BSE and the US Economy:
Input-Output Model Perspective

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The potential impact of a BSE outbreak on the US economy is modeled in input-output setting using 2002 US IMPLAN data. An outbreak of BSE would hurt the US beef industry, other agriculturally-related industry, and the rest of the economy as a whole. The worse effects occur in the beef cattle and farming industries. Generally, the economy of every county would be hurt given the fact that cattle are produced in all the 50 states. But it is apparent that the damage would be substantial in those regions and households which already suffer the severest economic damage.

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For nearly two decades, US beef demand has been affected by bovine spongiform encephalopathy (BSE) after its potential danger to human health was exposed by Holt and Phillips (1988), Dealler (1993), Sawcer (1993), and Lacey (1993). The BSE outbreak in the UK during the mid 1990s and its possible link to cases of human Creutzfeldt-Jakob disease led various agencies of the US government to implement control measures. The spread of BSE to Japan and Canada during 2003 led to increased USDA surveillance and research. Regulatory efforts increased again when a case of BSE was reported in the state of Washington that year. During the week following the Washington case, cattle prices fell by 16% and cattle future prices by 20% but they rose back in the following quarter. Coffey, Mintert, Fox, Schroeder, and Valentin (2005) cite a regionally targeted consumer survey and find most consumers did not change habits because of the BSE case but would given a major outbreak. Within days of the Washington case, 53 countries including major importers such as Japan, Mexico, South Korea, and Canada banned US beef imports. Exports had accounted for 10% of US beef revenue, and Jin, Skripnitchenko, and Koo (2004) suggest a worse case scenario of a 20% decline in US beef prices due to a BSE outbreak.

It has become commonplace to say that the consequences of the BSE crisis reach far beyond the farm gate. However, quantifying the extent and significance of these secondary impacts is more problematic. Aggregate estimates of employment and value-added generated by beef farming and beef processing provide only a partial understanding that exist between beef production, other farm sectors and ancillary industries and the sector's role in the national economy. These estimates do not capture the extent and economic importance of interindustry linkage. The beef

industry is linked to other sectors in the economy through a network of input purchases and output sales. Changes in the level of demand for beef, both in U.S. and other markets, will have spin-of effects on the quantity of inter-industry sales and purchases.

A U.S. input-output (I-O) model is developed using IMPLAN 2002 economic data to capture not only the direct effects of reduction in demand for cattle industry output due to BSE on beef production but also other nonagricultural sectors. Output, income, and employment impacts arising from reduced demand for beef are estimated. The long-run effects of BSE on the US economy would be serious in the absence of effective stabilization measures. The worse effects would take place in the beef cattle and farming industries.

A Review of BSE and the Beef Market

In the week following the Washington BSE case in December 2003 cattle prices fell by 16% and cattle future prices by 20% but they rose back during the first quarter of 2004. Had the low prices held, the cattle industry would have lost $2 billion during the first quarter of 2004.

The consumer survey of Henderson (2003) suggests US beef demand could fall as much as 15% with a BSE outbreak. Coffey, Mintert, Fox, Schroeder, and Valentin (2005) use a regionally targeted consumer survey and find over three quarters of consumers did not change habits because of the BSE case but that subsequent cases, particularly multiple ones, could have a significant impact. Jin, Skripnitchenko, and Koo (2004) estimate there would be a 20% domestic decline of beef consumption with additional BSE outbreaks in the United States.

Within days of the Washington case 53 countries including major importers such as Japan, Mexico, South Korea, and Canada banned imports of US beef. Exports of $4 billion accounted for 10% of US beef production during 2003 and the bans reduced exports by 82%. If all

exported beef were consumed domestically, the increased quantity would have lowered domestic beef prices 16% as developed by Henderson (2003).

During the second half of 2004 cattle future prices remained perhaps 10% lower than had been expected. Francl (2003) points out that based on the expected sale of over 25 billion pounds in 2004 every $10 per hundredweight drop in price results in a $2.5 billion drop in revenue. Lost exports would then account for a loss of $1 billion revenue with total lost revenue of about $3.5 billion. From 1998 to 2002, the US exported a yearly average of $1.4 billion of beef products. This export volume increased the price of cattle about $40 per head during that period. Also, gross receipts from sales of cattle and calves in 2000 totaled $41 million accounting for 21% of all agricultural receipts (Feuz 2005).

A Brief Review of Literature on BSE and Consumers' Responses

BSE has mainly occurred in European countries and, therefore, studies of BSE outbreak and consumers' responses have focused on European cases. Studies have approached the BSE case from three different directions. The first group investigated consumers' responses using contingent valuation method (CVM). The second group analyzes structural changes in consumers' preferences or producers' profits while the third group investigates economic impacts of the outbreaks.

A study among the group is an examination by Latouche, Rainelli, and Vermersch (1998). They conducted a survey using CVM to analyze consumer behavior in the area of Rennes, France after the BSE crisis. Their survey revealed that consumers were waiting for greater transparency and they would accept paying for it.

In regard the issue of consumers' preferences after the BSE outbreak, Mangen and Burell (2001) investigated a structural change in Ductch consumers' preferences for meat and fish, following

U.K. government's announcement. They used switching Almost Ideal Demand System (AIDS) model and a sample period that covers January 1994 through may 1998. The hypothesis of constancy of the parameters of the AIDS model for meat and fish was rejected against a more general time-varying parameter model. The combined effects of the underlying trends and irreversible components of the BSE effects were against beef, minced beef, and meat products, in favor of pork, prepared meat, poultry and fish and the result was what?.

As for the third group, Ashworth and Mainland (1995) reviewed economic consequences of the BSE outbreak for the British meat industry. Adda (2002) investigated the effects of past consumption of risky goods on current consumption patterns, using the "mad cow" crisis as a natural experiment. Consumers with intermediate levels of past consumption decreased their demand for beef and sought higher quality products, while low-and high-stock consumers did not alter their behavior after crisis. Verbeke and Ward (2001) investigated fresh meat consumption in Belgium during the period from 1995 through 1998 using an AIDS model. In specifying the demand system, they incorporated a media index mainly pertaining to BSE; their results showed that television publicity has a negative impact on beef expenditure, in favor of pork. Burton and Young (1996) investigated the impact of BSE on the demand for beef and other meats in the United Kingdom. Indices of media coverage of BSE are incorporated in a dynamic AIDS model of meat demand.

In the U.S, Henderson (2003) conducted consumer surveys during the BSE outbreak in Washington the results suggested U.S. beef demand could fall by as much as 15 percent. However, research indicated that the impact on domestic demand could be small because consumers respond differently to food safety concerns than long-run health concerns. To investigate the potential impact of additional U.S. BSE discoveries, Coffey, Mintert, Fox,

Schroeder, and Valentin (2005) used a regionally targeted consumer survey. The results suggested that most consumers (77 percent) did not change consumption habits because of the first U.S. BSE case, but that subsequent discoveries, particularly of multiple cases, could have significant impact on demand.

Model Construction and Structure

Using data from the American Meat Institute (AMI), Otto and Lawrence (2001) put the final demand uses of processed cattle products as an estimated 2.52 billion pounds going into foreign markets and 24.25 billion pounds into domestic markets in 2001. These estimates for the various dimensions of the US beef industry at the producer and processor level represent the direct component of the industry with production inputs purchased by these sectors representing the indirect effects. In addition to these obvious producer and input supplying impacts, income earned in these agriculturally-related components of the beef industry is spent in the rest of the economy stimulating a wide range of sectors, including consumer-related businesses in urban areas.

This paper uses Input-Output (I-O) analysis to show the economic consequences of BSE outbreak in the US. The input-output method is based on the interrelationship between sectors in the economy and how each is affected by a change in the final demand for a sector's output. The model can be expressed in the following equation:

$$X = (I - A)^{-1} Y \qquad (1)$$

where X is an output for a sector, A is intermediate input usually referred as the technical coefficient, Y is final demand for X, and $(I-A)^{-1}$ is the Leontief inverse or the multiplier or interdependency matrix. The interdependency matrix shows the direct and indirect effect of a dollar change in final demand on the sector's output, a measure of the impact on the economy.

Two frequently used types of multipliers are outputs and household income multipliers, output of the sectors of the economy and income earned by household that is expected to be generated because of the new output. Multipliers can be type I, direct and indirect effects; or type II, direct, indirect and induced effects (Miller and Blair, 1985).

Output multiplier for sector *j* is defined as the total value of production in all sectors of the economy that is necessary to satisfy a dollar's worth of final demand for sector j's output. The output multiplier is the ratio of the direct and the indirect effect to the initial effect expressed by the following equation:

$$O_j = \sum_{i=1}^{n} \alpha_{ij} \qquad (2)$$

where, O_j is output multiplier and α_{ij} is the Leontief inverse matrix or matrix of interdependency $(I-A)^{-1}$.

The total output is the direct and indirect output effects without including the household. Initial output effect on the economy is simply the initial dollar's worth of sector j's output needed to satisfy the additional final demand. Output multiplier is the sum of the column vector of the interdependency matrix and shows where the spending would have the greatest impact in terms of total dollar value of output generated in the economy.

Income effect or household income multiplier measures the impact of change in final demand into change in income received by households. Income multiplier shows the direct and indirect effect of a dollar worth of output in terms of dollar's worth of new household income. It is expressed by the following equation:

$$H_j = \sum_{i=1}^{n} a_{n+1,i}\alpha_{ij} \qquad (3)$$

where, H_j is household income multiplier of sector j,$a_{n+1,i}$ is the household input coefficient for each industry (row vector) and α_{ij} is the Leontief inverse matrix or matrix of interdependency $(I-A)^{-1}$.

Empirical Analysis

To estimate the possible effect of a reduction in final demand for processed meat because of BSE, a US Input-Output (I-O) model and multipliers were developed using IMPLAN 2002 economic data. The whole economy is aggregated in to 18 major industries (see aggregation Table 1) and the output and household income multipliers are developed. The aggregation is done to isolate the economic activity of the meat processing, cattle industry, wholesale and retail trade, transportation real estate and financial agencies based on the assumption that beef is the main input, trade and transportation are essential for distribution, real estate and financial agencies will be affected the location and finance of a plant. The rest of the sectors are highly aggregated and the results are discussed cautiously.

The major assumption of input-output analysis is that a change in final demand will create a motion in the economy which will affect all the interrelated industries. The effect on the economy is expressed by a vector of interdependency coefficients. Table 2 provides these interdependency coefficients for the meat processing industry in the US. The sum of these coefficients is the output multiplier for industry. Output multiplier indicates the additional output of each industry required for a dollar of new final demand for processed meat. Type I multiplier is used to avoid exaggerating the effect of change in the final demand. The meat processing industry has an output multiplier of 2.4429, that is to say a dollar of final demand will

generate a total of about $2.44 in the whole economy. Different industries are affected and 1.0136 or 42% of this change is captured by the meat processing industry. The next major industry is food processing a highly aggregated sector, accounting for 14% of the impact. About 4% of the change is absorbed by the cattle industry. Wholesale and retail trade and transport accounted for 5 and 3 % of the total change, respectively, while real estate and financial agencies contributed 2 and 1%, respectively. The service industries as a group accounted for 14%.

BSE Effect on Output and Income

Final demand which includes household, government, export and import of the meat processing industry in 2002 at 2002 prices was $22,000.98 million (IMPLAN U.S. Economic data 2002). Jin et al. (2004) estimated that there would be a 20% decline in beef consumption with additional BSE outbreaks in the US. Coffey et al. (2005) showed that multiple cases of BSE will significantly affect demand. In the absence of other estimations on the decline in demand for processed meat because of BSE, this study simulates two BSE- induced-impact scenarios on output and income in the economy: *Scenario I*- output before BSE and after 20% decline in final demand because of BSE, and *Scenario II* - income before BSE and after 20% decline in final demand because of BSE.

The results of the two scenarios are presented in Tables 3 and 4. Table 3 shows the results of S*cenario I,* the total industry output generated by different goods and service producers in the economy would be about $53 billion for a final demand of $ 22 billion with the multiplier of 2.44. The meat processing industry will generate the major output worth of $22.3 billion but other industries will generate output because of direct and indirect linkages. The cattle industry will generate about $2.1 billion while the wholesale trade and transport industries generate $2.9 and $1.4 billion, respectively. Column 1 shows the output by each industry after 20% decline in

final demand, the total industry output declines to $43 billion. Meat processing declines from $22.3 to $17.8 billion and the cattle industry the major input supplier declines from $2.1 to $1.8 billion. The output generated by wholesale and retail trade and transportation declines from $2.9 to $2.3 and $1.4 to $1.1 billion, respectively. The output by the service industries, business/personal, government and other service, declines from $7.6 to $6.1 billion that is a loss of about $1.5 billion.

Table 4 illustrates impacts from scenario II; income before BSE and after 20% decline in final demand because of BSE. The income effect shows the direct and indirect impact of the change in final demand into changes in household income – wages and salaries, proprietary income, and other property income – received by households (labor and other factor supply) rather than total output. The table shows that the meat processing industry would generate $19.4 billion before the BSE, since the meat processing industry is the industry of concern a major share of the total income benefit the meat processing industry, $4.9 billion. The total income would decline into $15.6 billion with the 20% reduction in final demand due to BSE, a decline of about 25%. Column 3 shows the percentage distribution, has an interesting implication. It appears that besides meat processing accounting for 25% other non-rural based industries: food processing, wholesale and retail trade, and other services account for about 40% while rural based industries: farming, cattle, and other animals accounted for about 6% of the total income in the form of wages and salaries and other incomes received by households.

Both results showed that a decline in the demand for processed meat due to BSE will have negative impact on the meat industry but other related industries. Cattle producers are directly affected because meat is the major input, however other input supplier and services providers will be affected. It is appears that the trade industries, real estate, financial agencies and general

service providers will be affected. This also indicates that the impact is not only on rural economies but non-rural service providers.

Conclusions

The worse effects occur in the beef cattle and farming industries. The present model provides perspective on the potential of BSE to affect the economy. Since the cattle industry is a good source of income for real estate agencies the reduction in business by the industry would have impact on land and other property distribution and income. Generally, the economy of every county would be hurt given the fact that cattle are produced in all the 50 states. But it is apparent that the damage would be substantial those regions and households which already suffer the severest economic damage. These would have serious policy implications for rural economies. In regards to the economic and social dislocation which could occur as a result of these effects, there may be a case for the maintenance of income stabilization measures until the prospects for beef demand become clearer. The government should embark on programs aimed at restoring consumer confidence in the safety of beef, for example, through stricter production control standards and marketing campaigns.

The result of this paper is limited by the assumptions, the industrial aggregation and the data used should be interpreted within the limitations, however gives an indication of a possible nation wide economic problem. A more disaggregated model can produce a more refined and a more applicable result.

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Table 1. Input-output Aggregation Template

Industry	IMPLAN Code	Number of Industries Aggregated
Farming	1-10	10
Cattle	11	1
Other animals	12,13	2
Ag/forest services	14-18	5
Mining and power	19-31	13
Construction services	32-44,36-45	14
Food processing	46-67,69-89	46*
Meat processing	68	1
Other manufacturing	9 0-141	52*
Chemicals	142-256	156*
Fertilize/pesticide/pharmaceutical	158-160	3
Farm machinery	257-398	133*
Wholesale and retail trade	390	2
Transport	391-395	5
Financial agencies	427-430	4
Real estate	431	1
Business and personal services	432-496	65*
Government and other services	396-426, 497-509	44*

* Shows the highly aggregated industries

Table 2. Direct and Indirect Coefficients of the Meat Processing Industry, 2002

Industry	$(1-A)^{-1}$	Share of Total
Farming	0.0458	0.02
Cattle	0.0938	0.04
Other animals	0.0485	0.02
Ag/forest support	0.0143	0.01
Mining and Power	0.0386	0.02
Construction	0.0101	0.00
Food processing	0.3928	0.14
Meat processing	1.0136	0.41
Other manufacturing	0.0511	0.02
Petroleum and other chemicals	0.0860	0.04
Fertilizer/pesticide/pharmaceutical	0.0046	0.00
Farm machinery	0.0186	0.01
Wholesale and retail trade	0.1337	0.05
Transport	0.0650	0.03
Financial agencies	0.0362	0.01
Real estate	0.0420	0.02
Business/personal services	0.2209	0.09
Government and other services	0.1273	0.05
Output Multiplier	2.4429	1.00

Table 3. Scenario I: Direct and Indirect Gross Output before BSE and a 20% Decline in Final Demand of Meat Processing Industry due to BSE.

Industry	Output Before BSE ($million)	Output After BSE ($million)
Farming	1,008.13	806.50
Cattle	2,063.78	1,651.02
Other animals	1,067.88	854.31
Ag/forest support	314.15	251.32
Mining and Power	849.50	679.60
Construction	221.70	177.36
Food processing	8,641.21	6,912.97
Meat processing	22,300.63	17,840.51
Other manufacturing	1,124.07	899.26
Petroleum and other chemicals	1,892.99	1,514.39
Fertilizer/pesticide/pharmaceutical	101.97	81.58
Farm machinery	408.78	327.02
Wholesale and retail trade	2,941.42	2,353.14
Transport	1,429.12	1,143.29
Financial agencies	795.95	636.76
Real estate	924.09	739.27
Business/personal services	4,859.77	3,887.82
Government and other services	2,801.58	2,241.27
Totals	53,746.74	42,997.40

Table 4. Scenario II: Direct and Indirect Income before BSE and a 20% Decline in Final Demand for Meat Processing due to BSE.

Industry	Output Before BSE ($million)	Output After BSE ($million)	Percent of Total
Farming	557.65	446.12	0.03
Cattle	223.49	178.79	0.01
Other animals	291.30	233.04	0.01
Ag/forest support	151.14	120.92	0.01
Mining and Power	520.50	416.40	0.03
Construction	96.99	77.59	0.00
Food processing	2,466.74	1,973.39	0.13
Meat processing	4,881.21	3,904.97	0.25
Other manufacturing	445.92	356.74	0.02
Petroleum and other chemicals	610.63	488.50	0.03
Fertilizer/pesticide/pharmaceutical	44.06	35.25	0.00
Farm machinery	146.68	117.34	0.01
Wholesale and retail trade	2,129.58	1,703.66	0.11
Transport	640.61	512.49	0.03
Financial agencies	443.81	355.05	0.02
Real estate	652.00	521.60	0.03
Business/personal services	3,042.53	2,434.03	0.16
Government and other services	2,107.92	1,686.33	0.11
Totals	19,453	15,562	1.00