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# Economic Impacts of Banning Subtherapeutic Use of Antibiotics in Swine Production

**B. Wade Brorsen, Terry Lehenbauer, Dasheng Ji, and Joe Connor**

Public health officials and physicians are concerned about possible development of bacterial resistance and potential effects on human health that may be related to the use of antimicrobial agents in livestock feed. The focus of this research is aimed at determining the economic effects that subtherapeutic bans of antimicrobials would have on both swine producers and consumers. The results show that a ban on growth promotants for swine would be costly, totaling \$242.5 million annually, with swine producers sharing the larger portion in the short run and consumers sharing the larger portion in the long run.

*Key Words:* banning subtherapeutic use, feed efficiency, mortality rate, sort loss

**JEL Classifications:** Q18, D61

Food animal production in the United States uses antimicrobial agents to promote animal welfare and to enhance the efficiency of livestock production. Of the total antibiotic production for both human treatment and animal purposes, approximately 25% is used in food animals and 90% of that portion has been reported as being used in subtherapeutic concentrations for disease control and as growth promotants (Angulo; APHIS).

Antimicrobial agents have been added to feed and used extensively in swine production since their introduction in the early 1950s (Radostits, Leslie, and Fetrow). Swine performance is potentially improved by using sub-

therapeutic concentrations of antibiotic or chemotherapeutic drugs to increase rate of gain or improve feed conversion (FDA). Because of the economic benefit to producers, antimicrobial drugs are used in about 90% of the starter feeds, 75% of the grower feeds, and over 50% of the finisher feeds (Cromwell).

Growth promotant or subtherapeutic use of antimicrobials administered in animal feeds has been strongly criticized as a serious public health threat, causing life-threatening infections that are resistant to antimicrobial therapy (Angulo; Witte). This concern has developed around the following issues: (1) subtherapeutic use of antimicrobials in animal feeds creates antimicrobial-resistant bacteria; (2) if subtherapeutic use were eliminated, the level of resistance of bacteria harbored by animals would be reduced; and (3) reduced resistance to antibiotics in animals would improve human health because the potential for transmitting antibiotic-resistant bacteria<sup>1</sup> from animals to humans would be reduced (National Re-

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search Council 1998b). However, in spite of these claims, there appears to be no clear-cut, definitive answer regarding whether subtherapeutic use causes adverse effects on human health (Mathews). Nonetheless, it appears that human health officials are moving toward withdrawing antimicrobials that are used for growth promotants in animals if these drugs are also used for human therapeutics (Herrick).

Earlier studies on the economic impacts of bans on antimicrobial use in swine production conducted in the 1970s indicated an increase in the market price of pork and a 4–20% reduction in the quantity of pork supplied to the market (Gilliam et al.; USDA). In 1985, the Animal Health Institute estimated that growth promotants save hog producers an estimated two billion dollars in annual production costs. Shifts in technology and changes in management systems would likely alter these results, which were obtained more than 15 years ago.

In two of the more recent economic studies dealing with the ban on subtherapeutic antimicrobials in swine production, a basic assumption was made that would appear to seriously flaw the results of these reports (Manchanda; Wade and Barkley). Both of these studies assumed that there would be an increase in the demand for pork of 5% because of perceived improvements by consumers that pork produced under these bans would be more wholesome and less likely to contain antibiotic residues. This assumption seems to be unfounded because further decrease in the extremely low level of current antibiotic residue rates would be unlikely. The study by Wade and Barkley reported net economic gains for both producers and consumers due to the proposed ban on antibiotics. If the demand for

antibiotic-free pork were genuine, market solutions<sup>2</sup> or labeling would be appropriate rather than an outright ban through regulation.

The most recently published economic evaluation (National Research Council 1998a) of the effects of a ban on subtherapeutic use of antimicrobials in swine production also included some assumptions and methods that were questionable. This study assumed that there would be no change in consumption with a concomitant increase in the market price of meat. No elasticity measurements were included in this study that would make adjustments for changes in consumer demand due to price increases and provide for economic changes related to substitution effects among competing goods, such as beef or poultry.

The current climate of increased regulatory pressures by health officials and notable deficiencies or flaws in previously reported studies on the economic impact of restricted antimicrobial use policies indicate the need to obtain better quality information about this potential economic problem facing the U.S. pork industry.

The objective of this study is to develop useful economic estimates of the impact of potential restricted-use policies for antimicrobial agents used in swine production as growth promotants. By using a model similar to that used by Wohlgenant, the economic impacts of banning antimicrobials in swine production are measured by the changes in producers' and consumers' surplus.

### **Estimation of the Surplus Changes from the Bans of Antimicrobials**

Wohlgenant's model allows feedback between the beef and pork markets and can be used to measure the changes in producers' and consumers' surplus due to shifts in both demand and supply curves. Our purpose is to measure the changes in producers' and consumers' sur-

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<sup>1</sup> While many of the antibiotics used in swine (see APHIS for a list of them) are not approved for human use, they are still members of drug families that include human antibiotics. Bacteria could develop resistance in such a way that it was resistant to all drugs within a drug family. Most bacteria that infect swine do not infect humans. But the fear is that resistant bacteria could mutate and infect humans or that the resistance could be transferred to human bacteria through plasmids (Institute of Medicine).

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<sup>2</sup> Organic pork is available at relatively high prices in organic-food stores, but consumption is low. Producing organic pork requires much more than just using no subtherapeutic antimicrobials, so organic pork prices would greatly overestimate the cost of a ban.

plus in beef, pork, and poultry. Wohlgenant's model is modified in two dimensions: first, the two-commodity model is extended to a three-commodity model; second, the parameters corresponding to the shifts in demand curves are set equal to zero and thus only effects of supply shifts are considered. Note that the model used by Wohlgenant assumes a parallel shift in supply. When the real shift in supply is not parallel, the impact might be overestimated or underestimated (Taylor). Given that over 90% of swine producers use subtherapeutic antibiotics, a parallel shift appears to be a reasonable assumption. Explicitly, the modified model is

$$(1a) \quad Q_j^* = \eta_{j1}P_1^* + \eta_{j2}P_2^* + \eta_{j3}P_3^*,$$

$$(1b) \quad P_j^* = S_j W_j^*,$$

$$(1c) \quad X_j^* = -(1 - S_j)\sigma_j W_j^* + Q_j^*, \quad \text{and}$$

$$(1d) \quad W_j^* = (1/\varepsilon_j)X_j^* - k_j, \quad j = 1, 2, 3,$$

where asterisks denote approximate relative changes (i.e.,  $X^* = dX/X$ ); subscripts 1, 2, and 3 denote beef, pork, and poultry, respectively;  $Q$  represents quantity of retail product;  $P$  is retail price;  $X$  is quantity of farm product,  $W$  is farm price;  $\eta_{ji}$  is the elasticity of demand for the  $j$ th retail product with respect to price of the  $i$ th product;  $\sigma_j$  is the elasticity of substitution between the farm product and marketing inputs in producing the  $j$ th product;  $S_j$  is the farmer's cost share of the  $j$ th retail product;  $\varepsilon_j$  is the elasticity of supply of the  $j$ th farm product; and  $k_j$  is the relative decrease in production cost for the  $j$ th farm product.

Once the parameters in equation (1) are given, the values of the variables with asterisks can be determined by solving the equations simultaneously. Using the total farm revenue and total consumer expenditures on each product and dropping the commodity subscripts to simplify notation, changes in producers' and consumers' surplus can be calculated as

$$(2a) \quad \Delta PS = WX(W^* + k)(1 + 0.5X^*)$$

$$(2b) \quad \Delta CS = -PQP^*(1 + 0.5Q^*),$$

where  $\Delta PS$  denotes the change in producers'

surplus and  $\Delta CS$  denotes the change in consumers' surplus. The total farm revenue,  $WX$ , and total consumer expenditures,  $PQ$ , in each of the markets are predetermined.

All parameters necessary to apply the equations in (1) and (2), except the parameter representing the change in production costs, will be based on other researchers' results (e.g., Brester and Schroeder; Wohlgenant). The production cost change parameter,  $k$ , is determined by simulations described as follows.

### Production Cost Changes Due to Banning Use of Growth Promotants

The production cost changes due to banning the use of antimicrobial growth promotants are measured indirectly by the net benefits from using growth promotants. Three key components were identified as the most important for contributing potential economic advantages for growth promotant use at the producer level: (a) improved feed efficiency over drug cost, (b) reduced mortality rate, and (c) reduced sort loss at marketing. The net economic benefit for growth promotants in swine production is the sum of these components. The per animal net benefits are then used to calculate the net benefit at the industry level.

#### *Economic Benefit from Improved Feed Efficiency over Drug Cost*

The stochastic relationship between the economic benefit per pig and the improvement in feed to gain conversions ( $F/G$ ) in swine production is modeled as

$$(3) \quad \text{economic benefit} \\ = \alpha + \beta(\text{improvement in } F/G) + \varepsilon,$$

where  $\alpha$  and  $\beta$  are the parameters to be estimated and  $\varepsilon$  is a random variable with zero mean. Improvement in  $F/G$  is a random variable with a probability distribution to be determined.

Scientific literature was reviewed to determine the probability distribution of the improvement in  $F/G$  and the parameters  $\alpha$  and  $\beta$ .

This literature search provides the data shown in Table 1. Reports were restricted to feeding trials using antimicrobial compounds that are presently available for use in swine; reports on those compounds under development or not yet approved for use by FDA in swine feed were excluded. Data from feeding trials limited to extremely brief periods of the production cycle, such as those associated with segregated early weaning programs and from the report based on producer surveys instead of actual feeding trials, were excluded from calculations.

Improvements in feed-to-gain ratio (*F/G*) for subtherapeutic levels of antimicrobials were reported as ranging from -1% (a decrease) to 5% or greater for grower/finisher hogs. The mean improvement in *F/G* was 2.74%, with a standard deviation of 1.88%, based on 16 different values in the literature from feeding trials covering significant periods of the grower/finisher phase of swine production. These data best fit a normal distribution compared with alternative distributions. Thus, *F/G* is assumed to follow a normal distribution with 2.74 as the mean and 1.88 as the standard deviation (Figure 1).

A linear regression is used to determine the parameters  $\alpha$  and  $\beta$ . Economic values derived from drug use during extremely brief periods of the production cycle or from therapeutic dose rates were excluded from the regression analysis. The regression based on the data in Table 1 shows the following estimated equation:

$$\begin{aligned} (4) \quad \text{economic benefit} \\ = 1.68 + 0.66 (\text{improvement in } F/G) \\ (0.46) \quad (0.16) \\ R^2 = 0.86. \end{aligned}$$

This result is used to estimate the economic benefit per pig from the improvement in *F/G*.

#### *Economic Benefit from Reduced Mortality Rate*

Subtherapeutic use of antimicrobials affects mortality rates, especially on younger pigs, al-

though these effects are not well documented. Only two of the published reports in Table 1 provided data about differences in mortality rates associated with the use of antimicrobial agents. Walter, Holck, and Wolff evaluated therapeutic levels of tiamulin and chlortetracycline fed from 11 weeks of age for a period of 16 weeks to more than 1,000 modern cross-bred lean genotype barrows in a commercial swine production system. Treatments were divided among continuous delivery of medication in feed, "pulse" delivery of medication for 7 days administered every 2 or 3 weeks, and a nonmedicated control group. Mortality rates for pigs in these groups were 0.55, 1.92, and 5.22%, respectively, with both medication groups having significantly less mortality than controls. Gourley evaluated low-level continuous and high-level "pulse" (1 week out of 4) medication regimens for delivering chlortetracycline in feed to 576 grower/finisher pigs from a lean genotype, high health swine herd. The third treatment was a nonmedicated control group. The mortality rates for the three treatment groups were 2.60, 2.08, and 3.13%, respectively. Although both medicated groups had lower mortality than the nonmedicated group, none of the three mortality levels were significantly different from the others. The average mortality benefit from the two published reports is 1.43%, but the nonmedicated control group in the Walter, Holck, and Wolff study had death losses above those normally expected in commercial herds. We therefore model the mortality benefit associated with growth promotants as a symmetric triangular distribution with minimum 0, most likely 0.75, and maximum 1.5%.

The market price used for hogs is \$45.00 per cwt. This price is based on an approximate 10-year average market hog price (Walter, Holck, and Wolff). The market price of hogs is used indirectly to establish the value of 40 lb. feeder pigs needed to calculate benefits associated with reduced mortality rates. Using current feeder pig pricing schedules as a guideline (Iowa Department of Agricultural Market News), we also assume that heavier feeder pigs are worth \$0.45 per pound for additional weight over 40 lbs. Weights of pigs

**Table 1.** Reported Effects of Growth Promotants Fed to Swine on Feed Efficiency and the Associated Economic Benefits (F:G is feed to gain; NR is not reported)

Drug	% Improvement in F:G Ratio	Net Economic Advantage (\$/pig)	Comment	Used to Estimate Improvement in F:G Ratio?	Author(s)
Carbadox	5.60	1.36	Early weaning period only	No <sup>a</sup>	Anderson, Campbell, and Walter
Tiamulin + chlortetracycline	7.50	2.66		No <sup>a</sup>	
Carbadox	6.90	NR	To 35 kg	No <sup>b</sup>	Cromwell and Stahly
Tiamulin	5.70	NR	To 30 kg	No <sup>b</sup>	
Tiamulin	3.10	NR	To 57 kg	Yes	
Chlortetracycline	1.72	2.17 <sup>c</sup>	Grower/finisher	Yes	Gourley
	4.50	NR	Historical data	Yes	
Chlortetracycline	1.03	2.12 <sup>c</sup>	Dose: 50 g/ton	Yes	Gourley and Wolff
	0.34	1.86 <sup>c</sup>	100 g/ton	Yes	
Bambermycin	3.74	NR	Five different locations	Yes	Hagsten, Grant, and Meade
Tylosin	2.30	NR		Yes	
Chlortetracycline	-6.42	NR	Producer survey	No <sup>d</sup>	Losinger
Tylosin	5.00	4.88 <sup>c</sup>	Commercial farms	Yes	Mackinnon
Carbadox + virginiamycin	5.47	NR	NRC diet	Yes	Schwartz
	3.51	4.85 <sup>c</sup>	High density diet	Yes	
Chlortetracycline	-0.67	NR	Seven-state study	Yes	Speer
Various	-0.33	NR	Six-state study	Yes	
Tylosin	4.57	NR	Dirt lots	Yes	
Bacitracin	3.30	NR	Analysis of 85 trials	Yes	Tillman
Methylene disalicylate	2.40	NR	High lean genetics	Yes	
Tiamulin + chlortetracycline	3.80	3.87 <sup>c</sup>	Lean genotype pigs	Yes	Walter, Holck, and Wolff

<sup>a</sup> Data were limited to early weaning period.

<sup>b</sup> Data were limited to only a portion of the grower/finisher phase.

<sup>c</sup> Economic data that were used to develop economic association with corresponding improvements in F:G ratio.

<sup>d</sup> Data were developed from a producer survey and not based upon feeding trials.

<sup>e</sup> Economic data that were not used because antimicrobials were fed at therapeutic rates.

**Table 2.** Sort Loss Discounts for Underweight Hogs and Differences in Distributions between Market Hogs for Growth Promotant Use Based on Targeted Days (All-In/All-Out) Production System

Estimated Live Weight Range (lb.)	Hot Carcass Weight Range (lb.)	Carcass Midpoint Used for Calculations	"Sort Loss" (Discount) <sup>a</sup>	Estimated Distribution of Market Hogs by Use of Growth Promotants <sup>b</sup> (%)		Difference in Distributions (%)	Difference in Carcass (\$)
				Without	With		
Under 190	Under 140	137.0	(\$13.50)	7.61	3.59	4.02	0.743
191–200	141–148	144.5	(\$13.50)	6.14	4.27	1.87	0.365
201–210	149–155	152.0	(\$9.76)	8.87	7.31	1.56	0.231
211–220	156–163	159.5	(\$6.00)	11.42	10.82	0.60	0.058
221–229	164–169	166.5	(\$1.26)	11.77	12.34	–0.58	–0.012
230–240	170–177		Base price				
Totals						7.47	1.385

<sup>a</sup> Per scalded carcass cwt using grid pricing discounts for underweight hogs from America's Best Pork<sup>®</sup> Carcass Merit Program (Farmland) (effective 7/16/2001).

<sup>b</sup> Distributions were based on data for average ending weights and standard deviations (232.1 ± 29.40 lb. and 236.7 ± 25.94 lb. for control and growth promotant groups, respectively) reported by Tillman. The normal distribution function was used to determine cumulative proportions for each weight range within each group as inputs for calculating differences in distributions.

that would not die due to feeding growth promotants is modeled as a triangular distribution with a minimum value of 40, most likely value of 60, and maximum value of 80 lbs.

#### *Economic Benefit from Reduced Sort Loss at Marketing*

When the weights of market hogs fall outside of the packer-specified weight range, pricing discounts are applied, especially for light-weight hogs, based on price schedules or "grid" pricing. The term "sort loss" has been used by the swine industry to describe the dollar loss related to these market hogs, which receive price discounts. Growth promotants improve the uniformity of average daily gain and therefore reduce the ending weight variability and associated sort loss for market hogs (Gourley; Gourley and Wolff; Tillman). The size of the sort loss benefit would vary according to the type of feeding management. Production systems using targeted days on feed would achieve potentially greater benefits related to reduced sort loss compared with targeted marketing weight management systems because the time schedule for a targeted days

system would typically provide less opportunity for delayed marketing to allow additional gain for lighter weight pigs. A report by Tillman provided data on average ending weight and standard deviations for the effect of a growth promotant on reducing sort loss in market hogs compared with a control group based on a targeted days on feed production system. The normal distribution function was used to determine cumulative proportions within each group. Then the cumulative proportions were used as inputs for calculating differences in distributions between these two groups. Sort losses at slaughter were based on grid pricing discounts announced by Farmland for underweight hogs (Table 2). These data provide an overall mean value of \$1.39 with standard deviation of \$0.15 per hog benefit for growth promotants in reducing sort loss for targeted days production systems. To avoid overestimating the benefit from reduction in sort loss, it is assumed that this benefit would be only one third as much, i.e., mean \$0.46 with standard deviation \$0.05 for hogs produced under targeted weight production systems because of increased opportunity to allow longer feeding periods to achieve desired

**Table 3.** Management of Swine Farms Related to Growth Promotant Use in Grower/Finisher Pigs and Prevalence of All-In/All-Out Production System

	Swine '95 Report	
	Mean	SE
Growth Promotant Use		
Percent of swine operations	91.3	2.0
Percent of grower/finisher hogs on those operations	92.7	1.5
Percent of pigs receiving growth promotants	84.6	
Input used for simulation model	85.0	2.0
Grower/finisher management		
Percent hogs, all-in/all-out production system	51.0	2.2

Sources: Animal and Plant Health Inspection Service; Centers for Epidemiology and Animal Health.

market weights, which would reduce the chance of price discounts. No benefits were included for any reduction in days on feed associated with the use of growth promotants.

#### *Estimating the Total Net Economic Benefits at Industry Level by Simulation*

As outlined before, the total net economic benefits from using growth promotants are from three random sources, i.e., normally distributed improvement in *F/G*, triangularly distributed reduced mortality rate, and normally distributed reduced sort loss at marketing. To estimate the total economic benefits, we need to convert the scale from producer level to industry level.

The number of market barrows and gilts slaughtered per year is extrapolated from annual USDA livestock slaughter summary reports for years 1994–2000. These summaries report figures ranging from 86.5 to 96 million head for years 1996 and 1999, respectively. Based on these data, annual production of 100 million market barrows and gilts is assumed for the simulation.

The proportion of grower/finisher pigs receiving antimicrobials as growth promotants and the proportion of grower/finisher pigs managed as all-in/all-out are based on population estimates from the Swine '95 project (Animal and Plant Health and Inspection Service; Centers for Epidemiology and Animal Health) (see Table 3). We project that 85% of grower/finisher pigs would receive growth promotants in feed and that 55% of hogs

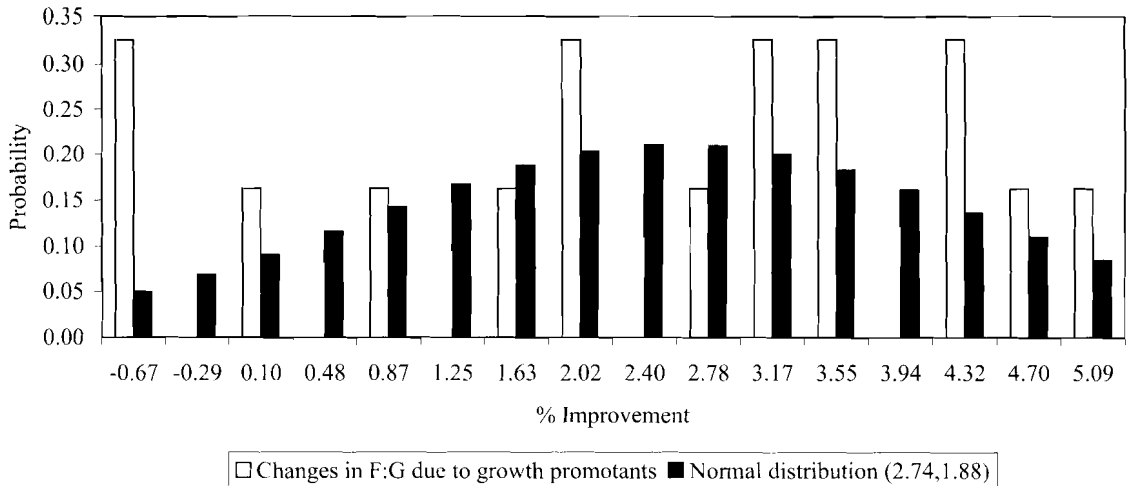
would be raised in an all-in/all-out grower/finisher system.

Once the probability distributions of the three sources of economic benefits at the industry level are given, the total net economic benefits are estimated by summing the benefits of each of the three components. The expected net benefit could have been well approximated with analytical methods by assuming normality. The Monte Carlo method, however, accommodates nonnormal distributions and provides a convenient way of calculating the uncertainty of the estimate.

## **Results**

Based on a 5,000 iteration simulation, the total estimated net benefit for subtherapeutic use of antibiotics in swine production was calculated as \$2.76 ± \$0.56 per hog as determined by the previously described components (Figure 2). Although a wide spread in the value of this benefit was possible, the majority of values most likely to occur would range from \$2.37 to \$3.11 per hog. The average benefit of \$2.76 per hog was used to calculate the proportional change in production costs for the swine industry and the resulting impact on economic values related to changes in supply and demand of pork in the United States if the use of subtherapeutic antibiotics in feed were banned. If the resulting change in cost of pork production is lower or higher than assumed, all numbers change proportionately. The calculated average increased cost of production of \$2.76 per hog due to loss of the net benefits





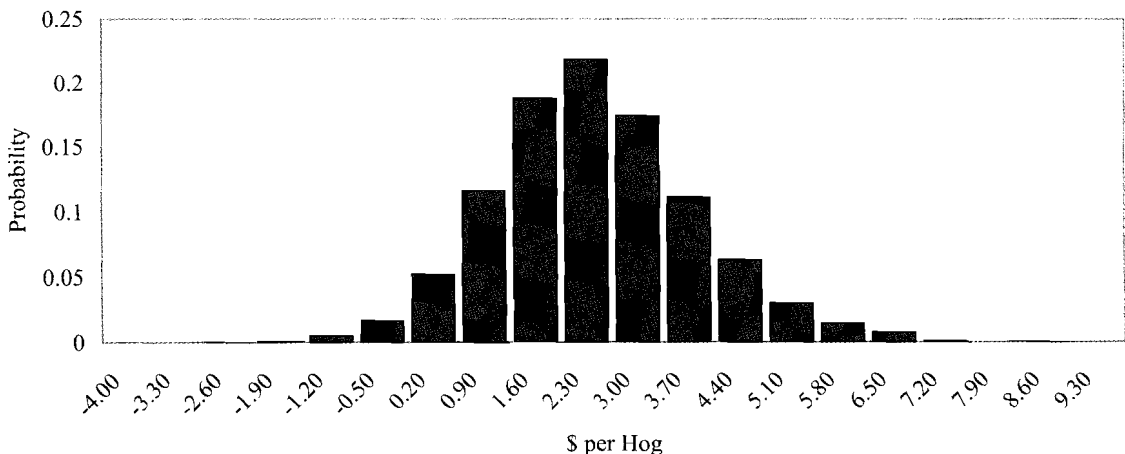
**Figure 1.** Distribution of Improvement in Swine Feed Efficiency Due to Growth Promotants

associated with growth promotants was considered to be the best estimate for figuring the cost change listed in Table 4. Two different sets of supply elasticities are considered because they are key parameters and there is little data on what values to use.

Given all parameters and data in Table 1, the variables with asterisks in equation (1), i.e., the retail products, retail prices, farm products, and farm prices for the three commodities, are obtained by solving the simultaneous equations (1). Substituting the solution for (1) into (2), we obtained changes in producers' and consumers' surplus. By setting specific parameters equal to zero, the changes

in producers' and consumers' surplus obtained are the ones due to banning subtherapeutic antibiotics in swine only or both swine and poultry production.

The total annual loss in the short run would be \$242.5 million (the sum of the first row in Table 5). Table 5 shows that, in the short run, the estimated loss borne by swine producers would be \$153.5 million. In the long run, the swine producer surplus loss would be \$99.2 million if the elasticity for each of the commodities is 0.5, and only \$62.4 million with a more elastic supply. The results from the two sets of long-run elasticities show that a change in the elasticity does not change the total im-



**Figure 2.** Distribution of Net Benefit Values for Growth Promotants

**Table 4.** Estimates of Parameter Values for the U.S. Beef, Pork, and Poultry Industries

	Value		
	Beef	Pork	Poultry
Price elasticity of demand for beef ( $\eta_1$ )	-0.6	0.1	0.21
Price elasticity of demand for pork ( $\eta_2$ )	0.14	-0.35	0.04
Price elasticity of demand for poultry ( $\eta_3$ )	0.05	0.07	-0.3
Elasticity of substitution ( $\sigma$ )	0.72	0.35	0.35
Elasticity of farm supply, short run ( $\epsilon_{SR}$ )	0.15	0.2	0.2
Elasticity of farm supply, long run ( $\epsilon_{LR1}$ )	0.50	0.50	0.50
Elasticity of farm supply, long run ( $\epsilon_{LR2}$ )	0.70	1	1
Farmer's share of consumer's dollar ( $S$ )	0.49	0.4	0.4
Increase in production costs <sup>a</sup> ( $k$ )	0	0.02023	0
Total farm revenue ( $WX$ )	\$35 bil.	\$12 bil.	\$17 bil.

<sup>a</sup> The proportional change in production costs was calculated as increased production cost per hog due to growth promotant ban = \$2.76,  $\$2.76 \times 84.6\%$  utilization of growth promotants = \$2.33 per hog for industry, weight of one pig = 256 lb. = 2.56 cwt, market value per pig =  $\$45/\text{cwt} \times 2.56 = \$115.20$ , production cost increase =  $\$2.33/\$115.20 = 2.023\%$ .

part<sup>3</sup> but only affects the allocation of the benefit change between the producers and consumers. The results reported in Table 5 are based on \$45.00 per cwt market price for hogs. A sensitivity analysis was done for \$40.00 per cwt and \$50.00 per cwt, respectively. If the market price for hogs decreases from \$45.00 per cwt to \$40.00 per cwt, both producers and consumers would bear 11.1% less loss in both the short and long run. If the market price increases from \$45.00 per cwt to \$50.00 per cwt, the loss borne by the producers and consumers would increase by 11.1% in both the short and long run.

<sup>3</sup> Simulations were also considered where the ban was allowed to apply to poultry and therefore poultry supply also shifted. Because of the low price elasticity between pork and poultry, it does not make much difference to swine producers as to whether the ban included swine only or also included poultry.

Measuring the benefits is beyond our expertise, but we can give the reader some perspective based on other literature. The cost effectiveness of regulations varies widely (Tengs and Graham). Hahn, Lutter, and Viscusi focus on the mortality benefits of regulations because they argue the other benefits are less than 10% of mortality benefits. Viscusi (p. 73) reports that estimates of the value of a human life were 3–7 million 1992 dollars (4–9 million 2002 dollars). Angulo, Tauxe, and Cohen estimated that 10% of salmonella infections becoming resistant to fluoroquinolones would cause 19 deaths a year. Swine have no life-threatening disease that is as easily transmittable to humans as salmonella in poultry and fluoroquinolones are not approved for use in swine. Therefore, the lives saved with a ban in swine would likely be less than in poultry. Lutter, Morrall, and Viscusi estimate that each

**Table 5.** Change in Producer and Consumer Surplus from Increase in Production Costs Due to Banning Subtherapeutic Antibiotics in Swine Only (\$M)

Situation	Producers			Consumers		
	Beef	Pork	Poultry	Beef	Pork	Poultry
Ban, short run	14.3	-153.5	7.0	-14.3	-89.0	-7.0
Ban, long run <sup>a</sup>	15.5	-99.2	7.1	-15.5	-143.2	-7.1
Ban, long run <sup>b</sup>	16.1	-62.4	5.5	-16.1	-180.0	-5.5

<sup>a</sup> The elasticities of farm supply for beef, pork, and poultry are 0.5.  
<sup>b</sup> The elasticities of farm supply for beef, pork, and poultry are 0.7, 1, and 1, respectively.

\$15M in income reduces mortality by one statistical death. Thus, a total ban would cause 16 statistical deaths due to reduced income and therefore the net effect of a ban might be an increase in mortality. There is also a positive probability of some unforeseen catastrophic event. But Shogren (p. 314) argues that the probabilities of such events are often overestimated.

## Conclusion

A ban on the use of antimicrobial agents as growth promotants for swine would be costly, totaling \$242.5 million annually, with swine producers bearing \$153.5 million of the cost in the short run. In the long run, the loss borne by consumers would likely be larger than the loss borne by producers. Based on a 30-year planning horizon and a 4% discount rate, the net present value of these increased costs would be \$4.2 billion.

The ban considered here was a complete ban on all microbial agents. A ban that included only the few antibiotics that are also used for humans might have little effect on the swine industry. Also, producers might be able to change management practices in unexpected ways to compensate for the loss of antimicrobials. Thus, the actual losses from a ban might be smaller than the losses estimated here.

It should be noted that wide ranges of published elasticity estimates were available. The elasticity estimates determined whether producers or consumers incurred the cost of the ban. Because pork production uses few resources that are specialized and fixed in the long run (although this may change with increasing regulation), its supply curve is likely elastic in the long run and so consumers would incur more of the long-run cost of the ban.

The estimates of the total cost of banning subtherapeutic antimicrobial use in swine were roughly half of that estimated by the Committee on Drug Use in Food Animals (National Research Council 1998a). The key difference was that they assumed that marketing cost would increase proportionately to any

change in production cost, while this model held marketing costs constant.

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