Economic Analysis of Pharmaceutical Technologies in Modern Beef Production

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Executive Summary

Cattle production is the largest single agricultural sector in the U.S. with cash receipts of $49.2 billion in 2005. The industry includes more than 980,000 farms with cattle in all 50 states. Like the rest of agriculture, cattle producers have adopted efficiency and quality improving technology to meet consumer demands for a safe, wholesome and affordable food supply. Rod Preston and Tom Elam chronicled the 50-year evolution of beef production technologies and estimated a significant savings of resources to produce our current supply of beef. Conversely, if the U.S. did not use growth enhancing technologies for cattle production, the beef industry and supply would be significantly smaller and beef prices to consumers significantly higher.

This research extends Preston and Elam's earlier work by using meta-analysis to combine information from over 170 research trials evaluating pharmaceutical technologies in the cow-calf, stocker and feedlot segments of beef production. These results were used to estimate the economic value of parasite control, growth promotant implants, sub-therapeutic antibiotics, ionophores and beta agonists at the farm/ranch level in 2005. These results were analyzed using the Food and Agriculture Policy Research Institute (FAPRI) model of U.S. agriculture to estimate the impact on beef production, price, and trade if these pharmaceutical technologies were removed from the market.

While much of the discussion about technology use is focused on growth and efficiency in the feedlot sector, animal health and well-being are also important. This analysis found that parasite control in the cowherd has a significant impact on calf production and cost to the beef system. Growth and efficiency-enhancing technologies in the feedlot also have a significant impact on cost of production. These technologies will be particularly important in a bioeconomy-era of higher feed costs.

Using 2005 prices and production levels, the estimated direct cost savings to producers of the five pharmaceutical technologies evaluated was over $360/ head for the lifetime of the animal. Selling prices would have to increase 36 percent to cover the increase in costs without these technologies. However, producers and consumers adjust to the changing costs. The FAPRI model of the U.S. beef sector shows a:

- 14% smaller calf crop
- 18% reduction in U.S. beef production
- 180% increase in net beef imports
- 13% increase in retail beef prices

Cattle prices do increase, but not as fast as cost of production. Packers and feedlots adjust to maintain operating margins similar to current levels resulting in lower returns to beef cow herds and a smaller feedlot and packing industry. Pork and poultry production expand to fill this void for domestic and export customers.

Some consumers are requesting natural or organically produced beef and research suggests that a portion of these consumers are willing to pay a premium for such products. However, the complete elimination of efficiency-enhancing technologies will result in high beef prices to all consumers and the U.S. would need to import significantly more beef to meet its demand. The smaller beef industry would mean fewer cattle operations and less employment in rural communities.

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Cattle production is the largest single agricultural sector in the U.S. with cash receipts of $49.2 billion in 2005. The industry includes more than 980,000 farms with cattle in all 50 states. These operations vary from small, extensively managed range and pasture-grazing herds to large intensively-managed feedlots. While resources and management may differ, all cattle operations, like much of agriculture, face narrow operating margins because of the competitiveness of global markets. Also, like the rest of agriculture, cattle producers have adopted efficiency and quality-improving technology to meet consumer demands for a safe, wholesome and affordable food supply.

Preston and Elam chronicled the 50-year evolution of beef production technologies and estimated the benefit of the various technologies. The accumulation of these technologies has resulted in a significant savings of resources by reducing the inputs of pasture, range and cropland required to produce our current supply of beef. Conversely, if U.S. producers used only the resources currently used in cattle production, the supply of beef would be significantly smaller and beef prices to consumers significantly higher.

The purpose of this paper is to evaluate the impact of pharmaceutical technologies on the beef industry at a point in time, more specifically, 2005. The objectives are two-fold:

- Estimate the farm or ranch level economic costs and benefits of selected pharmaceutical technologies under current market conditions.
- Estimate the aggregate impact on U.S. beef production, trade and consumer prices if these technologies did not exist.

Following a brief literature review is a description of the methodology used to summarize the numerous individual research projects into regional cost-of-production estimates for cow-calf, stocker and feedlot enterprises. Then these farm/ranch-level impacts are used in the FAPRI model of U.S. agriculture to estimate the impact on beef production, trade and prices. The final section will summarize the analysis, discuss winners and losers and identify the key elements that may alter the results.

Introduction

Beef cattle producers regularly use technologies to improve animal health and comfort as well as to enhance performance and profitability. These technologies include parasite control, ionophores and growth promotants. Their adoption rate is relatively high because of their effectiveness and economic return, but this rate differs for cowherds, stockers and feedlots. National surveys have documented adoption rates by producers and numerous controlled research studies have documented the performance impact. These research studies are summarized here.

Nearly 73 percent of the cow-calf operations dewormed cattle and 84 percent of the cows received some injections in 1996 (Calf Health and Productivity Audit, 1997). Individual trials show the effect of dewormers on pregnancy rate ranged from an increase of 2.4 percent (Purvis et al., 1994) to 120 percent (Larson et al., 1992). The dewormer's effect on the

[1] USDA Meat Animals Production, Disposition, and Income 2005 Summary, April 2006
http://usda.mannlib.cornell.edu/usda/current/MeatAnimPr/MeatAnimPr-04-27-2006.pdf

weaning weight ranged from an increase of nearly 0.3 percent (Stroh et al., 1999) to over 13 percent (Stromberg et al., 1997).

An estimated 14 percent of all cow-calf operations used some implants in calves prior to weaning. The Calf Health and Productivity Audit (1997) showed the use of implants prior to weaning was more common in the largest operations (55 percent) compared to the smallest operations (9 percent). Individual trial effects of the growth promotant implants on weaning weight ranged from a slight increase of 0.3 percent (Simms et al.,1983) to an increase of 10.7 percent (Wallace et al.,1984) A large percentage of cow-calf operations (81 percent) used some form of fly control (Calf Health and Productivity Audit,1997). Individual trials measuring the effect of fly control on calves' average daily gain (ADG) ranged from an increase of 0.3 percent (Quisenberry and Strohbehn, 1984) to 21 percent (Lynch et al.,1982).

Individual trial effects on stocker cattle's ADG differed across trials and technologies. Studies on deworming ranged from a decrease of 9 percent (Mertz, Hildreth and Epperson, 2005) to an increase of 191 percent (Sanson et al., 2003). Similar studies on growth promotant implants showed ADG ranged from a decrease of 0.6 percent (Brazle, 1996) to an increase of 45 percent (Brazle, 1988). Meanwhile, the effect of sub-therapeutic antibiotic use in stockers ranged from a decrease of 21 percent (Brazle and Kuhl, 1989) to an increase of 27 percent (Brazle and Kuhl, 1989). Finally, effects of ionophores on stocker ADG ranged from a decrease of near 3 percent (Corah and Brazle, 1986) to an increase of 24 percent (Lomas, 1982).

Feedlots are significant users of technologies. Overall, 92 percent of all feedlots use growth promoting implants when cattle are place on feed. The use of implants is more common in the largest operations (99.6 percent) compared to the smallest operations (89.5 percent) (Baseline Reference of Feedlot Management Practices, 1999). Individual trials on growth promoting implants reported a range in ADG from a decrease of near 5 percent (Foutz et al., 1997) to an increase of near 38.6 percent (Gerken et al., 1995) with an average value near 14 percent. The range in individual trial effects of growth promoting implants on feed to gain (FTG) ranged from an increase of 7.7 percent (Henricks et al., 1997) to a decrease of 22.8 percent (Gerken et al., 1995) with an average of an 8.8 percent decrease in FTG.

Eighty-three percent of the feedlots used some antimicrobials in feed or water with the incidence of antimicrobial use being higher for animals placed on feed at 700 lbs or less (Health Management and Biosecurity in U.S. Feedlots, 1999). Results from individual trials measuring the effects of sub-therapeutic antibiotics on ADG ranged from a decrease of 9 percent (Ramsey et al., 2000) to an increase of 11 percent (Zinn, Song and Lindsey, 1991). Individual studies of sub-therapeutic antibiotics on FTG ranged from an increase of 19 percent (Rogers et al., 1995) to a decrease of 8 percent (Lee and Laudert, 1984).

Overall, 93 percent of feedlot operations fed ionophores, and 46 percent fed coccidiostats (Health Management and Biosecurity in U.S. Feedlots, 1999). A higher percentage of operations in the Central region fed probiotics (34 percent) compared to operations in other regions (13 percent). The list of additives is not mutually exclusive since operations may have used more than one additive (Health Management and Biosecurity in U.S. Feedlots, 1999). The results of ionophore research on ADG in feedlot cattle ranged from a decrease of 20 percent (Brandt and Pope, 1992) to an increase of 20 percent (Spires et al., 1990). Individual trials evaluating effects of ionophores on FTG ranged from an increase of 7 percent (Brandt and Pope, 1992) to a decrease of 19 percent (Lomas, 1983).

Parasiticides and avermectins are the most commonly used products, with some type of dewormer used in over 99 percent of feedlots (Health Management and Biosecurity in U.S. Feedlots, 1999). Ninety-nine percent of feedlots also regularly use some method of fly control (Health Management and Biosecurity in U.S. Feedlots, 1999). Approximately 98 percent of feedlot operations vaccinate against respiratory diseases and 86 percent of operations vaccinate against clostridial diseases as part of the initial processing of incoming cattle. Ninety-two percent of the feedlots implant steers and 96 percent treat for parasites shortly after placement in the feedlot (Health Management and Biosecurity in U.S. Feedlots, 1999). MGA® was fed to all of the female cattle on 62 percent of the large operations and 46 percent of the small operations that placed female cattle on feed (Health Management and Biosecurity in U.S. Feedlots, 1999).

In summary, pharmaceutical technologies are widely used in all segments of the cattle industry. Some, such as parasite control, are used in all segments. A high percentage of feedlots use several technologies. While these technologies are generally beneficial for animal performance and profitability, individual research trial results do vary. This difference likely reflects the specific nutritional, environmental and genetic conditions of animals in the study. Consequently, it is difficult to apply the results from any one research trial to the broader industry. In the following section, we discuss a procedure for systematically combining the numerous research results to arrive at a representative value and a distribution of expected impact from the use of these technologies in the cattle industry.

Methodology

The purpose of this study is to evaluate the overall value of pharmaceutical technologies by estimating the cost of eliminating their use in each of the beef cattle production segments (cow-calf, stocker and feedlots). The pharmaceutical products analyzed are: parasite control, growth promotant implants, sub-therapeutic antibiotics, ionophores, and beta agonists. Meta-analysis (a set of techniques to integrate empirical studies of the same or similar issues) was used to combine numerous individual research studies of these pharmaceutical technologies. It is a highly valuable way to review and summarize research literature, and is now widely used in medicine and the social sciences. This analysis reviewed over 170 published articles and incorporated the mean responses, variation (standard deviation) and size of the studies evaluated. Where there was not enough information reported in the literature for a particular technology, a similar approach was used to combine the results of the studies to arrive at a mean and the largest standard deviation that would be significant at $P<0.05$. Given the combined distribution, a Montecarlo simulation of 20,000 events of the expected effect of the technology on production parameters was generated for each product in each production system where information was available. The output of this step is the change in production and/or efficiency resulting from using an individual technology versus not using it. Later, the procedure is used to look at a combination of often-used technologies compared to no technologies. Finally, these production and efficiency parameters are put into a farm/ranch level cost-of-production budget to estimate the cost and benefit of pharmaceutical technologies on a per-head basis. In the next section, these net return results were analyzed using the FAPRI aggregate model of U.S. agriculture to determine the broader impact of pharmaceutical use on resource use, trade and food prices.

Table 1. Beef Cow-calf and Stocker Regions Identified for Budgeting Purposes

Region	States in region	University budgets used
Cow-calf		
Southeast	LA, MS, FL, AL, GA, TN, SC, NC, VA, WV, KY	Louisiana
North Central	ND, SD, NE, KS	North Dakota
South Central	OK, TX	Texas
Central	MN, WI, IA, MO, AR, IL, MI, IN, OH	Missouri
Northeast	New England States	Pennsylvania
West	WA, OR, CA, NV, ID, MT, UT, WY, CO, AZ, NM	Colorado
Stocker		
Southeast	LA, MS, FL, AL, GA, TN, SC, NC, VA, WV, KY	Louisiana
North Central	ND, SD, NE, KS	Kansas
South Central	OK, TX	Oklahoma and Texas
Central	MN, WI, IA, MO, AR, IL, MI, IN, OH	Missouri
West	WA, OR, CA, NV, ID, MT, UT, WY, CO, AZ, NM	Colorado

The cattle industry was divided into three production segments: cow-calf, stocker and feedlot, and into geographical regions where appropriate. Six cow-calf and five stocker regions were identified (Table 1). Feedlot production was treated as one region because the diets and use of technologies are similar across all major feedlot regions. Cost-of-production budgets for these three segments were developed using selected University extension budgets for major production states in each region. For cow-calf operations, the literature reports changes in pregnancy rate, weaning weight and calf ADG as a response to the use of pharmaceutical products. For stocker operations, the literature reports changes in ADG. There is limited evidence of reduction in death loss as a response to the use of pharmaceutical products. The literature reports that using pharmaceutical products in feedlots leads to changes in ADG, FTG, average marbling score and average yield grade.

Beginning with the mean and standard deviation summarized from existing literature for the expected impacts of the pharmaceutical technologies of interest, 20,000 observations (unless otherwise noted) of effects of each product in production efficiencies were generated using simulations. The rank correlation between variables was included in the random generation of the distribution. These variables are then entered into the regional budgets, weighted by the location of the U.S. inventory to generate the expected dollar impact of removing the technologies. Initial cattle and corn prices are average 2005 prices reported by the USDA. A sensitivity analysis was run to determine how robust the results are to changes in feed price and feeder cattle price. This procedure resulted in an average farm/ranch level net return and the risk of returns associated with removing these pharmaceutical technologies.

Cow-calf segment

Six regional cow-calf operation budgets were used to evaluate the cost of eliminating pharmaceutical products (Table 1). Representative cull cow prices were developed based on the average of the monthly Auction Cattle Prices for the year 2005 as reported by the USDA Agricultural Marketing Service. The prices used were from:

West: Colorado, Washington, Montana, New Mexico, Oregon, and Wyoming
North Central: Kansas
South Central: Texas and Oklahoma
Central: Missouri
Southeast: Tennessee, Georgia and Alabama
Northeast: Pennsylvania

The estimated feed cost across the regions ranged from $183/cow/year to $247/cow/year. Annual veterinary and health products cost ranged from $10/cow/year to $25/cow/year. Additional cost for the pharmaceutical technologies were not included in the analysis, nor was this budget item changed when the technologies were removed The only changes in production efficiency for cow-calf operations that is consistently reported in the literature is the effect of the technologies on pregnancy rate, average daily gain (ADG) and calf weaning weight. Therefore, we have only included changes of pregnancy rate and calf weaning weight in the program. We assumed that the calves are weaned on a fixed date and sold at weaning. The changes in calf ADG affect the weaning weight and, therefore, the sale weight. It is assumed that feed consumption is the same at higher weaning weights as it is at lower weaning weights when pharmaceutical technology is used. This analysis is based only on the impact of pregnancy rate and sale weight and not on any value difference due to a prescribed vaccination or treatment program. A sensitivity analysis determined that the results are robust to changes in feed costs in all cases.

Results

Table 2 shows the estimated effects of three different technologies (growth promoting implants, dewormers, fly control) on weaning rate and weaning weight. Deworming is the technology that affects weaning rate (includes both pregnancy rate and survival rate of the calf) the most, with an expected value of 23 percent. This is a very large impact, which explains why 73 percent of beef cowherds are de-wormed. The three technologies have similar impact on the weaning weight. All the effects are different than 0 with 99 percent confidence.

Table 2. Impact of Pharmaceutical Technologies on Beef Cowherd Weaning Rate and Weight

	Wean Rate		Wean Weight	
	Effect	Std. Error	Effect	Std. Error
Growth Promoting Implants	2.54%	0.0049	3.07%	0.0023
Dewormers	23.62%	0.0600	4.24%	0.0033
Fly Control	nd	nd	2.56%	0.0048

The larger the effect of a technology on production efficiency, the larger its effect on cost of production. The expected impact on the breakeven selling price of eliminating the dewormers was 34.3 percent, which represents an added cost of $165.47/head produced (Table 3). The second most important technology is growth promoting implants, which have an effect of 5.8 percent on the breakeven price and $28.03/head increase in costs.

In combination, these three technologies have a significant impact on the cost of production in beef cow operations. Removing these three technologies is expected to increase the breakeven selling price nearly 47 percent or $225/head with the results being different than 0 with a 99 percent confidence. In many cases, producers have a fixed land base which limits the number of beef cows they can maintain. As weaning rate and weight decrease, there are fewer calves sold to cover the cost of maintaining the herd. Producers must still retain replacement heifers but do so from a smaller number of calves. Thus, the cost-per-calf sold increases dramatically.

Table 3. Estimated Impact on Breakeven Selling Price and Cost of Production from Removing Pharmaceutical Technologies from the Beef Cowherd

	Breakeven price		Cost per head	
Technology	Mean	Std. Error	Mean	Std. Error
Growth Promoting Implants	5.80%	0.00011	28.03	0.05
Dewormers	34.34%	0.00048	165.47	0.23
Fly control	3.05%	0.00012	14.71	0.06
All technologies	46.78%	0.00057	225.55	0.28

The results are robust to changes in feed cost (Table 4). Feed prices are simulated as 20 percent higher or lower to evaluate the impact of pharmaceutical technologies under different price scenarios. The efficiency gains of the technologies are more important at higher feed prices.

Table 4. Sensitivity of Eliminating All Product on Beef Cowherds when Feed Prices are 20 percent Higher or Lower

	Breakeven price		Cost per head	
	Mean	Std. Error	Mean	Std. Error
Baseline	46.78%	0.00057	225.55	0.28
Feed price up	46.90%	0.00058	247.13	0.31
Feed price down	46.63%	0.00057	203.98	0.26

Stocker Operations

Five regional stocker operation budgets were used to evaluate the cost of eliminating pharmaceutical technologies. The budgets represent the West, North Central, South Central, Central and Southeast regions, and were weighted by stocker cattle inventories to represent a national impact. Representative feeder-cattle prices for each weight range were developed based on the average of the monthly Auction Cattle Prices reported for the year 2005 as reported by the USDA Agricultural Marketing Service. The prices used were:

West: Colorado, Washington, Montana, New Mexico, Oregon, and Wyoming
North Central: Kansas
South Central: Texas and Oklahoma
Central: Missouri
Southeast: Tennessee, Georgia and Alabama auctions

In 2005, the estimated feed cost across the regions ranged from $0.30/day to $0.45/day. The labor cost ranged from $6/head to $24/head. Veterinary and health product costs were estimated at $10/head. Additional costs for the pharmaceutical technologies were not included in the analysis, nor was this budget item changed when the technologies were removed.

Because ADG is the only change in production efficiency for stocker operations that is attributed to technology and is consistently reported in the literature, it was the only parameter included in the analysis. We assumed that the animals were sold when they reach a desired live weight. The changes in ADG affect the number of days the cattle remain in the operation to reach the desired final weight and, therefore, impact costs.

Montecarlo simulations were repeated for 20,000 draws from each distribution of the effect of each technology on ADG. The resulting values were used to estimate the breakeven price if each technology were eliminated from the stocker production systems. The change in the expected cost was estimated as the average breakeven price without the technology compared to the average breakeven price with the technology. A sensitivity analysis was run to determine the impact of 20 percent higher or lower feed prices and 10 percent higher or lower calf prices.

Results

Table 5 shows the estimated effects of five different technologies (implants, ionophores, sub-therapeutic antibiotics, dewormers, fly control) on ADG. All the effects are different than 0 with 99 percent confidence. Dewormers and growth promoting implants are the two technologies that affect ADG the most in stocker operations. The impact of ionophores, sub-therapeutic antibiotics and fly control were all similar, but less than implants and dewormers.

Table 5. Effect of Pharmaceutical Technologies on Average Daily Gain in Stocker Cattle

	Effect	Std. Error
Implants	12.85%	0.0062
Ionophores	7.74%	0.0094
Sub-therapeutic antibiotics	6.87%	0.0127
Dewormers	17.79%	0.0106
Fly control	8.09%	0.0103

The greater the effect of a technology on production efficiency, the larger its impact on cost of production. Eliminating dewormers affected the breakeven price by 2.7 percent, which represented a cost of $20.77/head produced (Table 6). The second most important technologies are growth promoting implants which have an effect of 2.3 percent on the breakeven price, a cost of $18.19/head. Ionophores and sub-therapeutic antibiotics have an expected cost-of-production impact of $11.51/head and $9.57/head, respectively. Fly control has a smaller impact. All the results are robust to changes in feed prices and feeder cattle prices.

Table 6. Estimated Cost of Production Impact of Pharmaceutical Technologies in Stocker Operations

	Breakeven price		Cost per head	
Technology	Mean	Std. Error	Mean	Std. Error
Implants	2.31%	0.00005	18.19	0.04
Ionophores	1.46%	0.00006	11.51	0.05
Sub-therapeutic antibiotics	1.22%	0.00011	9.57	0.08
Dewormers	2.74%	0.00020	20.77	0.15
Fly control	0.80%	0.00008	6.28	0.06
All technologies	10.40%	0.00037	80.79	0.28

Some literature indicates that the effects of growth promoting implants, ionophores and sub-therapeutic antibiotics are additive. We assumed that the dewormers and fly control effects are additive as well. Therefore, the effects of each technology from the Montecarlo simulations were added and the resulting values were used to estimate the breakeven price if these five groups of products were eliminated from the stocker production systems. The estimated impact of eliminating these five technologies on the breakeven price was 10.4 percent or $80.79/head, and was significantly different than 0 with a 99 percent confidence.

The results are robust to changes in feed prices and calf prices (Table 7). As expected, efficiency and performance-enhancing technologies have a larger impact when feed prices are higher. The cost savings decreased when higher calf prices were compared to the base price of feed. Operating costs were then a smaller percentage of total costs.

Table 7. Sensitivity Analysis of Feed and Calf Prices when Eliminating All Pharmaceutical Technologies

	Breakeven price		Cost per head	
	Mean	Std. Error	Mean	Std. Error
Baseline	10.40%	0.00037	80.79	0.28
Feed price up 20%	11.22%	0.00079	87.19	0.60
Feed price down 20%	9.49%	0.00067	73.65	0.51
Calf price up 10%	9.69%	0.00069	75.23	0.52
Calf price down 10%	11.18%	0.00079	86.83	0.60

Feedlot effects

A single budget was used to evaluate the cost of eliminating pharmaceutical products in feedlot production systems. Representative feeder-cattle prices for each sex and weight range were developed based on the average of the monthly Auction Cattle Prices reported for Missouri, Kansas, Nebraska, South Dakota, North Dakota, Texas and Oklahoma for the year 2005 as reported by the USDA Agricultural Marketing Service. The monthly average of 2005 fed-cattle price for interior Iowa and Southern Minnesota (USDA, Agriculture Marketing Service) was used as the fed cattle price. The initial feed cost was estimated at $0.038/lb., representative of prices in 2005. The labor cost was estimated at $27/head. Veterinary services and health product costs were estimated at $10/head. Additional cost for the pharmaceutical technologies was not included in the analysis, nor was this budget item changed when the technologies were removed.

Literature research was done to find the expected value and the distribution of the effect of growth promoting implants on ADG and FTG (expressed as lbs feed/ lbs gained). Research on the impact of pharmaceutical technologies is typically reported separately for steers and heifers. This analysis modeled each technology for both sexes, but combined the results into a single, weighted average feedlot effect across both steers and heifers based on the share of steers (63.5 percent) and heifers (36.5 percent) slaughtered in 2005 and 2006. A sensitivity analysis was run by moving the feed prices up and down 20 percent and the feeder cattle price up and down 10 percent.

Guiroy et al. (2002) found that for the same empty body fat (28 percent) at slaughter, the final weight at slaughter is higher for implanted animals than for non-implanted ones, with the incremental gain depending on the anabolic dose used. We used their results to estimate the increase in final weight needed to reach the same empty body fat, i.e., the same approximate quality and yield grade, with or without implants. The procedure generated 1,000 observations of the effects on final weight and the estimated average increase in weight for each of the groups (four groups in steers and two groups in heifers). Perry et al. (1991) analyzed the effect of trenbolone acetate and estradiol implants on beef steers and the results show little effect on yield when the animals were fed to reach the same final marbling score. Therefore, no changes in marbling and yield grade distributions are included in this analysis.

Montecarlo simulations were run to get 20,000 draws from each distribution to measure the effect of pharmaceutical technologies on ADG, FTG and final weight. The rank correlations between ADG and FTG and between ADG and final weight were included in the simulations. Final weight is impacted by implants and beta-agonists, while the remaining technologies affect only days on feed. The resulting values were used to estimate the breakeven selling price if these technologies were eliminated from feedlot production systems. The change in the expected cost-per-head was estimated as the average breakeven price without technologies over the average breakeven price with technologies. Table 8 summarizes the average impact and the standard error.

Table 8. The estimated Impact on Average Daily Gain and Feed to Gain from Eliminating Pharmaceutical Technologies from Beef Feedlots

	ADG		FTG		Rank
	Effect	Std. Error	Effect	Std. Error	Correlation
Implants	14.13%	0.0021	-8.79%	0.0014	-0.6940
Ionophores	2.90%	0.0030	-3.55%	0.0022	-0.6893
Antibiotics	3.37%	0.0037	-2.69%	0.0008	-0.5728
Beta-agonists	14.04%	0.0053	-12.59%	0.0011	-0.9679
Dewormers	5.59%	0.0159	-3.91%	0.0000	-0.9273

From the literature reviewed and the simulation procedure outlined, we estimated that the growth promoting implants and beta-agonists have the largest increase on ADG and FTG. Implants resulted in an increase of ADG by 14.1 percent and a decrease of the FTG by 8.8 percent. The rank correlation is -0.694 between the increase the ADG and the decrease the FTG. Beta-agonists have an ADG effect similar to implants, but a larger FTG impact. Dewormers, sub-therapeutic antibiotics and ionophores had a lesser, but still statistically significant impact on costs. Dewormers improved ADG 5.6 percent and reduced FTG 3.9 percent. Sub-therapeutic antibiotics and ionophores improved ADG approximately 3 percent and reduced FTG approximately 3 percent.

The simulations of the individual technologies were used in the budget model to estimate the impact on the cost of production. Table 9 reports the percentage change in selling price needed to break even and the cost-per-head increase in production cost in the feedlot if these pharmaceutical technologies were eliminated. Of the technologies considered, implants have the largest cost savings effect with a savings of 6.5 percent or $68/head — savings that would be lost if these technologies were eliminated. Dewormers generated the second largest cost savings. Ionophores and beta-agonists reduce costs approximately $12-13 per head or about 1.2 percent. The impact of beta-agonists is smaller than reported in the table above because they are used for a relatively few days at the end of the feeding period. Sub-therapeutic antibiotics have an important, but smaller cost reduction.

Table 9. Percentage and Dollar per Head Change in Cost of Production Resulting from Elimination of Pharmaceutical Technologies

	Breakeven price		Cost per head	
Technology	Mean	Std. Error	Mean	Std. Error
Growth Promoting Implants	6.52%	0.00063	68.59	0.67
Ionophores	1.18%	0.00002	12.43	0.03
Sub-therapeutic Antibiotics	0.56%	0.00002	5.86	0.02
Beta-Agonists	1.24%	0.00001	13.02	0.01
Dewormers	2.11%	0.00002	22.16	0.02
All technologies	11.99%	0.00064	126.09	0.67

The final line of Table 9 reports the effect of simulating these technologies in combination, rather than individually. Some literature reports that the effects of growth promoting implants, ionophores and sub-therapeutic antibiotics are additive. Therefore, the effects of each one from the Montecarlo simulations were added and the resulting values were used to estimate the breakeven price if these five groups of products were eliminated from the feedlot production systems. These results reflect a small degree of additive effect. The sum of the individual technologies reduces cost-per-head an estimated $122.06/head, compared to the $126.09/head savings when simulated together.

The results of the combined technologies simulations were evaluated under higher and lower feed and feeder cattle prices (Table 10). As expected, the pharmaceutical technologies that improve ADG and FTG produce greater cost savings and are more important when feeder prices are higher.

Table 10. Sensitivity of Cost of Production Results to Changes in Feed and Feeder Cattle Prices Elimination of Pharmaceutical Technologies

	Breakeven price		Cost per head	
	Mean	Std. Error	Mean	Std. Error
Baseline	11.99%	0.00064	126.09	0.67
Feed price up 20%	12.28%	0.00059	132.96	0.64
Feed price down 20%	11.69%	0.00069	119.22	0.71
Calf price up 10%	11.75%	0.00066	133.11	0.75
Calf price down 10%	12.28%	0.00061	119.07	0.60

Across all segments

The effects of pharmaceutical technologies for each segment were combined and weighted by region and adoption rate. For that purpose, the cow-calf effects in the different regions were weighted by the percentage of total calves produced in each area. A similar procedure was followed for the stocker operations.

When the adoption rate of each technology was included in the analysis, eliminating the dewormers in the entire production chain impacted the breakeven prices by 19 percent, which represents a cost of nearly $190/head produced. Eliminating growth promoting implants from the entire production chain impacted breakeven prices by over 7 percent, which represents a cost of $71.28/head produced. The estimated increase in breakeven selling price if all the technologies studied were eliminated from the entire chain was 36.6 percent, which represents a cost of $365.65/head produced.

Table 11. Impact on Estimated Breakeven Selling Price and Cost per Head from Eliminating Pharmaceutical Technologies Throughout the Beef Industry

	Breakeven price		Cost per head	
Technology	Mean	Std. Error	Mean	Std. Error
Growth Promoting Implants	7.14%	0.00049	71.28	0.49
Dewormers	19.02%	0.00071	189.81	0.71
All technologies	36.63%	0.00134	365.65	1.33

Since the adoption rate of the technologies is relatively high, it is important to account for the existing use of technologies before estimating the cost of eliminating them. The estimated impact of banning pharmaceutical technologies is significant, but the fully integrated industry impact is less than the sum of the individual segments listed above, which do not reflect the adoption rate.

Market Implications

The combined impact of pharmaceutical technologies on cost of production was integrated across the three production sectors. The results are additive and, in fact, show a complementary effect as healthy animals are better able to use other inputs efficiently. The results were weighted by a reported adoption rate of technologies in each segment. For example, nearly 95 percent of feedlots use technologies, but only 74 percent of beef cowherds use dewormers. As a result, elimination of pharmaceutical technologies would not impact 26 percent of beef cowherds.

The impact of eliminating pharmaceutical technologies on cost of production and overall beef production was run as a scenario through the FAPRI model of U.S. agriculture. FAPRI uses comprehensive data and computer modeling systems to analyze the complex economic interrelationships of the food and agriculture industries. FAPRI prepares baseline projections each year for the U.S. agricultural sector and international commodity markets. These multi-year projections provide a starting point for evaluating and comparing scenarios involving macroeconomic, policy, weather and technology variables. These projections are intended for use by farmers, government agencies, agribusinesses and others who do medium-range and long-term planning. The analysis compares a ban on pharmaceutical technologies to the current baseline with existing technologies and holds other factors constant. The underlying assumption is that the ban on pharmaceutical technologies, while significant to the beef sector, is not large enough to impact the macro economy, corn or other input markets. It does include the market interactions with pork and poultry markets and beef trade.

A summary of the results, assuming that a ban on pharmaceutical technologies was implemented in 2000, is shown in Table 12. The table represents 2005 five years after the ban was initiated, and most of the adjustment has occurred. It also shows the percent change and the difference from the baseline in two scenarios, with and without pharmaceutical technologies. The change and difference are based on a three-year average in years 4-6 after the ban rather than only one year.

The technology impact on production efficiency described earlier was incorporated into the FAPRI model. The results indicate that the U.S. beef market would adjust to a new equilibrium without pharmaceutical technologies as a smaller industry with higher beef and cattle prices. The model estimated that the number of beef cows is unchanged, but there are 14 percent fewer calves weaned and carcass weights decline, reducing beef production 18 percent or 4.5 billion pounds annually. There are fewer total cattle, fewer cattle on feed and fewer cattle slaughtered. Net imports of beef would increase dramatically: 180 percent or nearly 2.2 billion pounds. Consumers would eat less of a higher-priced product. Domestic per capita beef consumption would decline 8.5 percent while retail prices would increase 13 percent.

Table 12. Summary of Model of U.S. Beef Sector With and Without Pharmaceutical Technologies for 2005, Five Years After Ban Initiated in 2000

	Values after 5 Years		Average Years 4, 5, 6	
Inventory (Million Head)	With Technology	Without Technology	Percent Change	Difference
Beef Cows, Jan 1	32.9	33.0	0.2%	0.1
Total Calf Crop	37.8	32.5	-14.1%	-5.3
Steer and Heifer Slaughter	27.2	22.6	-16.5%	-4.5
Cattle and Calves, Jan 1	95.4	83.7	-12.2%	-11.7
Cattle on Feed, Jan 1	13.7	11.4	-16.9%	-2.3
Beef Supply and Use (Million Lbs)				
Production	24,784	20,225	-18.1%	-4545.6
Net Imports	2,901	5,123	180.7%	2180.1
Retail Consumption (lbs)	65.4	59.9	-8.5%	-5.6
Prices and Returns (S/cwt)				
Nebraska 11-13 cwt Steers	87.28	104.94	20.2%	17.33
OKC 6-6.5 cwt Steers	120.02	147.48	22.8%	26.52
Utility Cows, Sioux Falls	54.36	67.72	25.3%	13.09
Retail Beef ($/Lbs)	4.09	4.63	13.1%	0.53
Cow-calf Returns ($/cow)				
Receipts	584.51	627.28	7.0%	40.77
Expenses	446.17	491.29	10.1%	45.94
Net Returns	138.34	135.99	-7.9%	-5.17
Source: Food and Agricultural Policy Research Institute				

Cattle prices would increase along with retail prices. Nebraska fed-cattle prices would increase 20 percent or more than $17/cwt without the technologies. However, slaughter weight is reduced and decreased FTG efficiency would mean feedlots could not bid as aggressively for feeder cattle. Feeder cattle prices would increase 23 percent or approximately $26/cwt for Oklahoma City 600-650 pound steers, but not as much they would if feedlots had better efficiency. Cull-cow prices would increase $13/cwt.

However, the higher feeder cattle and cull-cow prices would only partially offset the higher cowherd cost due to the reduced weaning rate. Cowherd returns were very good in 2005 and are projected to decline in the years ahead under either scenario. In the end, cowherd returns are modestly lower, approximately 8 percent or $5 per head, without the use of pharmaceutical technologies. Thus, the industry would reach a new equilibrium with cow-calf returns lower than before the ban on technologies. The overall beef industry would be smaller with fewer cattle on feed, reduced slaughter and more beef imports.

A smaller, higher cost beef industry would be beneficial for competing meats. Pork and broiler production would both be expected to increase 1.4 percent in response to restrictions on beef technologies. Pork and broiler meat exports would increase over

6 percent and per capita consumption would increase 0.67 percent and 0.54 percent, respectively. In spite of the larger supply, retail prices of pork and broilers would also increase because of higher retail beef prices. Thus, competing meat industries would benefit from restrictions on pharmaceutical use that would increase cost of production in the beef sector.

As with other technologies in agriculture, the benefit of pharmaceutical technologies accrues to consumers in the form of larger supplies at lower prices. Early adopters of technologies typically benefit from lower costs before the larger supplies that the technologies create result in lower prices. In the case of a ban on pharmaceutical technologies, the incentives are reversed. Producers want to be the last to quit using the cost-saving technologies, as their ban would result in higher prices due to higher costs of production and reduced supplies. While the surviving producers are expected to earn similar returns with or without these technologies, the industry would be smaller and there will be fewer producers.

Summary

Pharmaceutical technologies are widely used in the U.S. cattle industry and with good cause. They significantly reduce the cost of producing beef by improving the growth and efficiency of cattle production across all segments of the industry. Adoption rates vary across segments, but are quite high with over 95 percent of feedlot cattle using some or all of the technologies considered. Cowherds do not use implants and ionophores as regularly as do feedlots, but they have high adoption rates for parasite control.

While much of the discussion about technology use is focused on growth and efficiency in the feedlot sector, animal health and well-being are also important. This analysis found that parasite control in the cowherd has a significant impact on calf production and cost-of-production in the beef system. Growth, and efficiency-enhancing technologies in the feedlot also have a significant impact on cost of production. These technologies will be particularly important in a bioeconomy-era of higher feed costs.

This study incorporated research findings from over 170 trials using meta-analysis to evaluate the impact of individual pharmaceutical technologies on cattle performance and cost of production. Using 2005 prices and production levels at the farm/ranch level, cost savings created by the five pharmaceutical technologies evaluated was more than $360/head over the lifetime of the animal, after accounting for adoption rates. Fed-cattle selling prices would have to increase 36 percent to cover the increase in costs across all segments.

These efficiency and cost differences were incorporated into the FAPRI model of U.S. agriculture. The U.S. beef market would find a new equilibrium as a smaller industry with higher beef and cattle prices. There would be fewer total cattle, fewer cattle on feed and fewer cattle slaughtered. Beef production would fall 18 percent or 4.5 billion pounds annually. Net imports of beef would increase 180 percent or nearly 2.2 billion pounds per year. Per-capita consumption would decline 8.5 percent while retail prices would increase 13 percent. Pork and poultry would expand to fill this void in domestic and export markets. Cattle prices would increase along with retail prices. Nebraska fed-cattle prices would increase 20 percent, approximately $17/cwt. Oklahoma City 600-650 pound steer prices would increase 23 percent or more than $26/cwt and cull cow prices would increase as well, up $13/cwt.

However, the higher feeder cattle and cull-cow prices would only partially offset the higher cowherd cost due to the reduced weaning rate. After the adjustment, cowherd returns would be approximately 8 percent or $5 per head lower without the use of pharmaceutical technologies. The beef industry would be expected to have the same number of beef cows, but fewer calves would be weaned, leading to fewer total cattle, reduced slaughter and more beef imports.

As with other technologies in agriculture, the benefit of pharmaceutical technologies accrues to consumers in the form of larger supplies at lower prices. Early adopters of technologies typically benefit from lower costs before the large supplies the technologies create result in lower prices. In the case of a ban on pharmaceutical technologies, the incentives are reversed. Producers would want to be the last to quit using the cost-saving technologies as cost of production rise and supplies would decline, leading to higher prices. Once the industry was fully adjusted to the ban on technologies, remaining producers would be expected to earn returns similar to before the ban. However, there would be fewer producers.

Cost of production is a generic measure of resource use. Technologies allow the animal to utilize forage and grain resources more efficiently to produce beef to meet consumer demand. Some consumers are requesting natural or organically produced beef and research suggests that a portion of these consumers are willing to pay a premium for such products. However, if pharmaceutical technologies were banned from use in the U.S., cost of production would rise, forcing some producers and resources out of the cattle industry. The feedlot and beef packing sectors would be downsized because there would be fewer calves produced and more beef would be imported. The smaller supply of beef would result in higher prices to all consumers, not just those willing to pay a premium for natural and organic production practices.

References: For a full list of the references cited in this paper please see:
www.econ.iastate.edu/faculty/lawrence/pharmaeconomics2006.pdf