

Economic Impact of a Ban on the Use of Over-the-Counter Antibiotics

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and Jay Fabiosa

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Abstract

Antibiotic drugs are currently used in 90 percent of starter feeds, 75 percent of grower feeds, more than 50 percent of finishing feeds and at least 20 percent of sow feeds (USDA/APHIS). A ban on the use of feed-grade antibiotics would lead to changes in production processes and practices in production of pork, and hence would have an economic impact on the U.S. pork industry and pork market. This study considers the economic effects of a ban in pork production, with no change of regulation on other meats. The analysis uses a set of technical assumptions that are based in large part on a historical analysis of how the Swedish ban influenced the Swedish pork industry to anticipate the potential economic effects. A range of cases is examined. The cases use evidence from the experience in Sweden to describe what is most likely, given this evidence and (other) various expert opinions, to occur if the ban were to be implemented in the United States.

The estimated effects of a ban on the use of over-the-counter antibiotics would increase production costs per head by \$6.05 initially, and by \$5.24 at the end of the 10-year period considered for the most-likely case, with reservations for all uncertainties about assumptions made. However, with higher prices due to reduced supply, net profit would decline only by \$0.79 per head. The net present value of forgone profit to the industry over 10 years is \$1.039 billion. These results include the costs of adding troughs and space to allow restricted feeding. On the consumer side, the effects of a ban would raise the retail price of pork by \$0.05 per pound, and increase costs of pork to a family of four by \$11 per year, or, increase costs for all consumers by \$748 million per year. The estimated impact of a ban on an “average” or “representative” farm presented here masks very wide differences across farms. The greatest impact may be on densely populated farms in areas with large numbers of hog farms who have older buildings and who do not follow sound management practices. While certain general patterns stand out, technical evidence from the Swedish experience must be regarded very cautiously as an exact indicator of what might happen in the United States.

Key words: antibiotic, ban, economic impact, finishing feeds, grower feeds, hog farms, over-the-counter, pork industry, pork market, sow, starter feeds.

ECONOMIC IMPACT OF A BAN ON THE USE OF OVER-THE-COUNTER ANTIBIOTICS IN U.S. SWINE RATIONS

Executive Summary

Antibiotic drugs are currently used in 90 percent of starter feeds, 75 percent of grower feeds, more than 50 percent of finishing feeds and at least 20 percent of sow feeds U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS). A ban on the use of feed-grade antibiotics will lead to changes in production processes and practices in production of pork, and hence is likely to have an economic impact on the U.S. pork industry and pork market. On average, the cost of feed-grade antibiotic use for all animal producers has been estimated to be about 3.75 percent of total ration costs, or about 50 percent of the value of the compounds to animal producers (Beran 1987, cited in NRC 1999). To anticipate the potential effect on U.S. pork production, this study uses a set of technical impacts that are based in large part on a historical analysis of how the Swedish ban influenced the Swedish pork industry.

Three cases are examined: a best-case (I), a most-likely case (II), and a worst-case (III). The range of cases uses evidence from the experience in Sweden to describe what is most likely, given this evidence and (other) various expert opinions, to occur if the ban were to be implemented in the United States. Cases I and III are developed by revisiting each of the assumptions and considering the worst- and best-case impacts. Case I combines all of the best-case assumptions. While cases I and II focus on results and assumptions directly related to effects of a ban on over-the-counter feed antibiotics, case III attempts to include a larger array of issues, including effects of animal welfare legislation. To do so, Danish pig production results have been included in the technical assumptions of case III, and the differences applied to US conditions.

The economic model incorporates both biological and economic processes that govern production and consumption. The processes include

- binding biological limits (e.g., weight gain rates, length of gestation),

- lags of variables to capture time periods required in production, and accounting identities to ensure consistency in the stock (e.g., animal inventory), and
- flow variables (e.g., number of animals slaughtered, pig crop, and mortality). The model also includes technical parameters such as feed efficiency, weight and weight gain, mortality, and sow efficiency. Economic data include information on fixed costs (buildings), veterinary costs, and any new investments required for buildings.

The analysis of the impacts of a ban on feed-grade antibiotics is conducted by comparing the results obtained using baseline values and assumptions, to those obtained by using assumptions about the new requirements and changes in raising of hogs under conditions implied by the ban. Technological changes are introduced by re-specifying some of the biological and technical parameters of the model to reflect changes in the new production technology. Simulations were conducted by using the revised technical parameters in the model. To account for increased weight variability due to the ban, alternative distributions of weights were characterized, and applied to a price grid with penalties for “sort loss.”

Based on information gathered during a visit to Sweden and Denmark, and from other sources, the technical assumptions for the different cases examined are summarized in Table 1.

Table 1. Technical assumptions for the three cases

	<u>I (Best)</u>	<u>II (Most-likely)</u>	<u>III (Worst)</u>
Age at weaning	no increase	+ 1 week	+ 1 week
Days from weaning to reach 25 kg	no increase	+ 5 days	+ 12 days
Feed efficiency from 50 to 250 lbs	no change	- 1.5%	- 1.5%
Piglet mortality	+ 1.5% pts	+ 1.5% pts	+ 4.0% pts
Fattening-finish mortality	no change	+ 0.04%	no change
Piglets per sow	no change	- 4.82%	- 3.84%
Veterinary and therapeutic costs (per pig) net of costs for feed grade antibiotics	+ \$0.25	+ \$0.25	+ \$0.25

In addition to the technical assumptions made for the *most-likely case (II)* in Table 1, additional space would be required for the nursery and finishing periods if restricted feeding and longer time in the nursery will be required. This new construction would cost \$115 per head of

nursery space and \$165 per head of finishing space, or an estimated cost of additional space required of about \$1.42 billion. Additional farrowing space for sows, required under two of the scenarios, would also add costs. The *most-likely case* implements these changes.

Case III uses factual production differences between the best quartile of pork producers in Denmark and Sweden in 1996 to suggest that inferior results in Sweden are caused by its “model” of ban on feed-grade antibiotics from 1986 and its animal welfare law of 1988. However, the scenario is very uncertain because it includes so many other factors, such as genetics, feed and feeding techniques, the fact that more than 50 percent of the herds in the Danish statistics are SPF while none are in the Swedish, and national differences regarding business structure, economic supports and investments (Jonasson and Anderson, 1997). With all of these reservations, the parameters in Table 1 define a worst-case.

Under *scenario (III)*, piglets require 11.7 more days to reach 25 kilograms. Average feed cost from weaning to feeder pigs is adjusted to account for the additional feeding days. Piglet mortality is increased by 4 percentage points; there is no change in mortality for fattening-finishing pigs. Pigs per sow per year declines by 3.84 percent. Cost components included in the profit estimation are the same as those in the most-likely scenario.

The *best-case scenario (I)* assumes that the only effect of the ban of antibiotics in feeds is in the increase of piglet mortality by 1.5 percent. New investment in additional nursery and finishing spaces is still required, but not for farrowing space. The range of producer impacts provides a bound to estimates of the economic effects of a ban.

With reservations for all uncertainties about the assumptions made, the estimated effect of a ban on the use of over-the-counter antibiotics on production costs would increase costs per head by \$6.05 initially, and by \$5.24 at the end of the 10-year period considered for the most-likely case. However, with the higher prices, net profit would decline only by \$0.79 per head by the end of the period. The net present value of forgone profit to the industry over 10 years would be \$1.039 billion (with a range over the cases from \$1.135 to \$0.429 billion). These estimates include the costs of adding troughs and space to allow restricted feeding, costs totaling \$960 million, or \$1.20 per hog, about 20 percent of the increased costs. If the assumption on the need

for restricted feeding capacity is incorrect, then the estimated values overstate the impact estimate. This is obviously an area where additional research is needed.

On the consumer side, retail prices would increase by \$0.05 per pound. The effect of the change in retail price on cost per U.S. family (of four) would be approximately \$11 per year in additional costs, or \$748 million per year in total. This estimate considers only the change in pork, with no change in other meats.

While certain general patterns stand out, the Swedish experience must be regarded very cautiously as an exact indicator of what might happen in the United States (see full report). First, if the lactation period has to be increased, more farrowing space will be needed and pigs/sow/year will decrease. Also, if use of restricted feeding is necessary, almost all U.S. producers will be forced to make some adjustments. All these assumptions will have to be researched under U.S. conditions before final cost conclusions can be made.

The estimated impact of a ban on an “average” or “representative” farm masks very wide differences across farms. The Swedish experience suggests that those who follow good hygienic and health practices will see the smallest impact. The greatest impact may be on densely populated farms in areas with large numbers of hog farms who have older buildings and who do not follow sound management practices. The social impacts of the changes may be very different than the economic impacts.

In the assumptions for the different cases, consumers respond only to changes in the price of pork. We have not altered the prices of poultry or beef, which are likely to be affected similarly by a ban. Nor have we factored in any positive effect of such a ban on consumer willingness to pay for pork produced without the use of feed-grade antibiotics. Consumer pressure and responses have been shown to be important in the Swedish and other European experiences, but they are difficult to estimate with the lack of reliable data in the United States. However, one very important consumer response should be mentioned, and that is the one that may occur on export markets. So far there is very little evidence to suggest that these export customers are concerned about the use of antibiotics among suppliers. However once the European Union (EU) or Danish industry can guarantee reliable supplies of antibiotic free pork, this situation may

change. Losses to the U.S. pork industry associated with a loss of an important export customer, such as Japan, would dwarf the losses associated with the ban described above.

Introduction

U.S. pork producers are currently permitted to use 29 over-the-counter antibiotics and chemotherapeutics in feed (National Research Council, 1999, Tables 2-6 and 2-7). Of these, five are listed only as growth promotants (bambermycin, efrotomycin, oleandomycin, penicillin, and virginiamycin) while seven are listed both for growth promotion and “various infections” and 17 only for infections. Recommended concentrations in feed vary greatly as well as withdrawal times. These products improve feed conversions and rate of gain, and they reduce morbidity and mortality in growing pigs (Hayes 1981; Cromwell 1991). They are also said to increase sow productivity and reduce the incidence of mastitis and agalactia (Cromwell 1991). Antibiotic drugs are currently used in 90 percent of starter feeds 75 percent of grower feeds more than 50 percent of finishing feeds and at least 20 percent of sow feeds (Dewey et al. 1999, reporting data from NAHMS).

The use of antibiotics in animal feed has come under review due to concerns that antibiotic resistance developed in food animals might be transferred to humans; for example, see Swann (1969), NRC (1980), CAST (1981), Institute of Medicine (1989), WHO (1997), SOU (1997) and NRC (1999). This literature suggests a tendency for scientists in Europe to favor a ban and for scientists in the United States to oppose such a measure. For a recent example of a representative U.S. position see NRC (1999). For a recent representation of the European position see Wegener et al. (1999) or SOU (1997). However, there are also strongly opposing opinions on both sides, in the United States and Europe, which demonstrates a continued intense debate about the antibiotics issue.

One possible reason for the divergence in scientific opinion across the Atlantic is that human resistance to vancomycin has emerged in both the United States and the European Union (EU). The EU had permitted the use of avoparcin, a closely related antibiotic in animal feeds, until 1997. This drug was not permitted for use in animal feeds in the United States. While it would not be the case that vancomycin resistance in humans was related to avoparcin use in animal feeds in the United States, this possibility cannot be ruled out in Europe (see Hayes 1999).

Current EU regulations state that antimicrobials used in either human or in veterinary therapeutic medicine are prohibited from use as feed-additive growth promoters in livestock (Hayes 1999). A ban on over-the-counter feed antibiotics was implemented in Sweden in 1986. Similar bans were enacted in Norway in 1992, for grower-finishing hogs in Finland 1996, Denmark 1998, and in Poland and Switzerland in 1999.

In December 1998, the EU Commission and Council of Ministers followed suit by restricting the use of feed additives to only avilamycin, bambarmycin, salinomycin, and monensin. Avilamycin is now (October 1999) also under consideration for being banned. The decisions are interimistic and will be reviewed within two years. Shortly after the ban was imposed, Pfizer Animal Health and AlPharma sued Denmark and the EU for its ban on feed antibiotics, in particular virginiamycin and bacitracin. The EU Supreme Court dealt with the issue in June 1999. Pfizer's and AlPharma's claims were dismissed at that time, but a final ruling is not expected until one or two years from now.

Objectives

The purpose of this study is to estimate the likely economic effects of a ban on the U.S. pork industry and the U.S. pork market. The study uses a set of technical changes in the production of hogs that are based in large part on a historical analysis of how the Swedish ban influenced the Swedish pork industry. This information was collected by the authors during a ten-day trip to Sweden and Denmark in March 1999.

Swedish Developments

We need to make clear from the outset that the use of Swedish parameters in a model of the U.S. hog industry is problematic. Sweden implemented the ban on an industry that had very different production practices from those that prevail in the United States today. For example, Swedish pig farmers have never weaned pigs before five weeks, bedded solid floors are standard, and pen space is considerably larger than in the United States.

Swedish agricultural production is to a large extent (about 80 percent) organized in a trade union, The Federation of Swedish Farmers (LRF), which has considerable power to negotiate

policies with the government. Production statistics from 1997 show herd sizes to be from less than 50 to several hundred sows, and a large segment of multi-source finisher herds producing several thousand (5000-15000) hogs per year. Sweden's annual slaughter in 1998 was about 3.5 million hogs, with 20.1 weaned pigs/sow/year, 2.9 feed efficiency, and 850 ADG from 25 to 110 kg (LRF 1998). Production costs are somewhat higher than in Denmark.

Sweden entered the EU in 1995 and is still adjusting to the new rules. The considerable support to EU agriculture under the so-called Common Agricultural Policy (CAP) is, of course, helping the countries with large agricultural industries. It has also helped previously disadvantaged countries. Sweden's agricultural output is small by comparison, which affects the balance between dues paid to the EU and support received by the country's agricultural sector. Thus, Sweden has been the second largest per capita net payer (after Germany) to the EU since 1995.

Swine health in Sweden is generally good, with complete absence of viral diseases such as TGE, rotavirus, pseudorabies, and PRRS. The prevalence of influenza is very low, and there is virtually no salmonellosis due to decades of strong diagnostic efforts, quarantine, and indemnity procedures. Typically, compared to at least 23 swine pathogens for which there are federally licensed vaccines in the United States, only 7 are licensed in Sweden (Backstrom 1998).

Other contributing factors to the good health might be the generally low swine herd density in the country, low pen space density, geographic location with good breaks between winter and summer seasons, relatively small temperature differences between seasons, and protection from epidemics by surrounding seas.

The Antibiotics Issue in Sweden

At the time of the ban in 1986 the Swedish pork market was heavily regulated. In the early 1970s, strong pressure led to demanding animal welfare regulations. These were further advanced by a new law in 1988. Sweden had also implemented several restrictions on feed antibiotics in 1977 in response to the Swann Committee Report of 1969. That report, citing the recent discovery of the transmissible r-factor, aimed at restrictions of antibiotics to food animals when such drugs were important to human medicine. As a result, several non-prescription feed-

grade antibiotics were put under veterinary prescription to obtain better control but also to secure the availability of such drugs when needed for specific disease treatment, somewhat similar to the AMDUCA (Animal Medicinal Drug Use Clarification Act) and VFD (Veterinary Feed Directive) of 1996 in the United States.

Triggered by media reports that 30 tons of low dosage antibiotics had been used in feed in 1981, Swedish consumer pressure increased again sharply in the early 1980s. To restore consumer confidence, and supported by many farmers who had grown increasingly skeptical towards the use of feed antibiotics, the LRF asked for a voluntary ban on such antibiotics in 1985 (Stahle 1997), which was made law in 1986. It should be clear that veterinarians' rights to prescribe preventive and therapeutic medications remained intact.

Coinciding with the ban, post-weaning diarrheas initially lead to a 1.5 percent increase of post-weaning piglet mortality and almost one week longer time to reach 25 kg feeder pig size (Robertsson and Lundeheim 1994). There was no effect on the health of sows, nursing piglets, length of lactation, or number of weaned piglets per sow per year (Swedish Agricultural Statistics). Later, economic estimates assumed a slight increase (0.04 percent) of mortality and 1.5 percent impact on feed efficiency in finishing hogs. The net increase of consumer costs was estimated to be about \$0.12+/- 0.06/kg retail meat (SEK 8.10/US\$), half of which was due to the antibiotics ban and half to animal welfare legislation (Jonasson and Andersson 1996; Stahle 1998).

Also important are data on the ways that farmers chose to deal with the problems they encountered. Initially, the previously non-prescribed and widely used feed-grade olaquinox (Bayonox) continued to be applied to treat scours, now classified as a prescribed therapeutic antibiotic. Later, zinc oxide was found to be effective in reducing piglet mortality and was extensively used until environmental concerns about manure pollution restricted its use from 1997. It is now limited to the first two weeks post weaning, and the total use has declined sharply.

Overall, the total use of antibiotics was reduced almost 50 percent in 1986 (SOU 1997). Over the next few years, the use again increased about 20 percent where it leveled off until 1995, after which a new steep reduction began. In 1998, the tonnage (including "potency factors") of

animal antibiotics in Sweden was only 30 percent of the tonnage of active substance used in 1984 (Greko 1999). It should be noted that the Swedish statistics include all applications of antibiotics (injectibles and non-injectibles) to both companion and food animals. Thus, the statistics on usage of antibiotics are more complex than just the matter of feed antibiotics.

Despite all the differences between the U.S. and Swedish conditions, the Swedish experiences afford us some unique information. The information we collected shows quite clearly that the impact of the ban was smells in farms that “followed the rules.” The impact of the ban was greatest in farms with questionable hygiene practices. For example, farmers who weaned pigs into cold, old, continuous flow buildings (a too common practice in Sweden, we were told) encountered problems with post weaning diarrheas. Some of the conditions in which these problems occurred could not easily be replicated within a laboratory situation. Also important are data on the ways that farmers chose to deal with the problems they encountered. Almost all of the farmers who survived the initial problems switched to some form of all-in-all-out nursery batch production with less concentration of protein (17-18 percent CP) and concurrent increase of amino acids and enzymes in feed. The important thing about the Swedish experience is that the effects we see in the data include both negative effects of the way the ban impacted less well-organized producers and positive effects of the substitute measures that were brought into use.

Procedures

The following sections include a short overview of the economic model and discussion of the technical parameters, and cost and price data used to demonstrate the effect of the ban. A *most-likely* case (*case II*) uses evidence from the experience in Sweden to describe what is most likely to occur (given the evidence from Sweden and other expert opinion) if the ban were implemented in the U.S. These results are compared with the *base* case, or results with no change in feed-grade antibiotic use. Then we acknowledge our uncertainty with a worst-case (*case III*) and a *best-case* scenario (*case I*). These scenarios, or alternatives, are developed by revisiting each of our assumptions and assuming worst (best) case impacts. The best-case

scenario is found by combining all of the best-case assumptions. The differences between the best and worst cases provide the range for our results.

It is important to recognize that the framework used to evaluate impacts of a ban makes use of existing information on technical and economic relations to predict the impacts. New technologies to supplement the growth effects, changes in underlying economic relationships, or farm structural issues are not addressed explicitly within the model, yet may modify some of the predicted impact. Fixed costs, also, are not tracked fully in our estimates. We provide additional descriptive sections on fixed costs and the farm structural issues.

The economic model incorporates both biological and economic processes that govern production and consumption. The livestock model structure includes components for pork, beef, and chicken. More details are provided in Appendix A. The processes include binding biological limits (e.g., weight gain rates, length of gestation), lags of variables to capture time periods required in production, and accounting identities to ensure consistency in the stock (e.g., animal inventory) and flow variables (e.g., number of animals slaughtered, pig crop, and mortality). The model also includes technical parameters such as feed efficiency, weight and weight gain, mortality, and sow efficiency.

The model has a simultaneous econometric framework where the market equilibrium price and quantity for pork, beef, and chicken are jointly determined. For this analysis, input markets were assumed to be exogenous. For the pork sector, the model includes information on feed costs, labor costs, other variable costs, and fixed costs. The results include estimates for sow inventory, commercial pork production, retail price and barrow-gilt price, pork per capita consumption, costs per head and changes in profit (defined as farm price less costs). Retail prices and farm prices are related through marketing margins.

The results of the model estimates provide baseline projections. The analysis of the impacts of a ban on feed-grade antibiotics is conducted by comparing the results of the analysis using baseline values, to one that uses assumptions about the requirements and results of changes in raising of hogs under conditions implied by a ban. These comparisons include the previously described three scenarios.

Technical Assumptions

Based on information gathered during the visit to Sweden and Denmark, and from other sources, the basic technical assumptions for the most likely effects of the ban are as follows (also summarized in Table 1 in the Executive Summary).

- The age at weaning increases by one week, based on the assumption that the U.S. practice of early weaning (2-3 weeks) is dependent on antibiotics in the starter feeds and will have to be delayed one week.
- Days to reach 25 kg (approx. 50 pounds) increases by 5 days (Robertsson and Lundeheim 1994).
- Feed efficiency for pigs from 50 to 250 pounds declines by 1.5 percent, based on the Swedish assumptions (SOU 1997) and estimates from discussions in Denmark.
- Postweaning mortality increases by 1.5 percent (Robertsson and Lundeheim 1994), and mortality for fattening-finishing pigs increases by 0.04 percent (assumptions in SOU 1997).
- Piglets per sow decline by approximately 1 per year (4.82 percent) due to the increased age at weaning (Holden 1999; USDA data). The likely positive effects on sow reproduction by increased lactation length (wean to service interval and litter size) have not been included in the assumptions (Marsteller 1997; Tummarek 1999). With normal technical change (improvements) in pigs per sow per year, the baseline level in 1999 would again be met after nine quarters.
- Veterinary and therapeutic costs, net after the deduction of the cost for feed additives, increase by \$0.25 per pig, based on estimates from Sweden. For Sweden the estimate is that increased veterinary and therapeutic costs per piglet are \$0.25 (Jonasson and Andersson, 1996) and the reduced cost of feed-grade antibiotics is about \$0.10 per piglet (SOU 1997). For the United States, we estimate the net costs to be \$0.25 per pig.

The above changes were implemented in cases I and II.

Fixed Costs

Because of additional time after weaning and restricted feeding that might be needed in order to reduce nutritional stress, additional space would be required for the nursery and finishing periods for existing production capacity. In this context it is important to mention that Swedish and Danish expertise do not link restricted feeding to the ban on feed-grade antibiotics. Restricted feeding has always had a place in Scandinavia for reasons other than antibiotics (cost of feed, feed efficiency and improved leanness). However, our estimates are based on discussions and data from animal scientists, agricultural engineers, and others at Iowa State University. Additional troughs would use, in net, about 10 percent more floor space, and new construction would be required to provide this space. With a one-time capacity today of 40 million hogs, four million additional “spaces” (10 percent of 40 million) would be required. The new construction would cost \$115 per head for nursery space and \$165 per head for finishing space, or a total cost to the industry of \$1.12 billion (i.e., $(165+115) \times 4$ million). In addition, existing feeders would need to be replaced with pre-cast concrete troughs. This would cost \$7.50 per space for existing facilities and nothing for new facilities (except the extra space). The total cost would be 40 million times \$7.50 = \$300 million. Hence, the best estimate in cost of changed space required is about \$1.42 billion (Lawrence 1999; Harmon 1999; Stoker 1999). We also explore the sensitivity of results to the assumption on the need for expanded use of restricted feeding.

The longer weaning times would require new investment to expand sow nursery space. The costs for the additional sow nursery space are \$166.39 million. This cost assumes a farrowing sow inventory of 3.47 million, 4 percent increase in stay in the nursery due to extended weaning age, and \$1,200 cost per sow space (Harmon 1999). This assumes a 7x5 space with gates and passageways but without farrowing crates, a conservative estimate.

Fixed costs were depreciated over a 10-year period at an interest rate of 7 percent.

Additional Costs

Costs include

- feed costs from wean to feeder,

- feed costs for fattening-finishing (estimated in the model),
- labor cost based on farrow-to-finish hog production for operations of 1,600 head annual sales, North Central Region (USDA),
- standard veterinary cost (USDA),
- other variable costs (including fuel, lube, electricity, machinery and building repairs, and miscellaneous) (USDA), and
- fixed costs (including general farm overhead, taxes and insurance, interest, and capital replacement) (USDA).

The change in feed costs associated with a ban is reflected under the different cases evaluated. Other, additional costs include additional net veterinary treatment costs of \$0.25 per pig (after deduction of the present cost for in-feed antibiotics) and the additional fixed cost (both depreciation and interest cost) required (see above).

Increased Variability in Pigs and Sort Loss

Hog producers are penalized for marketing either too-light or too-heavy pigs. The sort loss entered the calculation of the marketing margin, reducing the effective price received by farmers. Observation in the Sweden and recent experiments in the United States indicate increased variability in ending weight after the removal of antibiotics in feeds. To account for this effect of increased weight variability on price, distributions of market weights for pigs under the baseline and different scenarios were characterized. A normal distribution was assumed for all cases.

For the baseline distribution, the 1998 national average carcass weight for hogs slaughtered under federal inspection was 189.75 lbs. Data from the Pork Chain Quality Audit were used to derive the baseline standard deviation. In the Audit data, 8.9 percent of total pigs were marketed with too-light carcass weight; this percent, and the normality assumption, imply a standard deviation of 14.63.

After a ban, the standard deviation of hog weights increases. Under a mean-preserving change in the distribution, we estimate the standard deviation to increase by 3.775 units, an amount interpolated from experimental results (reported from AlPharma). With the increased dispersion, the share of animals with too light carcass weight (i.e., penalized under sort loss)

increased to 14.2 percent. A price grid for Excel Corporation was used to estimate the sort loss, with estimates of average percent lean of 54.60 percent and a meat base price of \$52.00 per cwt. Under the *most-likely* case, the estimated change in sort loss is \$0.341 per cwt (\$0.644 per head) or 0.873 percent of the liveweight price.

Results

1. Most-Likely (II) Model Scenario

The major technical effects of the ban are on feed efficiency and piglet mortality, as described above. The changes in feed efficiency lead to changes in feed costs (Table 2).

Table 2. Feed efficiency and average daily gain—most likely

Weight		Feed Efficiency		Average Daily Gain	
Beginning	Ending	Baseline	Scenario	Baseline	Scenario
50	100	2.35	2.39	1.57	1.55
100	250	3.39	3.44	1.68	1.65

After the ban, piglet mortality is assumed to increase by 1.5 percent and mortality for fattening-finishing pigs increase by 0.04 percent. Mortality numbers were spread out by animal type based on their proportion in the inventory, and were adjusted accordingly. As weaning age is extended by one week, piglets per sow per year decline by 4.82 percent.

The results are presented in Table 3, and can be summarized as follows:

- Sow inventory declines by 0.97 percent in the new equilibrium (after 10 years), as farmers adjust to higher feed costs and the changes in sow productivity and pig mortality.
- Pork commercial production declines by 3.43 percent.
- Pork per capita consumption declines by 3.42 percent.
- Retail price and barrow-gilt price reflect the effects of reduced pork supply in the market. As pork supply decreases, the new retail price equilibrium increases by 2.21 percent, while the barrow-gilt price increases by 4.62 percent. The estimated retail price increases 5.2 cents per pound.

- Cost per head increases by \$6.05 in the first year and \$5.24 at the end of the projection period. This includes additional fixed costs of \$1.41 to \$2.79 per head.
- Profit per head declines by \$4.17 in the first year and by \$0.79 per head at the end of the projection period, or slightly lower than \$0.01 per pound of pork.

These changes over the projection period lead to a decline in the present value of industry profit over 10 years of \$1.039 billion. This is calculated as the sum of “forgone” profit over the 10-year period on the hogs marketed, discounted to present at a 7 percent discount rate.

Table 3. Most-likely (II) model scenario impact from baseline

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Percent change from baseline									
Sow stock	-0.16	-0.54	-0.64	-0.70	-0.76	-0.81	-0.87	-0.91	-0.94	-0.97
Farm price	2.24	4.90	5.01	4.91	4.82	4.75	4.70	4.66	4.64	4.62
Consumption	-1.46	-2.92	-3.13	-3.20	-3.25	-3.30	-3.34	-3.37	-3.40	-3.42
Production	-1.46	-2.93	-3.14	-3.21	-3.26	-3.31	-3.35	-3.38	-3.41	-3.43
Retail price	0.99	2.01	2.15	2.16	2.15	2.15	2.15	2.17	2.19	2.21
Pigs/sow	-1.32	-1.18	-1.16	-1.16	-1.15	-1.14	-1.13	-1.12	-1.11	-1.11
	Change from Baseline									
Cost										
Per head \$	6.05	6.34	6.21	6.05	5.89	5.75	5.61	5.49	5.36	5.24
Net profit										
Per head \$	-4.17	-1.82	-1.37	-1.25	-1.20	-1.17	-1.11	-1.02	-0.91	-0.79
Per pound \$	-0.03	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Industry m \$	-429	-190	-147	-136	-134	-131	-125	-116	-104	-91

2. Worst-Case (III) Model Scenario

Scenario III alters several of the technical assumptions from cases I and II. The data are taken from a comparison between Danish and Swedish production results among the best quartile of swine producers with records on hand (Jonasson and Andersson 1996). According to that study, piglet mortality was 4 percent higher, and time to 25 kg weight 11.7 days longer in Swedish production. Mortality of finishers remained unchanged. Feed antibiotics were still permitted in Denmark at that time, and the Danish animal welfare legislation was less stringent than the Swedish (no ban on sow stalls and crates, fewer pen space restrictions). The data have

been used in case III to claim that the differences might be an indication of inferior results because of the debated “Swedish model.” The claim is uncertain (at best) since it is well known that many “non-antibiotic” and “non-animal-welfare” factors (animal genetics, feed composition, feeding technique, management skills, state support, EU CAP, etc.) also differed between the two countries at that time. The Swedish statistics did not include SPF herds, while more than 50 percent of the Danish herds were SPF. Instead, Jonasson and Andersson suggested another method of assumptions, that was to apply the Danish rules on antibiotics and welfare to Swedish conditions (an approach that indicated much less differences between results).

In case III, pigs per sow per year declined by 3.84 percent (instead of 4.82 percent). With this rate of decline, the baseline level of pigs per sow that prevailed in 1999 is regained at the end of the fifth quarter due to on-going technical improvements.

The additional costs for fixed costs (buildings and space) and additional vet costs were assumed to be the same as the *most-likely* case. The cost components included in the profit estimation, including the sort loss, were the same as *most-likely* case.

The results of the worst-case (III) model are presented in Table 4. After the adjustments (in equilibrium), sow stock declines by 1.31 percent due to reduced profits from higher piglet mortality and longer time on feed; commercial pork production declines by 5.53 percent. Per capita pork consumption declines by 5.51 percent. With smaller pork supply, the new retail price equilibrium increases by 3.58 percent, while the barrow-gilt price increases by 7.61 percent. These price levels are higher than those of the most-likely scenario.

Under this worst-case scenario, total cost per head increased by \$7.92 in the first year and by \$7.45 at the end of the projection period. Of these costs, the additional fixed cost was \$1.42 to 2.80 per head, the same as for the most-likely case on a per head basis. Due to higher costs, though, profit declined by \$1.05 per head. Under this worst-case, the present value of industry profit over 10 years declined by \$1.135 billion. The results are summarized in Table 4.

Table 4. Worst-case (III) model scenario impact from baseline

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Percent change from baseline									
Sow stock	-0.20	-0.68	-0.82	-0.90	-0.99	-1.08	-1.16	-1.23	-1.28	-1.31
Farm price	4.43	8.57	8.53	8.26	8.04	7.88	7.77	7.70	7.65	7.61
Consumption	-2.52	-4.87	-5.16	-5.24	-5.30	-5.36	-5.41	-5.46	-5.49	-5.51
Production	-2.52	-4.89	-5.18	-5.26	-5.32	-5.37	-5.43	-5.47	-5.51	-5.53
Retail price	1.72	3.39	3.58	3.57	3.53	3.51	3.51	3.52	3.55	3.58
Pigs/sow	-1.01	-0.81	-0.76	-0.74	-0.72	-0.69	-0.66	-0.64	-0.62	-0.61
	Change from Baseline									
Cost										
Per head \$	7.92	8.59	8.50	8.33	8.16	8.01	7.87	7.73	7.59	7.45
Net profit										
Per head \$	-4.82	-1.87	-1.40	-1.33	-1.36	-1.38	-1.36	-1.29	-1.18	-1.05
Per pound \$	-0.03	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Industry m\$	-488	-188	-142	-138	-142	-146	-144	-137	-126	-113

3. Best-Case (I) Model Scenario

The best-case scenario includes several assumptions that reduce the anticipated effects of the ban compared to the *most likely* assumptions. The only effect of the ban on productivity is an increase of piglet mortality by 1.5 percent. There are no additional feeding days required; piglets per sow per year are unchanged from the baseline; veterinary costs increased by \$0.25 per head, as in the other cases. New investment in additional nursery and finishing spaces are still required, but not for farrowing space.

The results of the best-case scenario are presented in Table 5. The decline in sow stock is minimal and declines slowly from 0.06 percent in the first to fifth year, and ending with 0.11 percent lower stock in equilibrium, compared to the baseline. Commercial pork production declines by 1.48 percent, compared to 3.42 percent in the *most-likely* case. Per capita consumption declines by 1.48 percent. Retail price increases by 0.95 percent and farm price increases by 1.89 percent.

Under this case, the total cost per head increases by \$3.10 in the first year and \$2.10 at the end of the projection period. Of these costs additional fixed costs represent \$1.25 to \$2.50 per head. Forgone profit per head declines by \$0.88 in the first five years and \$0.28 in the remaining

period. The present value of industry profit over 10 years is estimated to decline by \$0.429 billion.

Table 5. Best-case model scenario impact from baseline

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Percent change from baseline									
Sow stock	-0.03	-0.07	-0.05	-0.03	-0.04	-0.06	-0.07	-0.09	-0.10	-0.11
Farm price	1.34	2.25	2.16	2.05	1.98	1.94	1.92	1.90	1.90	1.89
Consumption	-0.76	-1.41	-1.45	-1.44	-1.44	-1.44	-1.45	-1.46	-1.47	-1.48
Production	-0.76	-1.42	-1.45	-1.44	-1.44	-1.45	-1.46	-1.47	-1.47	-1.48
Retail price	0.51	0.96	0.98	0.96	0.94	0.93	0.93	0.93	0.94	0.95
Pigs/sow	0.01	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.04
	Change from Baseline									
Cost										
per head \$	3.10	3.13	2.97	2.80	2.65	2.52	2.41	2.30	2.20	2.10
Net profit										
per head \$	-1.89	-0.83	-0.63	-0.55	-0.50	-0.44	-0.37	-0.28	-0.19	-0.10
per pound \$	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
Industry m \$	-195	-88	-69	-62	-57	-51	-43	-34	-23	-12

Summary of Estimated Economic Effects on Producers

The estimates for the three scenarios show that costs per head would increase by \$6.05 to \$5.24 per head over the 10-year period estimated under the most-likely case, with somewhat lower values for the best-case (I) and higher values for the worst-case (III). The timing of these changes is also illustrated in Figures 1-3. However, since prices would be higher due to smaller supply (a result of the lower profits), net profit would decline only by \$0.79 per head by the end of the period (under the most-likely case), or less than \$0.01 per pound of pork in retail weight. The net present value of forgone profit to the industry over 10 years is \$1.039 billion (with a range over the scenarios from \$1.135 to \$0.429 billion).

Impact of the Ban on the Structure of the U.S. Hog Industry

The results presented above show the technical impacts of a ban on an “average” or “representative” farm. These results mask very wide differences across farms, and the distributional effects are not estimated in the model. Also, one must be cautious about using the

Swedish experience as an exact indicator as to what might happen in the United States, although certain general patterns do stand out.

First, if restricted feeding has to be used, almost all U.S. producers will have to make some adjustments. This practice is also common in other European countries that allow the use of feed-grade antibiotics. Most U.S. pork producers allow unrestricted feeding at this stage. It is not clear what would happen to U.S. practices should the use of feed antibiotics be prohibited. One scenario is that U.S. producers would encounter health problems in their stock, such as dysentery, and that they would use restricted feeding to reduce nutritional stress. This is the assumption in our estimates. A second scenario is that the costs of implementing a restricted feeding regime would be less than the expected health benefits and that the U.S. pork industry would continue ad-lib feeding. The results presented for the three cases (I, II, III) include the costs of adding troughs and space to allow restricted feeding. These costs totaled \$960 million in total or approximately \$1.20 per hog. If this assumption is incorrect, then these values overstate the effects by this amount. This is obviously an area where additional research is needed.

Also, another cost would be for a change to all-in-all-out production for farms with continuous production systems. It is estimated (Lawrence 1999) that as much as 20 percent of U.S. production still originates on farms that have not yet adopted all-in-all-out. The existence of these continuous flow systems is puzzling because the all-in-all-out method more than pays for itself. If these producers plan to remain in business they should adopt the all-in-all-out system regardless of whether the ban is implemented. Therefore, the results presented above do not include the costs of transforming these facilities. It seems likely that many of the remaining continuous flow systems are owned by individuals who are financially marginal, or who plan to stop production in the near future. A likely possibility is that the ban would cause the majority of these producers to exit the industry.

From a purely economic perspective the closing down of these older farms makes sense. The individuals involved likely have more productive uses for labor and capital, and the efficiency and disease status of the overall U.S. pork industry would improve. However many of these older operations are owned by small to medium family farms and some exist on farms that would not otherwise justify the full-time input of the producer. The ongoing trend away from this type

of production unit has created social tensions and any acceleration of this trend will only increase these tensions.

The impact of the ban will also differ across commercial producers. The Swedish experience suggests that those who follow good hygienic and health practices will see the smallest impact. The largest impact would be expected on densely populated farms in counties with large numbers of hog farms who have older buildings and who do not follow sound management practices. In this context, the on-going elimination of low dosage feed additives in Denmark, with its very high swine population density and large numbers of old barns, may provide a more important source of information on possible impacts in the U.S. than comes directly from the Swedish experience.

Larger, modern three-site confinement systems will likely see the smallest impact. Anecdotal evidence suggests that the impact of the ban on the very largest producers would be minimal. Many of these producers have created systems where disease and health problems have been greatly reduced and the principal benefit they receive is via the growth promoting effects of the antibiotics. One of these producers suggested that the net benefit of using antibiotics in feed amounted to only \$0.50 per animal. These producers would likely improve their competitive position should a ban be implemented. Again, the social impacts of such a trend might be very different than the economic impact.

Impact of a Ban on Consumer Demand

In the results described above, consumers respond only to changes in the price of pork. Table 6 provides an estimate of the approximate annual costs to consumers, calculated by multiplying the projected change in retail price by the per capita consumption. The estimated increase in retail prices for the most-likely case is 5.2 cents per pound, with an estimated range between 8.4 cents, for the worst-case, and 2.2 cents for the best-case.

In the analysis, we did not alter the price of poultry or beef, despite the likelihood that the other animal products would be affected similarly by a ban, nor have we factored in any positive impact of such a ban on consumer willingness to pay for pork produced without the use of feed-grade antibiotics. The logic behind the latter assumption is that consumers who want to pay a premium for this kind of pork will encourage producers to produce antibiotic-free pork for niche

markets. Currently, this market segment does exist, but it is small. We did not attempt to make assumptions on changes in consumer preferences from the current situation. Producers in this segment will obviously not see any technical impacts. Any consumers who do not purchase this specialized pork will be worse off once their choice set is restricted and will not likely increase their pork consumption. The well-documented consumer concerns in Europe on these questions have, so far, not been heard as much in the U.S.

As shown in Table 6, with the increase in retail price of 5 cents in the most-likely case, the effect on the consumers' expenditure on pork per year (calculated for a family of four) is about \$11 per year. Over all consumers, the increased costs for pork is estimated to be \$748 million per year. These estimates are based on an examination of the effects of a ban on the pork industry. If the ban were applied to all meats, including beef and poultry, the overall increase in costs for consumers would be higher as production for all meats would adjust.

Table 6. Approximate annual costs to consumers

Items	Units	Scenarios		
		Most-likely	Worst-case	Best-case
Change in Retail Price	\$/lb	0.052	0.084	0.022
Per Capita Consumption	Retail weight lb	53	53	53
Extra Cost per Capita	\$/capita/year	2.75	4.45	1.18
Extra Cost per Family	\$/family/year	11.02	17.84	4.73
Extra Cost National	million \$/year	748	1212	322

One very important consumer response may occur in export markets. The U.S. pork industry currently depends on export markets such as Japan to absorb ever-increasing quantities of U.S. pork. The U.S. pork market has therefore become very sensitive to developments in these markets. So far there is very little evidence to suggest that these export customers are concerned about the use of antibiotics among suppliers. However, once the EU or Danish industry can guarantee reliable supplies of “antibiotic free” pork this situation may change.

Possible factors that might lead to such a change would include:

- (1) a marketing campaign by EU or Danish producers that used the antibiotic issue to disparage U.S. pork;

- (2) a well-publicized dispute between the EU and United States about the safety of U.S. pork; or,
- (3) a decision by Japanese society that it does not want to have to compete with low-cost U.S. producers.

This latter development might occur if the next round of world trade negotiations forces Japan to further liberalize import barriers against pork. This development would lead to a rapid deterioration in the competitive position of the domestic Japanese industry and might force Japanese policymakers to find a non-tariff barrier to replace the existing protection system. Losses to the U.S. pork industry associated with a loss of an important export customer such as Japan would dwarf the losses associated with the ban described above.

Suggested Research

Before the impacts estimated in this report can be confirmed, field studies are needed to test the assumptions regarding production systems and weaning age. In particular, the effect of withdrawal of feed antibiotics in starter feeds should be studied in nursery pigs weaned at different ages and in different production systems (all-in-all-out, etc.). Another issue is the effect of restricted versus ad-lib feeding on the need for antibiotics. It is not at all clear from the Scandinavian experiences that restricted feeding will be needed during the grower-finisher phase of production.

Finally, research and prognostication of consumer attitudes on these issues in the United States are perhaps the most important aspect for understanding the future challenges to American pork production from any changes in the use of over-the-counter antibiotics in swine rations.

Figure 1. Most-Likely (I) Scenario

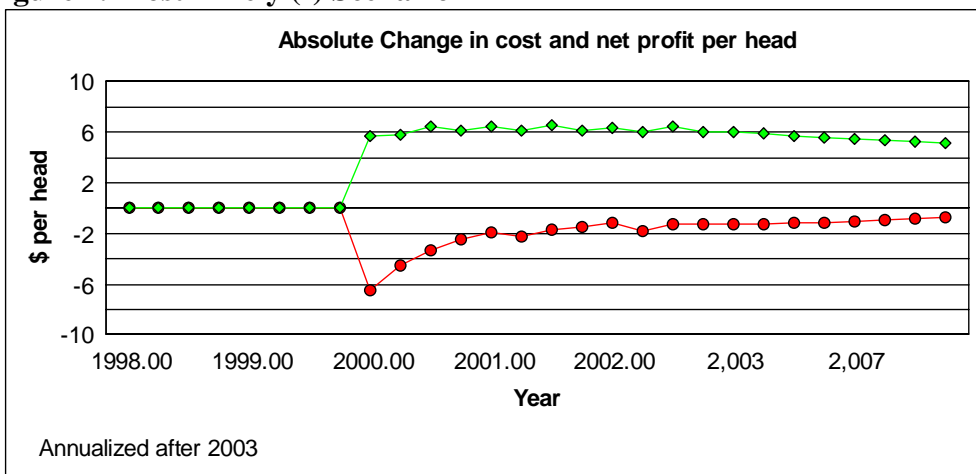


Figure 2. Worst-Case (III) Scenario

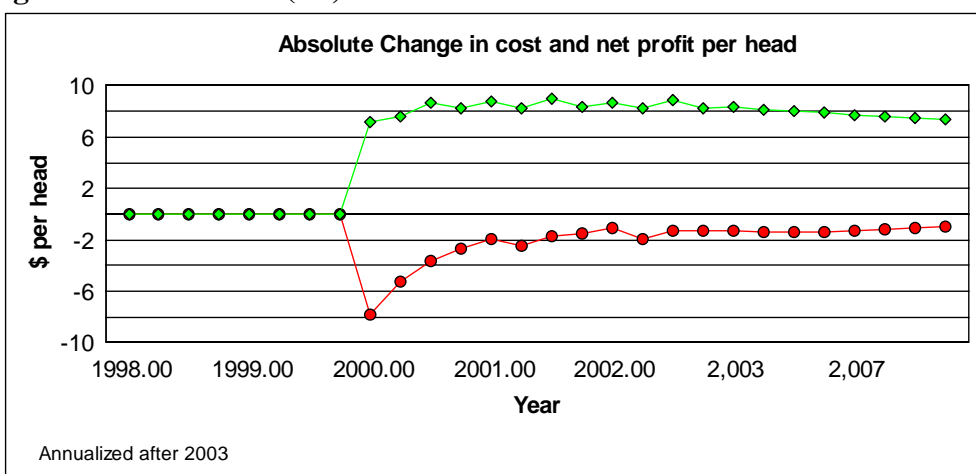
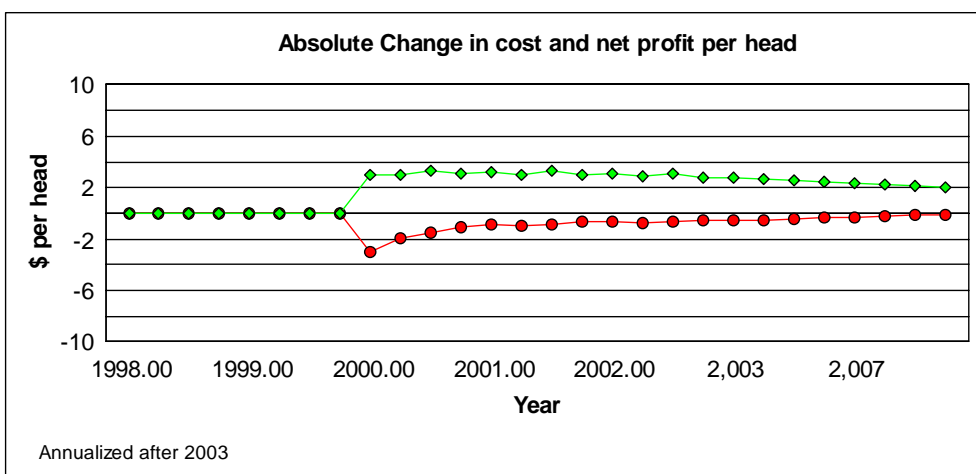


Figure 3. Best-Case (I) Scenario



Appendix A

Economic Model

See Buhr (1989) for the detailed model specification. The model can be described by “block”: live inventory and production; meat supply; meat demand; and price transmission. For this analysis, input markets were assumed to be exogenous.

Live Inventory

The live inventory block includes three important and interrelated stock variables: breeding inventory, gilt-barrow inventory, and pig crop. This section of the model captures two major producer decisions: the number of gilts to add to the breeding herd, and the number of gilts or barrows, and sows or boars to slaughter. These decisions are conditioned on the given production technology, feed price, gilt and barrow price, interest rates, and other relevant economic variables. The production technology involves parameters such as pigs per litter, weaning age, days on feed, and feed efficiency.

The available number of gilts or barrows for slaughter is determined by the gilt-barrow inventory, export, import, and mortality. The slaughter decision links the live inventory block of the model to the next block, which is the meat supply block.

Meat Supply

The meat supply section of the model involves technical conversions of variables. Information on the number of pigs slaughtered combined with the average liveweight allows the calculation of pork production measured as liveweight. With additional information on dressing percentage, the production in liveweight is converted into pork production in carcass weight. The total available pork in carcass weight is obtained as the sum of pork from other sources (e.g., on-farm production and beginning stock) and the domestic commercial production. The intermediate output of this part is the total pork available.

Meat Consumption

The amount of pork consumption is the residual disappearance of pork; that is, what remains from the total pork available after removing all the other known uses of pork (e.g., export and ending stock). Total pork consumption can be converted into per capita consumption in retail weight by using the appropriate population data and conversion factors.

Meat Demand

The consumption decision of consumers is modeled in a two-stage budgeting framework that accounts for prices of pork and the substitute meats, beef, and chicken. Total income is apportioned first into major expenditure categories including meat. Then, the amount allocated to meat is further allocated to specific meat types including pork. Only the second step is directly specified in the model used here. The total meat expenditure (the first step) is determined outside the model estimation. The demand specification used to obtain the meat demand parameters in the second step is a linear approximation of an inverse version of the Almost Ideal Demand System (LA/IAIDS). The estimated demand relationships yield the estimated retail prices for pork, beef, and chicken (see appendix for estimated price flexibilities and scale parameters).

Price Transmission

A marketing margin equation is specified to directly link the retail and farm markets and to simultaneously determine the equilibrium price and quantity.

Note that changes in the swine industry induced by changes in production processes may have impacts on input markets, particularly for feed grains. However, for the analysis reported in this report, the price of feed grains is assumed to be determined outside of the model structure, i.e., exogenous.

Profitability

Profits are determined by subtracting costs from price received.

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