Economic Analysis of Pharmaceutical Technologies in Modern Beef Production

John D. Lawrence and Maro A. Ibarburu, Iowa State University

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. Preston and 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. used only the current resources for cattle production, the beef industry and supply would be significantly smaller and beef prices to consumers significantly higher.

This research extends the 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 farm/ranch level economic value of parasite control, growth promotant implants, sub-therapeutic antibiotics, ionophores, and beta agonists for the industry in 2005. These results were used in 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% to cover the increase in costs. However, producers and consumers adjust to the changing costs. The FAPRI model of the US beef sector shows a:

- 14% smaller calf crop,
- 18% reduction in US beef production,
- 180% increase in net beef imports, and
- 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 US would import significantly more beef to meet its demand. The small beef industry means 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[1] 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 from operating in a competitive global market. 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 to produce our current supply of beef. Conversely, if the U.S. used only the resources currently 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:

1. Estimate the farm or ranch level economic costs and benefits of selected pharmaceutical technologies under current market conditions.
2. 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 Food and Agriculture Policy Research Institute (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 enhanced performance and profitability. These technologies include parasite control, ionophores, and growth promontants. Their adoption rate is relatively high because of there effectiveness and economic return, but it does differ for cowherds, stockers, and feedlots. National surveys have documented adoption rates by producers and numerous controlled research studies have documented the performance impact and are summarized here.

Nearly 73% of the cow-calf operations dewormed cattle and 84% of the cows received some injections in 1996 (Calf Health and Productivity Audit, 1997). Individual trials effects of the dewormers on pregnancy rate ranged from an increase of 2.4%

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[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

(Purvis et. al., 1994) to 120% (Larson et. al., 1992). The dewormers effect on the wean weight ranged from an increase of nearly 0.3% (Stroh et. al., 1999) to over 13% (Stromberg et. al., 1997).

An estimated 14% 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%) compared to the smallest operations (9%). Individual trial effects of the growth promotant implants on wean weight ranged from a slight increase of 0.3% (Simms et. al., 1983) to an increase of 10.7% (Wallace et. al., 1984) A large percentage of cow-calf operations (81%) used some form of fly control. (Calf Health and Productivity Audit, 1997). Individual trials effects of fly control on calves average daily gain (ADG) ranged from an increase of 0.3% (Quisenberry and Strohbehn, 1984) to 21% (Lynch et. al., 1982).

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

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

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

Overall, 93% of feedlot operations fed ionophores, and 46% fed coccidiostats (Health Management and Biosecurity in U.S. Feedlots, 1999). A higher percentage of operations in the Central region fed probiotics (34%) compared to operations in other regions (13%). 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% (Brandt and Pope, 1992) to an increase of 20% (Spires et. al., 1990). Individual trials evaluating effects of ionophores in FTG ranged from an increase of 7% (Brandt and Pope, 1992) to a decrease of 19% (Lomas, 1983). Parasiticides and avermectins are the most commonly used products with use in over 99% of feedlots (Health Management and Biosecurity in U.S. Feedlots, 1999). Feedlots also regularly use (99%) some method to control fly population (Health Management and Biosecurity in U.S. Feedlots, 1999)

Approximately 98% of feedlot operations vaccinate against respiratory diseases and 86% 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% treat for parasites shortly after placement. (Health Management and Biosecurity in U.S. Feedlots, 1999). MGA® was fed to all of the female cattle on 62% of the large operations and 46% of the small operations that placed female cattle (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 generally beneficial for animal performance and profitability, the results of the individual research trials do vary. This difference likely reflects the specific nutritional, environmental, and genetic conditions of animals in the study conducted. As a result it is difficult to generalize from any one research trial to the broader industry context and impact. In the following section we discuss a procedure for systematically combining the numerous research results to arrive a representative value and distribution of expected impact from these technologies in the cattle industry.

Methodology

The purpose of the study is to evaluate the 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 was used to combine numerous individual research studies on these pharmaceutical technologies. It is a set of techniques to integrate empirical studies on the same or similar issues. 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 is 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 a combination of technologies that are often used 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 are used in the FAPRI aggregate model of U.S. agriculture to determine the broader impact on resource use, trade, and food prices of pharmaceutical technologies.

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.

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

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 and there is limited evidence of reduction in death loss as a response to the use of pharmaceutical products. The literature reports the use of 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 expect 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 and 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 US inventory to generate the expected dollar impact of removing the technologies. Initial cattle and corn prices are average 2005 prices reported by USDA. A sensitivity analysis was run to determine how robust the results are to changes in feed price and feeder cattle price. This procedure results 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 operations 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 reported for the year 2005 reported by 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
- 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 on 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 when pharmaceutical technology is used as it is at lower weaning weights. This analysis is based only on the impact of pregnancy rate and sale weight and not 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 on weaning rate and weaning weight. De-worming is the technology that affects weaning rate the most with an expected value of 23.6%. This is a very large impact and weaning rate includes both pregnancy rate and survival rate of the calf. It also explains why 73% of beef cowherds use de-wormers. The three technologies have similar impact on the weaning weight. All the effects are different than 0 with 99% confidence.

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

	Wean Rate		Wean Weight	
	Effect	St. Error	Effect	St. Error
Growth Promotant Implants	2.54%	0.0049	3.07%	0.0023
De-wormers	23.62%	0.0600	4.24%	0.0033
Fly Ccontrol	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 breakeven selling price of eliminating the de-wormers was 34.3% which represents an added cost of $165.47/head produced (Table 3). The second most important technology is growth promotant implants with an effect of 5.8% in the breakeven price and $28.03/head increase in costs. In combination these three technologies have a significant impact of cost of production in beef cow operations. Removing these three technologies is expected to increase the breakeven selling price nearly 47% or $225/head and the results are different than 0 with a 99% confidence. In many case producers have a fixed land base and are limited in the number of beef cows the land will support. As weaning rate and weight decrease, there are fewer calves sold to cover the cost of 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 Bee Cowherd

	Breakeven price		Cost per head	
Technology	Mean	St. Error	Mean	St. Error
Growth Promotant Implants	5.80%	0.00011	28.03	0.05
De-wormers	34.34%	0.00048	165.47	0.23
Flies 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% 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 Products on Beef Cowherds when Feed Prices are 10% Higher or Lower:

	Breakeven price		Cost per head	
	Mean	St. Error	Mean	St. 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 budgets for stocker operations were used to evaluate the cost of eliminating pharmaceutical technologies. The budgets represent the West, North Central, South Central, Central, and South East 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 reported by 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 region: Tennessee, Georgia and Alabama auctions

The estimated feed cost ranged across the regions in 2005 from $0.30/day to $0.45/day. The labor cost ranged from $6/head to $24/head. Veterinary and health products cost was estimated as $10/head. 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 change in production efficiency for stocker operations that is consistently reported in the literature is the effect of the technologies on ADG. Therefore, we have only included changes in ADG in the analysis. We assumed that the animals were sold when they reach a desired live weight. The change in ADG affect the days the cattle remain in the operation incurring cost to reach the desired final weight.

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 is eliminated from the stocker production systems. The change in the expected cost was estimated as the average breakeven price without the technology over the average breakeven price with the technology. A sensitivity analysis was run to determine the impact of 20% higher or lower feed prices and calf prices being 10% higher or lower.

Results

Table 5 shows the estimated effects of the five different technologies on ADG. All the effects are different than 0 with 99% confidence. De-wormers and growth promotant implants are the two technologies that affect ADG the most in stocker operations. Ionophores, subtherapeutic antibiotics, and fly control had similar control to each other, but less than implants and de-wormers.

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
Subtherapeutic antibiotics	6.87%	0.0127
De-wormers	17.79%	0.0106
Fly control	8.09%	0.0103

The higher the effect of a technology on production efficiency, the larger its impact on cost of production. The estimated effect on the breakeven price of eliminating the de-wormers was 2.7% which represents a cost of $20.77/head produced (Table 6). The second most important technologies are growth promotant implants with an effect of 2.3% in the break even price and $18.19/head. Ionophores and subtherapeutic 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	St. Error	Mean	St. Error
Implants	2.31%	0.00005	18.19	0.04
Ionophores	1.46%	0.00006	11.51	0.05
Subtherapeutic antibiotics	1.22%	0.00011	9.57	0.08
De-wormers	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 promotant implants, ionophores and subtherapeutic antibiotics are additive. We assumed that the de-wormers 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 are eliminated from the stocker production systems. The estimated impact on the breakeven price of eliminating these five technologies was 10.4% or $80.79/head and was significantly different than 0 with a 99% 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 decrease at higher calf prices compared to the base price as feed and operating costs are a smaller percent of total costs.

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

	Breakeven price		Cost per head	
	Mean	St. Error	Mean	St. 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 represent feedlot production systems to evaluate the cost of eliminating pharmaceutical products. 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 reported by USDA-Agricultural Marketing Service. The monthly average of 2005 fed-cattle price for interior Iowa and South Minnesota (USDA, Agriculture Marketing Service) was used as the fed cattle price. The initial feed cost was estimated as $0.038/lb., representative of prices in 2005. The labor cost was estimated as

$27/head. Veterinary and health products cost was estimated as $10/head. Additional cost for the pharmaceutical technologies were 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 promotant 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%) and heifers (36.5%) slaughtered in 2005 and 2006. A sensitivity analysis was run by moving the feed prices up and down 20% and the feeder cattle price up and down 10%.

Guiroy et. al. (2002) found that for the same empty body fat (28%) at slaughter, the final weight at slaughter is higher for implanted animals than for non-implanted ones, and the increments also depend on the anabolic dose used. We used their results to estimate the increase in final weight needed to reach the same empty body fat, e.g., the same approximate quality and yield grade, with or without implants. The procedure generated 1000 observations for each of the groups of effects on final weight (4 groups in steers and 2 groups in heifers and the estimate the average increase in weight. 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 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 of 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 effect only days on feed. The resulting values were used to estimate the breakeven selling price if these technologies are 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 Pharmaceutial Technologies from Beef Feedots

	ADG		FTG		Rank
	Effect	St Error	Effect	St 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
De-wormers	5.59%	0.0159	-3.91%	0.0000	-0.9273

From the literature reviewed and the simulation procedure outlined we estimated that the growth promotant implants and beta-agonists have the largest increase on ADG and FTG. Implants resulted in an increase of the ADG by 14.1% and decrease the FTG by

8.8%. The rank correlation is -0.694 between the increase the ADG and the decrease the FTG. Beta-agonists have a similar ADG effect as did implants, but larger FTG impact. De-wormers, subtherapeutic antibiotics, and ionophores had a lesser but still statistically significant impact on costs. De-wormers improved ADG 5.6% and reduced FTG 3.9%. Subtherapeutic antibiotics and ionophores improved ADG approximately 3% and reduced FTG approximately 3%.

The simulations of the individual technologies were used in the budget model to estimate the impact on cost of production. Table 9 reports the percent change in selling price needed to breakeven and the cost per head increase in production cost in the feedlot from eliminating these pharmaceutical technologies. Implants have the largest cost savings effect of the technologies considered with 6.5% and over $68/head higher cost if these technologies were eliminated. De-wormers the second largest cost savings. Ionophores and beta-agonists reduce costs approximately $12-13 per head or about 1.2%. The impact to 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 Pharmaceutial Technologies

	Breakeven price		Cost per head	
Technology	Mean	St. Error	Mean	St. Error
Growth Promotant 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
De-wormers	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 identifies that the effects of growth promotant 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 are 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 value of the pharmaceutical technologies that improve ADG and FTG have a bigger cost savings at higher feeder prices. Likewise, they are more important at higher feeder cattle prices also.

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

	Break even price		Cost per head	
	Mean	St. Error	Mean	St. 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 from each segment were combined and weighted by region and adoption rate. For that purpose the cow-calf effects in the different regions were weighed by the percentage of total calves produced in each area, similar procedure was followed for the stocker operations.

When the adoption rate of each technology was included in the analysis the expected impact on the breakeven price of eliminating the de-wormers on the entire chain was 19% which represents a cost of nearly $190/head produced. The expected value of the predicted effect on the breakeven price of eliminating the growth promotant implants on the entire chain was over 7% which represents a cost of $71.28/head produced. The estimated increase is breakeven selling price of eliminating all the technologies studied from the entire chain was 36.6% which represents a cost of $365.65/head produced.

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

	Breakeven price		Cost per head	
Technology	Mean	St. Error	Mean	St. Error
Growth Promotant Implants	7.14%	0.00049	71.28	0.49
De-wormers	19.02%	0.00071	189.81	0.71
All technologies	36.63%	0.00134	365.65	1.33

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

Market Implications

The combined impacts on cost of production of pharmaceutical technologies were integrated across the three production sectors. The results are additive and if 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 for technologies in each segment. For example, nearly 95% of feedlots use technologies, but only 74% of beef cow herds use de-wormers. As a result, elimination on pharmaceutical technologies would not impact 26% of beef cowherds.

The impact on cost of production and beef production from eliminating pharmaceutical technologies was run as a scenario through the FAPRI model of US agriculture. FAPRI uses comprehensive data and computer modeling systems to analyze the complex economic interrelationships of the food and agriculture industry. 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 or corn and other input markets. It does include the market interactions with pork and poultry markets and beef trade.

A summary of the results are shown in Table 12 and assumes that a ban on pharmaceutical technologies was implemented in 2000. The table represents 2005, five years after the ban was initiated and that most of the adjustment has occurred. It also shows the percent change and the difference from the baseline with technology and scenario 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.

Table 12. Summary of Model of US Beef Sector With and Without Pharmaceutical Technologies for 2005, 5 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

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

Cattle prices increase along with retail prices. Nebraska fed cattle prices increase 20% or more than $17/cwt without the technologies. However, slaughter weight is reduced and FTG increases meaning that feedlots cannot bid as aggressively for feeder cattle. Feeder cattle prices do increase 23% 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 increase $13/cwt.

However, the higher feeder cattle and cull cow prices 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, cow herd returns are modestly lower, approximately 8% or $5 per head, without the use of pharmaceutical technologies. Thus, the industry reaches new equilibrium with cow-calf returns lower than before the ban on technologies and a smaller industry with fewer cattle on feed, reduced slaughter and more beef imports.

The smaller, higher cost beef industry is beneficial for competing meats. Pork and broiler production is expected to increase 1.4% each in response to restrictions on beef technologies. Exports increase over 6% for pork and broiler meat and per capita consumption increases 0.67% and 0.54%, respectively. In spite of the larger supply, retail prices also increase because of higher retail beef prices. Thus, competing meat industries benefit from restrictions that increase cost of production in the beef sector.

As with other technologies in agriculture, their benefit 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 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 results 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 is smaller there will be fewer producers.

Summary

Pharmaceutical technologies are widely used in the US 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% 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 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.

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 the farm/ranch level cost savings of the five pharmaceutical technologies evaluated was more than $360 per head over the lifetime of the animal after accounting for adoption rates. Fed cattle selling prices would have to increase 36% to cover the increase in costs across all segments.

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

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

As with other technologies in agriculture, their benefit 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 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 decline leading to higher prices. Once the industry has fully adjusted to the ban on technologies, remaining producers are expected to earn similar returns as they did before. However, there will be fewer producers.

Cost of production is a generic measure of resource use. Technologies allow the animal to more efficiently utilize forage and grain resources 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 US 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 is imported. The smaller supply of beef will result in higher prices to all consumers, not just those willing to pay a premium for natural and organic production practices.

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