number of BSE cases with the livestock. Because of an incubation period of 3 to 7 years, BSE is especially pronounced in dairy cows. Therefore, we also compare the BSE cases with the milk production.

Table 1: Regional differences in BSE occurrence 2001

Länder	BSE cases	Bovine livestock in thousandths	milk production in thousand t	BSE case in percent of the livestock	BSE cases in percent of milk production
Germany	125	14227	4475	0,09	0,28
Bavaria	59	3987	1376	0,15	0,43
Lower Saxony	17	2765	767	0,06	0,22
Baden-Württemberg	12	1193	416	0,10	0,29
Schleswig-Holstein	12	1291	373	0,09	0,32
Rhineland-Palatinate	4	432	128	0,09	0,31
Saxony	4	535	208	0,07	0,19
Saxony-Anhalt	4	383	145	0,10	0,28
Brandenburg	3	631	182	0,05	0,16
Hesse	3	520	160	0,06	0,19
Mecklenburg-West-Pomerania	2	577	182	0,03	0,11
North Rhine Westfalia	2	1450	388	0,01	0,05
Thuringia	2	384	129	0,05	0,16
Saarland	1	58	15	0,17	0,67
Berlin	0	1	0	0,00	0,00
Bremen	0	12	3	0,00	0,00
Hamburg	0	8	1	0,00	0,00

Source: Own calculation with data from Ministry of Consumer Protection, Food and Agriculture and Federal Statistical Office Germany.

In Bavaria, we have the highest number of BSE cases. In comparison with the livestock Bavaria reached place two and Baden-Württemberg and Schleswig-Holstein simultaneously place three. The first place in this category, Saarland, has only one case and therefore a too small number to be a reliable result. In the category BSE cases in comparison to milk production Bavaria again has a top position. As a conclusion of this figures it must be suggested that some Länder have severe problems to control quality standards effectively.

3. A Model Describing Development of Prices on the Beef Market

In this part of the paper we take a look on the consumer market for beef. We prefer the method of partial analysis ignoring any relation to other markets than the beef market. Since only weekly data on prices is available and none non quantities, we focus on modeling the development on the consumer market, neglecting other possible effects. Throughout the following sections we assume many consumers with identical preferences described by quasi-linear utility functions and many sellers behaving as price-takers due to increasing marginal costs. Thus we can illustrate equilibria, if they exist, as intersection of a demand- and a

supply-curve. Foundations of constructing demand- and supply-function can be found in any textbook on microeconomics (for instance: Silberberg, 1990, chapter 8, 10 and 13 in the case of uncertainty)

3.1 The Situation before Detecting the First BSE Cow

There exists only one “good” quality of meat on the market. Especially the consumers have no reason to question the quality they are going to buy. The BSE problem is not yet known. Therefore we work within a world of complete markets.

Demand

We start assuming a representative consumer with a given yield y measured in units of money. He spends his income on buying beef in the amount of x and a composite good in the amount of x_0 . Denoting p the price of one unit of meat and assuming a price-level of 1 per unit of the composite good, we work with the following budget-restriction:

$$y = p \cdot x + x_0 . \quad (3.1)$$

In this paper we are not interested in relations with one or more goods within the composite good. Thus we assume that a change of p does not influence the relative prices of the goods combined to the composite good. Furthermore, we neglect income effects. Therefore we choose our assumptions in the way authors writing in the field of industrial organization do (Tirole, 1988, p. 7-8).

The representative consumer measures his utility U in terms of the composite good and the utility obtained from consuming beef is described by a concave function $V(x)$. We work with the following quasi-linear utility function:

$$U = V(x) + x_0 \quad \text{with} \quad V' > 0 \text{ and } V'' < 0 . \quad (3.2)$$

Maximizing (3.2) subject to the budget constraint (3.1) leads to the equivalent unconstrained problem:

$$\max V(x) + y - p \cdot x \quad \text{with respect to } x . \quad (3.3)$$

The solution of (3.3) gives the consumer's demand function, which is decreasing in p and independent of his income. As all consumers have identical preferences, aggregate demand $D(p)$ is independent of income, decreasing in p and independent of the other markets. Our demand function for the first case before having observed any infected cow shall be noted by

$$X_1^D = D_1(p) \quad \text{with } D_1' < 0 . \quad (3.4)$$

Supply

On the supply-side we assume many identical profit maximizing firms, behaving as price takers on markets for beef and factors. For ease of discussion, let them sell only one product, beef, which they offer using a linear increasing marginal cost curve:

$$x = (p - b) / a_1 \quad \text{with } p > b > 0, a_1 > 0. \quad (3.5)$$

If there are N_1 firms on the market, the aggregate supply function is described by

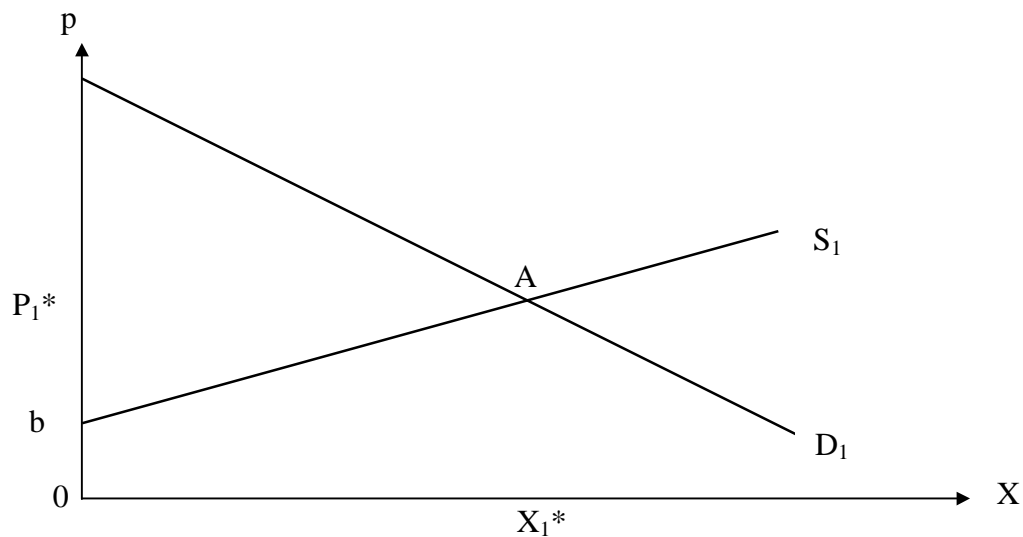
$$X_1^S = S_1(p) = N_1 \cdot (p - b) / a_1. \quad (3.6)$$

The supply-curve gets flatter in a X-p-diagram, if the amount of firms grows.

Equilibrium

We assume that consumers are willing to pay more than b units of money for one unit of beef. Then there exists a unique equilibrium point on the beef market, illustrated by (X_1^*, p_1^*) , the point of intersection of the graphs of (3.4) and (3.6).

Figure 3.1: Equilibrium on the beef market before BSE being detected



3.2 The Market Failure after Detecting the First BSE Cow

We now have to explain how consumers and firms behave after getting to know about the possibility to buy or sell beef coming from cattle being infected by BSE.

Demand

Our representative consumer cannot be sure anymore to buy a good quality. Furthermore he cannot observe which quality he is going to buy, since no test is available for him until now. He evaluates good qualities by $V_G(x)$ and bad qualities by $V_B(x)$. The measure for good qualities is the same used in the preceding section, that means $V(x) = V_G(x)$.

We assume $V_G' > V_B' > 0$ and $V_B'' < 0$.

Let π denote the probability of getting a good quality. In the situation of uncertainty the consumer regards his expected utility EU. In contrast to (3.3) our representative consumer has to solve the following problem

$$\max EU = \pi \cdot V_G(x) + (1-\pi) \cdot V_B(x) + y - p \cdot x \quad \text{with respect to } x. \quad (3.7)$$

The solution of this problem results to the new demand function

$$X_2^D = D_2(p) \quad \text{with } D_2' < 0. \quad (3.8)$$

Proposition: Decreasing demand after BSE information

Assume $V_G' > V_B' > 0$ and $0 < \pi < 1$, then the demand after detecting the first BSE case is lower than in the competitive situation before BSE was known, i.e. $D_2(p) < D_1(p)$.

Proof. Denoting p_1 and p_2 the prices resulting from the first order conditions belonging to problem (3.3) and (3.7). Thus we have

$$EU' = \pi \cdot V_G'(x) + (1-\pi) \cdot V_B'(x) = p_2 \quad \text{and} \quad U' = V'(x) = V_G'(x) = p_1. \quad (3.9)$$

Since $V_G' > V_B'$ and $0 < \pi < 1$, we can conclude

$$p_2 = \pi \cdot V_G'(x) + (1-\pi) \cdot V_B'(x) < \pi \cdot V_G'(x) + (1-\pi) \cdot V_G'(x) = V_G'(x) = V'(x) = p_1. \quad \text{QED.}$$

Thus we have shown that the demand curve turns to the left when the BSE problem is relevant on the beef market.

Supply

Firms observe the new demand function $D_2(p)$ and reduce their offer. Many butchers were no longer able to sell beef any more. Therefore we assume a decreasing number of the firms down to N_2 . Another reason for the reduction of the supply stems from the fact, that some parts of the cows like the brain are not allowed to be sold anymore. This raises the marginal costs. The supply-curve becomes steeper, denoted by

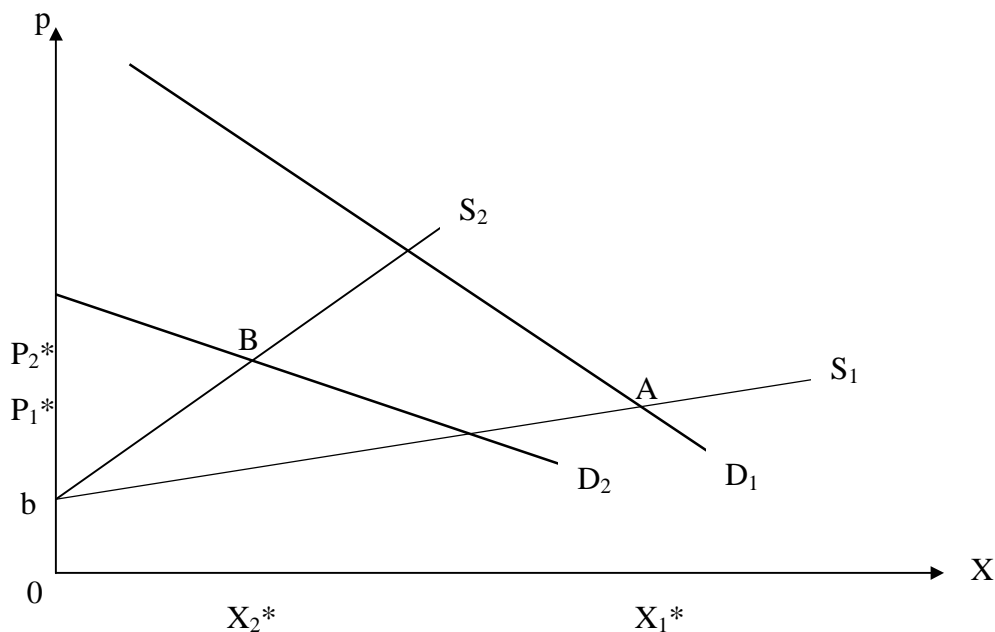
$$X_2^S = S_2(p) = N_2 \cdot (p - b) / a_2. \quad (3.10)$$

Equilibrium

Here we consider two possible results.

At first it could happen that consumers are not willing to pay more than b units of money for one unit of beef. In this case the market completely breaks down. As this did not happen on the German beef market, we come to the observable case with reduction of demand and supply, denoted by (X_2^*, p_2^*) , the point of intersection of the graphs of (3.8) and (3.10). The fact that consumer prices rose during the crisis is explained in our context by the decline of supply. The reduction of demand on its own would in result lower prices than in the situation before the BSE crisis.

Figure 3.2: Equilibrium on the beef market after BSE being detected



3.3 The Market Recovery Due to a BSE Test

Two weeks after having detected the first BSE case in Germany a quick-test was available to look for infected animals. We now extend our model to including this fact.

Demand

The existence of a test leads to a situation in which consumers can distinguish between tested and untested offers of beef, at least in principle. The development of the demand depends on the reliability of the test. If we assume that any cattle could be tested with certainty on being free from BSE and no fraudulent offers are on the market, the demand function $D_3(p)$ should fall together with the one from section 3.1, thus we have

$$X_3^D = D_3(p) = D_1(p) \quad \text{with } D_3' < 0. \quad (3.11)$$

The possibility of two qualities, tested and untested beef, or of fraudulent offers are subjects of further research of the authors.

Supply

Firms must decide whether they offer tested or untested meat. The latter raises the costs of the firms. Here we assume that the government only allows tested beef or that the firms prefer tested beef in order to build up credibility in the eyes of the consumers. Thus, in a first step the supply function will turn left furthermore. It is also possible that new firms enter the market later on. These two cases are described by the supply-functions

$$X_{31}^S = S_{31}(p) = N_2 \cdot (p - b) / a_3 \tag{3.12}$$

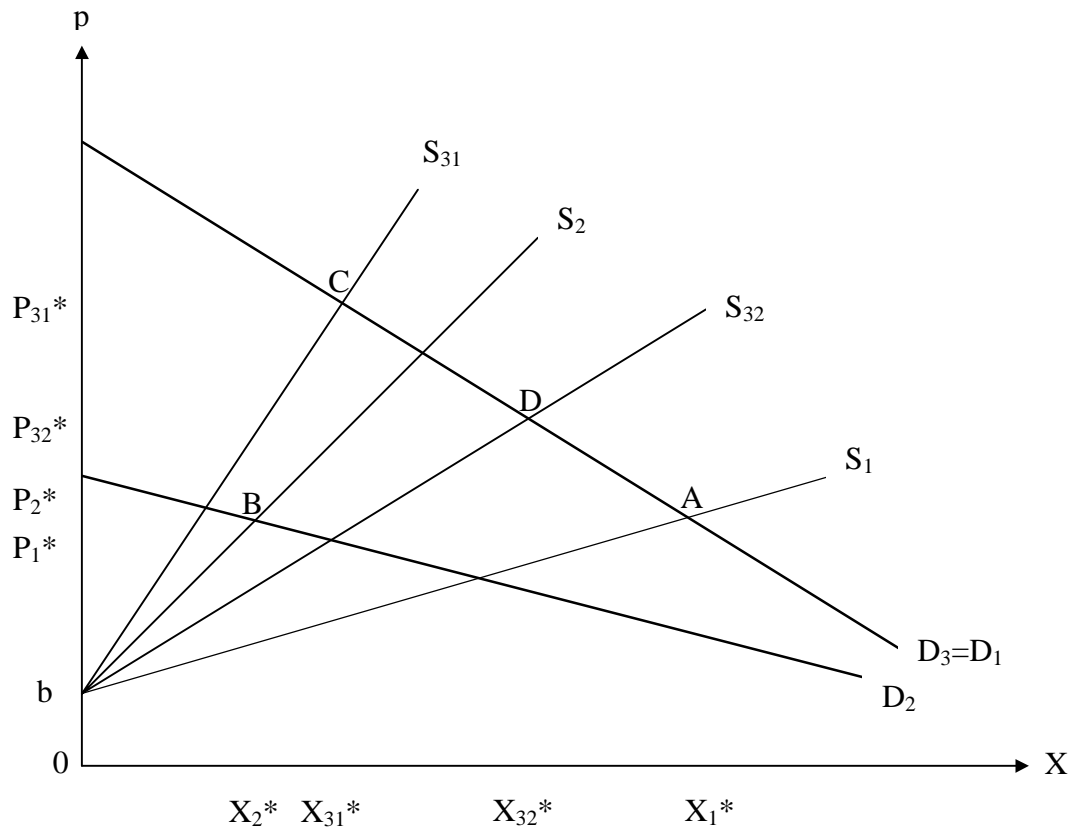
and

$$X_{32}^S = S_{32}(p) = N_3 \cdot (p - b) / a_3. \tag{3.13}$$

Equilibrium

Now we combine the demand function (3.11) with the two supply functions (3.12) and (3.13).

Figure 3.3: Equilibrium on the marked of tested beef



Their intersections describe two possible market solutions in the case of consumers confidence due to a BSE test, denoted by (X_{31}^*, p_{31}^*) and (X_{32}^*, p_{32}^*) .

Figure 3.3 summarizes the three steps of our analysis. Point A describes the equilibrium before the outbreak of BSE and point B the situation after detecting the BSE risk in the market. Point C and D are two possible equilibria after the introduction of a BSE test by government.

4. Empirical Results

Most empirical work so far has been done with data from United Kingdom. Mainland/Ashworth (1992) analyze the effect of BSE on the revenue from beef fatstock with ARIMA forecast techniques. They estimate a revenue loss of 216.6 million pounds for the period October 1989 to September 1990. Burton/Young (1996) and Burton/Young/Cromb (1999) estimate the impact of BSE on the demand for beef and other meats in Great Britain within a dynamic almost ideal demand system. They find significant effects of BSE on the allocation of consumer expenditure among meats. A regional input-output model is used by Caskie/Davis/Moss (1999) to quantify the effects in final demand for beef in Northern Ireland. They find a regional income loss of 0.5% of the regional GDP and 0.6% job losses caused by BSE.

Pennings/Wansink/Muelenberg (2002) show that in comparison with Dutch and US consumers, Germans are extremely risk averse. In the beginning of 2001, German consumers were willing to reduce their beef consumption by 73.2% to 91.1%, depending on the supposed vCJD infection probability.

In the empirical part of our paper, we analyze the influence of BSE on the relationship between consumer and producer prices in a cointegration framework. In the next section, we start describing the basics of our examination.

4.1 The Data

In Germany, in November 2000, the month of the outbreak of the German BSE crisis, there were 14.48 million cattle, 4.54 of them were dairy cows (Federal Statistical Office Germany, 2000). Two years later the livestock is 13.70 million cattle with 4.37 dairy cows (Federal Statistical Office Germany (2003).

Using data from the Ministry of Consumer Protection, Food and Agriculture (2003) from November 20, 2003 we have in total 283 BSE cases, 7 of them in the year 2000, 125 in 2001,

106 in the last year and 45 in this year. The average age of a BSE bovine is 5 years and 11 months, the youngest one was 2 years and 5 months and the oldest was 15 years and five months old. We also get information of the year of birth. The birth cohorts go from September 1987 to December 1999. On average, the infected BSE bovines are born in August 1995. The average animal population of one farm is 200 bovines, with a minimum of 4 and a maximum of 2,946 animals. In two cases, the BSE bovine come from the same cohort/farm. This implies that there is on average a higher probability of finding an infected bovine on farms with one confirmed BSE case. This probability is 0.0036% in comparison with 0.0020% in the whole cattle population. More clearly: if a person daily consumes small quantities of not-tested beef, and assuming the beef stemming from different cows each time, the probability of eating infected meat during the year would rise up to 0.73%! So, the BSE risk does constitute a serious risk that should not be neglected.

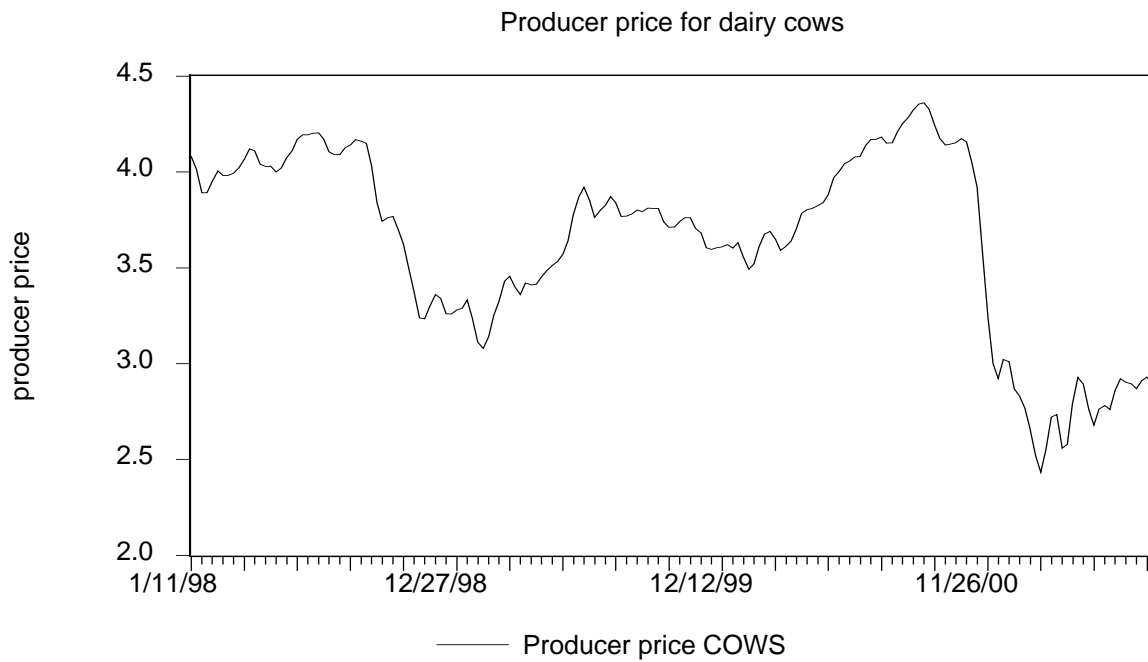
The BSE risk played an important role in the public discussion in Germany after the first BSE cases were found and the ignored risk suddenly became obvious. The beef consumption decreases sharply, e.g., 58.5% one week after detecting the first German case. We therefore have reason to expect the fear of eating infected beef to be reflected in the price level.

Because of their long life, dairy cows have a very high BSE risk and also a lower meat quality. Meat cows are not tested, because the incubation time of BSE is rather long (3 to 7 years) and BSE tests detect BSE only half a year before the outbreak of the disease. Meat cows however, normally get slaughtered before they reach the age where BSE may be detected. Therefore, we use producer prices of dairy cows (COWS) and compare them with different beef meet prices for low and middle quality.¹⁾ In detail, we use prices for boiling meat (BBOILING), ground meat (BGROUND) and joint of beef (BJOINT). We expect pronounced price reactions on the BSE information.

In figure 4.1 the producer prices of slaughtered dairy cows are presented. We see, as expected, that the producer prices fall sharply with the occurrence of the first own BSE case in November 24, 2000. Before the BSE case the price was around 3.60 DM/kg, two weeks later it has reached the 3.00 DM/kg. At the end of January 2001, market interventions were announced. Interestingly, the price reached the bottom with 2.55 DM/kg in the next two weeks. Afterwards, the price began to rise again. - It should be noted that producer prices of younger cows behave similar to those of dairy cows, but with less intensity.

¹⁾ The data is from ZMP, Bonn.

Figure 4.1:



The price development of the consumer prices presented in figure 4.2 is markedly different. Against the expected development, the consumer prices increase, especially the price for boiling meat.

Figure 4.2:

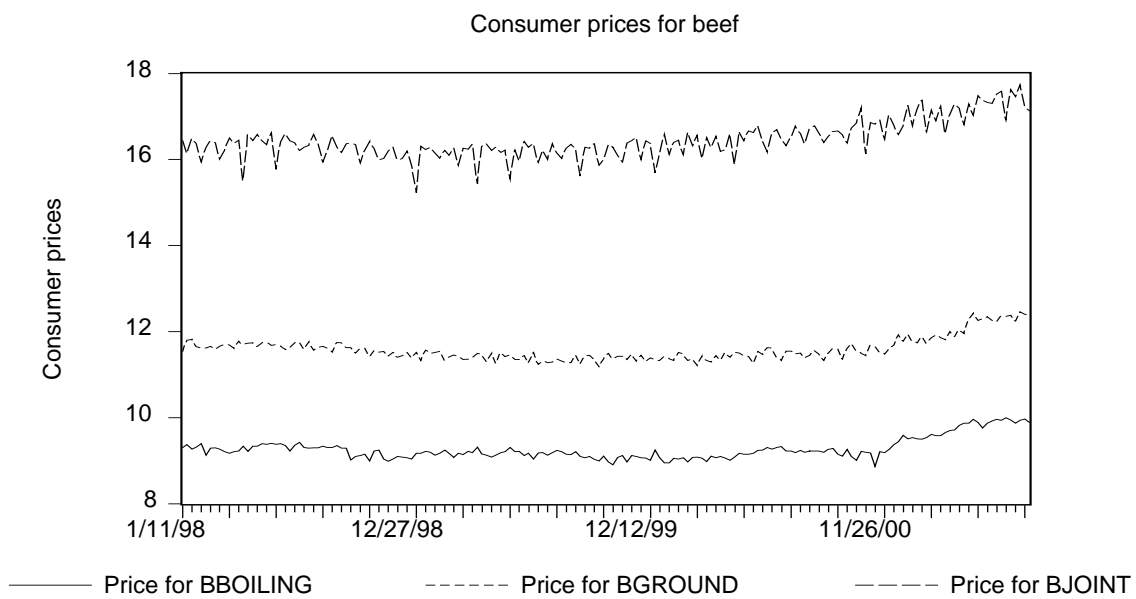
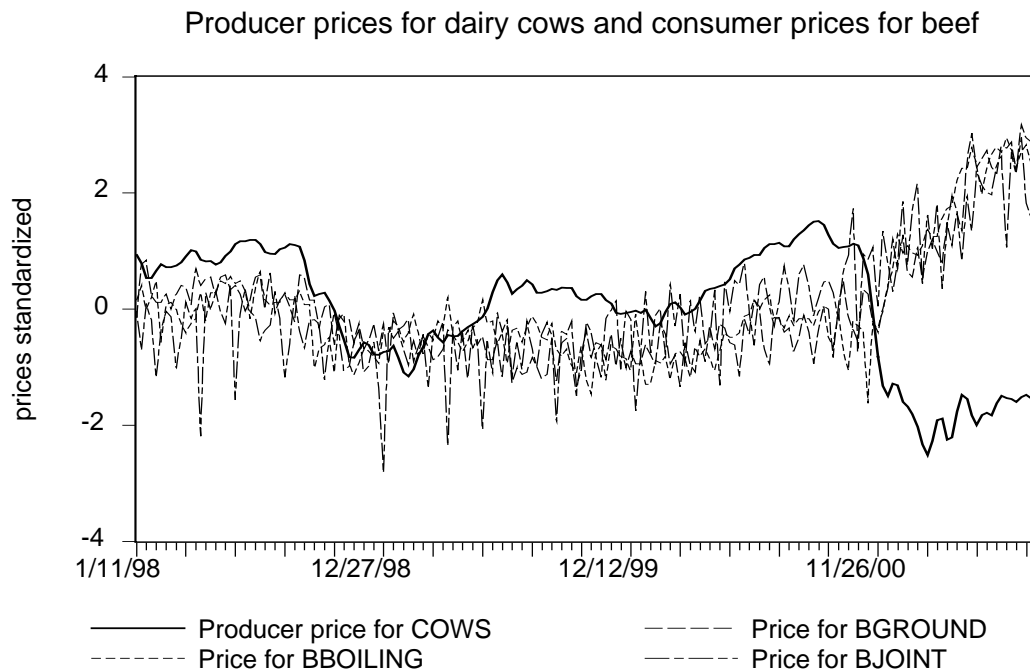


Figure 4.3:



In figure 4.3, we standardize all prices. We can see the joint band of shortly volatile consumer prices and, as a bold line, the development of the producer price for dairy cows. The gap between producer and consumer prices after the first German BSE case is very clear.

In the next section, we analyze the time series properties of the consumer and producer prices and estimate the relationship between them. Especially, we investigate the question of a possible break due to the new BSE information.

4.2 Unit Root Tests under Known Break Points

We test the hypothesis of a unit root for the four price series assuming a known breakpoint that influences the mean of the time series using a modified augmented Dickey-Fuller test by Perron (1990) and Perron/Vogelsang (1992). Therefore, in the first step, we regress the prices against a constant and the breakpoint dummy:

$$y_t = \mu_0 + \delta_1 DU_t + u_t \quad (4.1)$$

with $DU_t=0$ for $t \leq T_B$ and $DU_t=1$ for $t > T_B$, where T_B is a breakpoint that shifts the level of the time series. The breakpoint we use is the first confirmed BSE case on November 24, 2000.

In the next step, we apply the augmented Dickey-Fuller (ADF) test to the adjusted time series

$$y_{adj,t} := y_t - \mu_0 - \delta_1 DU_t,$$

$$\Delta y_{adj,t} = \alpha y_{adj,t-1} + \delta_1 \Delta y_{adj,t-1} + \dots + \delta_p \Delta y_{adj,t-p} + \beta_1 DU_{t-1} + \dots + \beta_p DU_{t-p} + e_t. \quad (4.2)$$

The optimal lag length p is chosen by the Schwarz criterion. The null hypothesis that the break adjusted y_{adj} time series are integrated of order one is $H_0: \alpha = 0$. We use the critical values from Perron (1990, p. 158) for the t -type test statistic. The results of this modified ADF test are presented in table 2. Additionally, a standard ADF test (with a constant and 4 lags) is presented for the time before the outbreak of the German BSE crisis. The results show that we have no clear evidence to reject the unit root hypothesis for the data. Only the boiling meat reaches the 10%-significance level. Therefore we assume that the adjusted time series are integrated of order one.

Table 2:

Unit Root tests for the price series in the presence of a break

Time series	Modified ADF ^(a)	ADF for $t < T_B$ ^(b)
COWS	-1.476	-1.72
BBOILING	-2.970*	2.53*
BGROUND	-2.295	-1.46
BJOINT	-2.573	-1.72

Note: ‘*’ shows that the hypothesis of a unit root can be rejected at the 10% level.

(a) The estimation period is 1/11/1998 – 7/01/2001. T_B is 11/24/2000, the number of observations is $T=182$ and the fraction of observations after T_B is $\lambda=0.82$. We use the critical values for $T=200$ and $\lambda=0.8$ indicated by Perron (1990).

(b) ADF test with constant and 4 lags. The estimation period is 1/11/1998 – 11/19/2000.

4.3 Robust Cointegration Test under Structural Breaks

We explain the producer price of dairy cow meat by a bundle of the three consumer prices. The results of the unit root test indicate that the price series are integrated of order one. We expect that these consumer and producer prices are cointegrated (i.e., share a long-run stationary linear combination) with a co-break caused by BSE information and additional costs of slaughtering and BSE testing.

Arranz/Escribano (2000) show that dynamic conditional error correction models based on economic variables that have simultaneous co-breaks do not require the use of dummy variables. In simulation experiments, they find for sample sizes with more than 100 observations that one should use the $N(0,1)$ critical values. This is valid for any value of the short term adjustment parameter, any jump size and for any type of segmented trend. In detail,

they analyze different timings of the break, breaks only in one series, simultaneous breaks in the two series, breaks in the level of the series, breaks in the first differences of the series and also the possibility of two breaks. In Monte Carlo experiments they show a very good power of their cointegration test. In many situations the size adjusted power is 100% or near 100%. We therefore employ this model for our data set.

The starting point is the error correction model

$$\Delta y_t = c_t + a\Delta x_t + b(y_{t-1} - \alpha x_{t-1}) + u_{1t}, \quad (4.3a)$$

$$\Delta x_t = \Delta \mu_x + u_{2t}, \quad (4.3b)$$

and

$$c_t := \Delta \mu_y - a\Delta \mu_x - b(\mu_{y,t-1} - \alpha \mu_{x,t-1}) \quad (4.3c)$$

where y_t and x_t are two cointegrated time series and μ_y, μ_x are unconditional means of y and x . They include all possible deterministic elements like constant terms, trends, segmented trends, dummy variables. Δ is the difference operator and a, b, α are parameters. The intercept c_t describes breaks in the differences $\Delta \mu$ as well as in the levels μ of the time series y_t and x_t . The time series have co-breaks in differences if $\Delta \mu_{y,t} - a\Delta \mu_{x,t}$ is a finite constant parameter, and in levels if $\mu_{y,t-1} - \alpha \mu_{x,t-1}$ is a finite constant parameter. In the case of a full co-break, meaning a simultaneous co-break in difference and in levels, $c_t = c$, we get the standard error correction model. The interesting hypothesis of no-cointegration is $H_0: b=0$.

Using the idea of Toda/Yamamoto (1995) and Dolado/Lütkepohl (1996) of robust granger-causality testing with integrated and possibly cointegrated variables Arranz/Escribano (2000) suggest to overparametrize the model by adding an extra lag to the error correction term in order to get standard inference results.

$$\Delta y_t = c + a\Delta x_t + b(y_{t-1} - \alpha x_{t-1}) + d(y_{t-2} - \alpha x_{t-2}) + u_t \quad (4.4)$$

The t -ratio of the parameter b in equation (4.4) converges to the standard Normal distribution (Arranz/Escribano, 2000, p. 42). So we can test the hypothesis of no-cointegration using the standard normal distribution for t_b .

When there are extra dynamic regressors, the model becomes

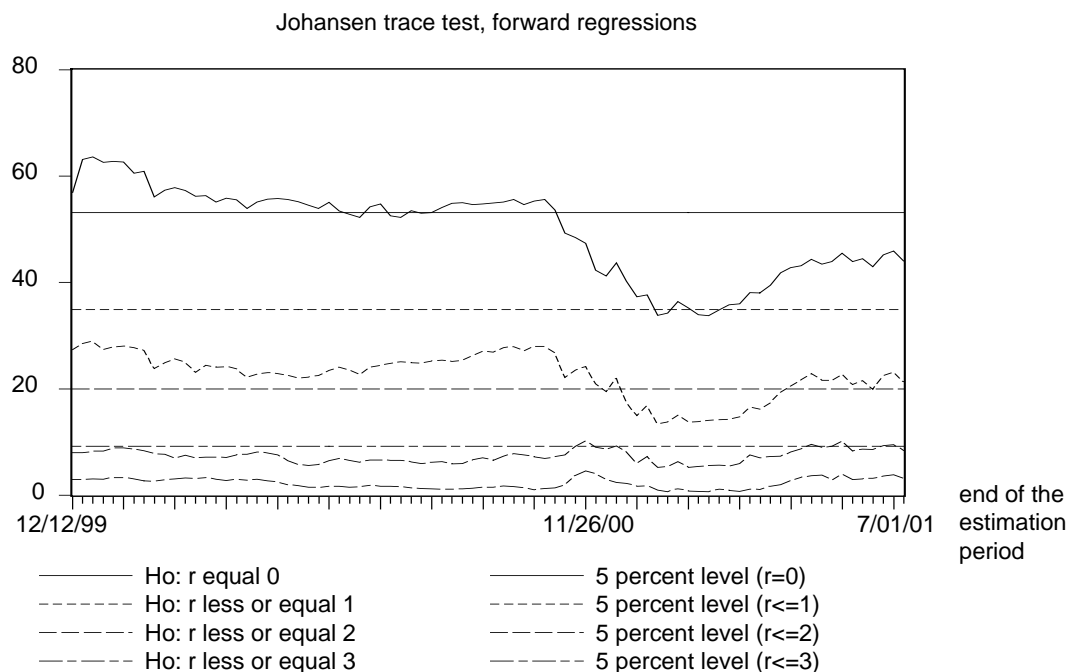
$$\Delta y_t = c + \delta_1 \Delta y_{t-1} + \dots + \delta_p \Delta y_{t-p} + a\Delta x_t + a_1 \Delta x_{t-1} + \dots + a_q \Delta x_{t-q} + b(y_{t-1} - \alpha x_{t-1}) + d(y_{t-k-2} - \alpha x_{t-k-2}) + u_t, \quad (4.5)$$

where $k=\max\{p,q\}$ is selected by using a consistent model selection criterion, in our case the Schwarz criterion. Alternative specifications of equation (4.5) are described by Arranz/Escribano (2000, p. 48).

4.4 Results of Cointegration Tests

We first employ recursive cointegration tests with the Johansen trace test (see Johansen/Juselius, 1990) in a four-dimensional vector autoregressive model of the price series with 4 lags and a constant term in the cointegration vector to analyze the dependence of the cointegration behavior on structural breaks. The lag length is suggested by the AIC criterion for the whole estimation period and also for the estimation period before the first German BSE case. We use forward regressions with the estimation period beginning on 1/11/1998 and at least 100 observations.

Figure 4.4:



The results are presented in figure 4.4. For the pre-BSE-period the null hypothesis of a cointegration rank equal to zero can be rejected at the 5%-significance level (critical values are taken from Osterwald-Lenum (1992, table 1*, p. 47)), but not the hypothesis of higher cointegration ranks. This means that we have one cointegration vector. With the first German BSE case the level of the test statistics begins to fall and we can no longer find any significant cointegration relationships.

The next cointegration tests are carried out in the break robust dynamic model suggested by Arranz/Escribano (2000) according to equation (4.4) and (4.5). The maximum lag length p,q

is set equal to 3. We use non-linear least squares estimation techniques to estimate these equations directly. The convergence rate sometimes is very slow, but all estimations converge. The outcome of the cointegration test strongly depends on the lag structure used. The optimal lag length chosen by the Schwarz criterion is $p = 2$ and $q = 0$. If we only select models under the restriction of equal lag length, the optimal lag length will be $p=q=1$. The test results of these estimations are presented in table 3.

Table 3:

Cointegration tests in a robust extended error correction model

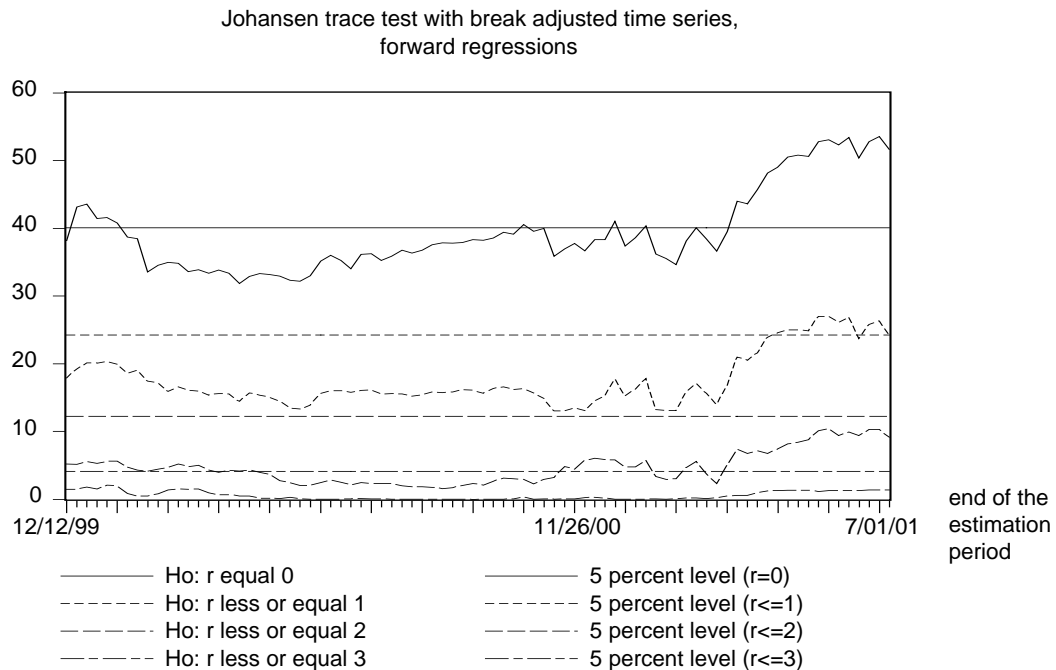
Model	equation (4.4)	equation (4.5)	
		(1,1)	(2,0)
Lags (p,q)	(0,0)	(1,1)	(2,0)
Coefficient b	-0.006	-0.427***	0.199
t_b -statistics	-0.862	-6.147	2.672
R^2	0.101	0.476	0.510
Schwarz criterion	-2.203	-2.721	-2.751
<i>Note:</i> *** shows that the hypothesis of no-cointegration can be rejected at the 1% level. The estimation period is 1/11/1998 – 7/01/2001.			

The message of the test results is not really clear. In the case of equation (4.4), the null hypothesis of no-cointegration cannot be rejected. If we allow additional dynamics according to equation (4.5), we find clear evidence against the null hypothesis of no-cointegration with $p=q=1$. But with $p=2$ and $q=0$, the no-cointegration hypothesis again cannot be rejected. In the last case, the error correction coefficient b is greater than zero and violates the cointegration condition of $-2 < b < 0$.

Additional recursive system cointegration tests with a simplified version of the Saikkonen/Lütkepohl (2000) trace test for time series with a level shift indicate that there might be at least one cointegration vector for consumer and producer prices. The Saikkonen/Lütkepohl (2000) system cointegration test is a two step procedure. In the first step, the time series are mean and break adjusted and in the second step a cointegration trace test is performed. To adjust the time series, we use estimates of a vector autoregressive model in levels with $p=5$ lags, a constant term and contemporaneous and lagged BSE dummies for the full sample period. The simplification is that we ignore the cointegration structure in this step. This might affect the small sample properties of the test, but not the asymptotic behavior, as remarked by Saikkonen/Lütkepohl (2000). In the next step, we perform the Johansen trace test with $p-1$ lags in the vector error correction model and no constant term in the cointegration equation for the mean and break adjusted series. We perform this step in

forward regressions, starting with $100-p$ observations. We use the critical values from Trenkler (2003, p. 7, table 3) assuming a constant term with a level shift in the cointegration vector. The results are presented in figure 4.5:

Figure 4.5:



A comparison with figure 4.4 reveals a similar outcome of the test up to the first German BSE case, but a lower significance level. The result might be explained by the loss of the first p observations in the first step of the procedure and by the small sample properties of the test. With the level break adjusted time series, the trace test lies below the 5%-significance level for some period before and after the outbreak of the BSE crisis. Nevertheless, for the full estimation period we find at least one highly significant cointegration vector.

5. Conclusions

Though the first BSE case in Germany was detected three years ago, the story has not come to an end. Thuringia has gotten its fifth BSE case on November, 19 2003. In our overview we started with the first case detected in Great Britain in 1986. Ten years later the causal relationship between BSE and the new variant Creutzfeldt-Jakob Disease (vCJD) was considered high probable and is no longer doubted at all today. By now, there are 143 victims in Great Britain. Future vCJD victims must be expected. In Germany there is a high probability that cases of BSE were and still will be undetected, because the monitoring and testing programs were inadequate.

In the second part of the paper, we present a simple model to describe the development of prices on the consumer market for beef. We work with a quasilinear utility function neglecting any substitution or income effects and develop the demand and supply functions based on one good production. With these instruments, we show the collapse of the market under the new occurrence of BSE risk, compared with a competitive situation under certainty. Due to a BSE test which works with certainty we explain the recovery of the market.

In the empirical analysis, we use weekly data of producer and consumer prices of beef in Germany for the years January, 1998 to July, 2001. A graphical inspection of the data shows strong structural break caused by the first BSE case. The producer price falls as expected, but the consumer prices rise. The prices series reveals a long-run cointegration relationship between the consumer and producer prices, which is affected by the outbreak of the BSE crisis. But we have some indication of a joint co-break between the series. Having eliminated the breaks in the consumer and producer price series, we now find a cointegration relationship for the whole period. This means there is evidence for a new price mechanism between producer and consumer prices after the BSE outbreak, reflecting change of behavior and additional costs.

The empirical facts suggest that our model should be extended. In future research, questions about uncertainty of the BSE test, substitution effects, product differentiation and fraudulent behavior on the supply side should be answered.

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