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ABSTRACT

The Economic Impact of Restricting Feed Additives in Livestock and Poultry Production

T. L. Mann and A. Paulsen

Society is continually faced with the decision of the trade-off between environmental risks and economic costs. The use of certain antibiotics and DES in livestock and poultry production has produced unacceptable environmental risks. The objective of this study was to determine the economic impact from banning the use of these two pieces of technology in beef, pork, broiler and turkey production. The economic impact was derived through use of an econometric simulation model of the livestock and poultry industries.

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THE ECONOMIC IMPACT OF RESTRICTING FEED ADDITIVES IN LIVESTOCK AND POULTRY PRODUCTION

T. L. Mann and A. Paulsen

I. INTRODUCTION

A. Problem Setting

It is unusual to consider the impact on agriculture and the economy of restricting or forbidding the use of a piece of technology which has proven profitable. Restricting the use of feed additives in animal feeds could eliminate the significant contribution of this one particular technological advance. It could force significant changes in animal feeding and housing methods, with resultant changes in quantity marketed and in final prices to the consumer.

The public policy choice of restricting or eliminating feed activities is one of many in a new group of very disturbing and controversial public policy decisions. These decisions involve a possible gain in human security or environmental quality at the expense of economic efficiency in some industry. In the past, most of such decisions were made in favor of immediate physical or economic efficiency, producer profit, and consumer benefits. Technological advance in any field has been considered good by definition. However, it appears that the long-run impact of technical change and its concomitant impact on human health,

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human security, and environmental quality is receiving due attention. This is not simply a monetary cost-benefit trade-off. In many instances, there does not exist a common yardstick to compare the costs and benefits. The use of a money measure may not be sufficient to compare health risks and economic efficiency. With the new awareness of environmental risks, there has been a shift in the pattern of decision-making. Many production practices, heretofore considered as given, are being re-examined and in instances restricted through public policy decision. These changes in public policy decisions towards production techniques directly affect the markets of outputs and inputs. Producers, quite realistically, fear that physical and economic efficiency, short-run profit, and even consumer benefit may be sacrificed. This does not mean that all decisions will be made in favor of environmental considerations at the expense of economic efficiency, but simply that both sides of the ledger now must be examined in detail.

In the present case, the complex question is simply stated as, "How much would supposed human health risks be reduced in exchange for a given sacrifice in economic efficiency?" One part of the answer would include an outline and documentation of the public health risks. This documentation should include the nature of the health risks and their severity. A second part of the answer would include an outline of the public policy choices. These administrative choices will have their basis in the nature of the biology of the public health risks. A third part of the answer would include an estimation of the costs involved in the adoption of particular public policy. It is a question not only of direct costs and impact on producers and consumers, but also a question of the pattern of impact, and pattern of adjustment. Of special interest is the question of outside influences mitigating or enforcing the "shock" to the system of a particular public policy. The final part to the answer would be a reflection upon the trade-off in health risks to economic costs. This would be the determination of the least-cost/most health risk reduction combination. Quite possibly there will not exist such a combination.

In this paper we will deal only with the derivation of cost estimates of restricting feed additives, one side of the story. Of particular interest to us is the question of the pattern of impact and adjustment of supplies and prices to these public policies. Thus, our purpose is twofold. First, we wish to report our results as to the economic impact to the producer and consumer of restricting certain feed additives to livestock and poultry production. Second, we wish to report on the success and failure from using an econometric simulation model of the livestock and poultry industries to accomplish our task.

We are defining feed activities to include those chemical and biological additives which livestock and poultry producers use to stimulate growth, increase feed efficiency, and reduce mortality. These additives include growth hormones such as DES and MGA, as well as antibiotics. For the sake of simplicity, the word antibiotic will be defined to include not only the true antibiotics, e.g., tetracyclines and penicillin, but also the synthetic antibiotics developed for use in human and veterinary medicine, i.e., sulphonamides and nitrofurans, and finally the aresenical compounds. This expanded definition of antibiotics includes those chemical substances produced organically or synthetically which inhibit or destroy bacterial infection or growth.

B. Food and Drug Administration Actions and Proposals

The Food and Drug Administration has taken several actions to combat what it believes to be the public health risks resulting from the use of feed activities in livestock and poultry feeds. First, as of January 1, 1973, FDA banned the use of DES in livestock feeds, but permitted its continued use as an implant in the ears of feeder steers and heifers. Then on April 27, 1973, it banned even this practice. This action was taken under the auspices of the "Deleaney Clause," legislation which requires the FDA to remove from human consumption channels any drug or similar compound which in laboratory tests is found to be carcinogenic. DES, fed in large doses to laboratory mice, produced cancer.

Second, the FDA has adopted proposals from its Task Force on "The Use of Antibiotics in Animal Feeds" that the sub-therapeutic use of tetracyclines, streptomycin, dihydrostreptomycin, sulfonamides, and penicillins be banned from livestock and poultry feeds according to the following schedule:

(1) in poultry -- January 1, 1973,

(2) in swine, cattle, and sheep -- July 1, 1973.
These antibiotics which are banned are those most commonly used by animal food producers to control disease, increase feed efficiency, and increase rate of gain (13). These actions were taken because of a perceived public health risk due to several factors. First, if the technology is not used properly, then residuals are left in the meat tissue. Second, there is the possibility of a build-up of resistant bacteria from the prolonged use of certain antibiotics at subtherapeutic levels. Finally, there is the fear that this resistance is transferable in the environment, and could be transferred to pathogenic bacteria.

II. PREVIOUS RESEARCH

Several studies have been completed which analyze the economic impact of eliminating the use of DES and antibiotics at subtherapeutic levels in livestock and poultry feeds. They have all used a comparative static framework, i.e., comparing the pre-banned period with the post-banned period. The major emphasis was to determine the impact on farm prices, retail prices, and per capita consumption. Studies completed by Paulsen (9) and Butz (1) were mainly concerned with the impact from restricting the use of antibiotics in swine production. In a study completed by USDA (2) for inclusion in the Report of Hearings on Food Additives by the U.S. House of Representatives Intergovernmental Relations Subcommittee, the impact from eliminating DES was analyzed. As with Paulsen, the USDA study also analyzed other possible welfare impacts such as higher feed grain usage and reduction in certain farm programs. Finally, preliminary USDA studies on the economic impact of restricting the subtherapeutic use of antibiotics followed this latter approach (11,12).[1]

There are certain inherent problems in the USDA antibiotics and DES studies. These problems are common to both studies as they assumed the same postulated producer adjustments.

The first problem concerns the scenario that the same number of animals would be fed for a longer period of time and marketed at the same weights as in the pre-ban period. In essence, this scenario assumes that producers would feed the present number of animals for a longer period of time and achieve the same output per time period as before. In a comparative static framework this is infeasible if one is comparing two equilibrium solutions, both of the same time length. For example, if a group of steers' rate of gain is slowed because of the withdrawal of DES, then it is impossible to get the same output in pounds per time period by keeping the same number of steers on feed. Whether the producer feeds the group longer is immaterial. It is a question of output per time period. Thus, from the inventory of cattle taken on January 1 of each year, one would find fewer animals coming

[1]These studies were later published (3).

to market for the first quarter of the year. Some of these animals would then be pushed back to second quarter marketings; some in the second quarter back to third quarter, etc. What is witnessed is a permanent backing up in the number of steers and heifers being marketed in any one quarter. If the elimination of DES or antibiotics reduces the animal's rate of gain, then simply feeding for a longer period of time will not maintain output at the pre-ban level. Again, what is crucial is the concept of output per equal time period, and the difference in pre- and post-ban output levels.

A second problem of both USDA studies is the scenario of feeding an increased number of animals for the same period of time as before to maintain the same output as in the pre-ban period. This type of adjustment seems to be a very long-run producer response. By this time, substitute technology could quite possibly have replaced those feed additives which were banned. Thus, the ceteris paribus assumption which underlies the comparative static framework used in this analysis would be violated.

Thus, only one producer adjustment is left which might be considered a viable response. This is where producers would feed the same number of animals for the same length of time. With a lesser rate of gain, this implies a lighter market weight for the animal and a reduction in aggregate output per time period. A summary of this producer adjustment is presented in Tables 1 and 2 for DES and antibiotics respectively. Table 1 presents the economic impact of eliminating DES on quantity produced (carcass weight) and price, assuming a complete pass through of costs from farm to retail level. Table 2 presents the same results from eliminating the subtherapeutic use of antibiotics in cattle, hog, broiler, and turkey production.

In a more general framework, Paulsen's study, and the USDA studies are incomplete because of methodology used for analysis. It appears that a comparative static framework is not sufficient to completely answer the question of economic impact. In an absolute sense, what is needed is a complete general equilibrium framework where the biological changes can be individually specified and the economic impact individually measured for both producing and consuming units. However, lacking such a complete model of the economy, it would still be helpful if this type of approach could be used. Specifically, the producer adjustments presented in Tables 1 and 2 do not account for the impact that changes in feed efficiency will ultimately have on producer costs.

Additionally, because of a lack of data, these studies made assumptions as to the rate of adoption of antibiotics and DES. Evidence from two surveys recently completed in Iowa was made available to replace these assumptions with closer estimates (4, 5).

A simulation model of the beef, hog, lamb, broiler, and turkey economies had been recently constructed by Rahn (8) and modified by

Table 1. Economic impact of restricting DES in cattle feeds (USDA Study, Situation I)

	Change in Carcass Weight or RTC Weight	Change in Price at Retail Level
Beef	-3.5%	+3.5 cents per pound
Pork	0	+1.6 cents per pound
Lamb	0	+1.1 cents per pound
Broiler	0	+0.6 cents per pound
Turkey	0	+0.5 cents per pound

Table 2. Economic impact of restricting subtherapeutic use of antibiotics in livestock and poultry feeds (USDA Studies, Situation C)

	Change in Per Capita Consumption	Change in Price at Retail Level
Beef	-2.05 lb.	+ 7.18 cents per pound
Pork	-6.21 lb.	+11.9 cents per pound
Lamb	0	NA
Broiler	- .89 lb.	+ 2.28 cents per pound
Turkey	- .28 lb.	+ 3.875 cents per pound

Mann et al (7). With these survey results and a simulation model, it was felt that more accurate estimates of the impact on prices, per capita consumption, resource returns, and costs to the consumer could be made. We felt that a more general approach to measuring the economic impact from banning feed additives could now be taken.

III. METHODOLOGY

An estimate of the economic impact of restricting feed additives was derived through simulation with use of a quarterly econometric model of the cattle, hog, sheep, broiler, and turkey economies (7). The basic model was modified to approximate the biological responses by each species without the use of certain feed additives. The biological impact after banning was entered into the model through appropriate adjustment of selected coefficients. Three biological responses were explicitly acknowledged. First was the immediate impact of reduced rate of gain on aggregate numbers coming to market. Second, reduced rate of gain and feed efficiency raises product costs, and producers were allowed to adjust to these increases in costs. Finally, in simulating the removal of antibiotics, an adjustment was made in certain coefficients to reflect increased livestock and poultry mortality.

Five simulation runs were made. The first is a benchmark which consists of a simulation by the basic model of the period from first quarter, 1973, to fourth quarter, 1979, under the assumption of no policy changes to ban antibiotics and DES. When quarterly simulation models are allowed to run beyond 6 to 8 quarters, the results quickly loose validity. For example, particular estimates of endogenous variables for third quarter, 1978, simply have little meaning, and very little faith can be placed in these estimates. However, the reasons for using a simulation model for this type for environmental impact analysis were to (1) capture the deviations or differences from the norm, (2) indicate the trend in the pattern of adjustment to environmental changes, and (3) estimate, based on accurate exogenous variable forecasts, the expected value of the endogenous variables up to eight quarters at most. The norm is defined as the benchmark, and biological changes entered into the model are expected to produce deviations from that benchmark for all endogenous variables. It is the deviations and the pattern of deviations of selected endogenous variables from the benchmark which are considered important to society. Specifically, prices and per capita consumption are considered important indications of welfare. The second use of the simulation model was to indicate the pattern of adjustment of the livestock and poultry industries to these changes in public policy. What would happen to the livestock and poultry economy as a result of changes in biological response? How would this type of shock affect the economic system and how does the system adjust? Out of the limits of the model (7 year forecast period), the pattern of adjustment would hopefully be captured.

A final comment on the benchmark concerns the period of analyis. Some past period could have easily been used, and deviations from actual values could have been recorded as estimates of the impact. However, one of the implied objectives of this study was to generate information useful for future public policy choices. To do this, estimates of the impact into the future were felt to be more helpful.

Four simulations were run reflecting different policy choices and their implications. The first policy simulation (simulation 2) used coefficients which reflect the impact of banning antibiotics only. The second policy simulation used coefficients adjusted for the impact of banning DES only (simulation 3). The third policy simulations estimated the impact of banning both DES and antibiotics (simulation 4). Finally, the fourth policy simulation assumed the development and release of replacement technology one year after both DES and antibiotics were banned (simulation 5). This simulation was an attempt to capture the phenomena of producers substituting some of the drugs and growth hormones still available as feed additives. The one year time period was assumed to be a reasonable estimate of the time lag in producer recognition of availability of replacement technology. Then producers were assumed to adopt the replacement technology over a one-year period. Thus two years after the ban of antibiotics and DES, the pre-ban levels of adoption were assumed reached, and all coefficients in the model were restored to their pre-ban values.

For antibiotics, three series of adjustments were entered into the model for each animal class. First is the immediate impact of the change in rate of gain on livestock numbers coming to market. This consists of shifting a certain percentage of numbers of animals for slaughter from one quarter to a succeeding quarter. This percentage is calculated as the estimated rate of adoption times the estimated improvement in rate of gain due to antibiotics. This calculation produces an estimate of the aggregate impact of withdrawal of antibiotics on the number of animals expected to be slaughtered in that particular quarter.

This procedure can best be seen by a detailed examination of the adjustment for hogs. From Mann <u>et al</u> (7), the barrow and gilt slaughter equation is written as:

(1) HBGQ (I) = -5910.8 + 338.8 D4 + 2886.1D3 + 4031.1D2 + 39.67
+ 39.67$HP(I-1) + 5.246 HPI(I-2) + .6243 HSFQ(1-2)
* HPSL(I-2) + .3984 HSFQ(I-3) * HPSL(I-2).

The variables are defined as:

HBGQ = barrow and gilt slaughter, million head

$HP = change in hog price

HPI = hog profitability index

HSFQ = sow farrowings, million head

HPSL = pigs saved per litter

HTC = total costs of producing a hundredweight of output

I = quarterly counter

D2, D3, D4 = seasonal dummy variables.

The hog profitability index is defined as:

(2) HPI(I) = HP(I) - HTC(I).

Equation (1) assumes that .62 of the barrow and gilt slaughter in quarter I comes from the pig crop (HSFQ * HPSL) in quarter I-2, and .39 of the barrow and gilt slaughter from the pig crop in quarter I-3. This biological response is then adjusted by changes in the hog price, the profitability index and seasonal dummy variables.

The first adjustment, to reflect changes in rate of gain on livestock numbers coming to market for slaughter, is to adjust the coefficients on the quarterly pig crop. Specifically, since aggregate rate of gain is reduced by 8.025 percent (75 percent rate of adoption times 10.7 percent decrease in rate of gain), this implies that 8.025 percent fewer butcher hogs will be coming from the pig crop lagged two periods and 8.025 percent more barrows and gilts will be coming from the pig crop lagged three quarters. Hence, the new equation for barrow and gilt slaughter is:

(3) HBGQ(I) = K + .5742 HSFQ(I-2) *HPSL(I-2) + .4304 HSFQ(I-3) * HPSL(I-3),

where K equals all the other variables in the original equation.

The second adjustment reflects the impact of changes in feed efficiency and in rate of gain on costs. Assuming the same rate of adoption and the rate of gain and feed efficiency estimates from Mann (6), rate of gain is assumed reduced by 8.025 percent and feed efficiency by 3.825

percent. The impact on costs is shown through the hog total cost variable as defined previously. The feed conversion ratio must be increased by 3.825 percent to reflect the aggregate impact of decreased feed efficiency. Labor requirements are increased by 8.025 percent on a per hundredweight basis as more time, hence more labor, is needed to produce the same hundred pounds of output. Fixed capital or overhead requirements are also increased by 8.025 percent as fewer pounds of output is now being throughput the same physical facilities. The old and new cost functions, which are on a per hundredweight basis, are presented below:

(4) HTC(I) = (1.559 CP(I) + .0075 SBMP(I)) * 6.05 + 1.27 * FLW(I) + 3.0

(5) HTC(I) = (1.559 CP(L) + .0075 SBMP(I)) * 6.28 + 1.37 * FLW(I) + 3.25

The impact on costs is felt not only on barrow and gilt slaughter, but wherever the hog profitability index enters an equation. For the hog sector of the simulation model, this includes the sow farrowings, sow slaughter, and average weight equations.

The final adjustment for antibiotics was for expected changes in mortality. For hogs, it was assumed that the results generated by Paulsen and Mann (10) hold, and that projected pigs saved per litter will be decreased by 1/3 pig per litter. This impact enters directly into the barrow and gilt slaughter equation by adjusting the pigs saved per litter forecast downward by 1/3 pig.

The sum of these adjustments is to spread out the number of hogs coming to market, account for changes in producer costs, and account for expected changes in mortality. These adjustments, in time, are felt throughout the model and produce the estimated impact of policy decisions to restrict antibiotics in swine production. The beef, broiler and turkey sectors were adjusted in like manner for antibiotics. Also the cattle sector equations were adjusted for reduced rate of gain and feed efficiency due to restricting DES. The adjustments were in addition to those changes induced by withdrawing antibiotics.[2]

In presenting results, a choice must be made among the many variables available. The present model generages 28 quarterly values for 48 endogenous variables for each of 5 simulations. The presentation of 6500 numbers would lead to complete somnolency. In the interest of balancing completeness with conciseness, the following variables were chosen:

(1) beef, pork, broiler and turkey wholesale price (quarterly)

(2) cattle breeder, and hog net profits (quarterly)

(3) total consumer expenditures at wholesale level (yearly).

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[2] Adjustments of coefficients are presented in Mann (6), tables 5-4 through 5-8. Estimates on rate of adoption of feed additives are presented in Mann (6), II. E. Estimates on average rate of gain, feed efficiency and mortality are presented in Mann (6), table 2.7.

The cattle price is the price per hundredweight of choice slaughter steers at Omaha. The hog price is the price per hundredweight of #1-2, 200-220 pound barrows and gilts at Peoria. The per capita consumption variables used in estimating total consumer expenditures at the wholesale level are on a carcass weight basis.

Two variables are used as proxies for estimating resources returns. They are cattle feeder net profit and hog producer net profits. They are calculated to reflect the approximate net profit per head a cattle or hog producer would earn if he used the specified quantity of inputs per unit of output and sold at the average cattle or hog price for the quarter. These net returns per head are calculated for a 1000 pound steer and 220 pound hog.

IV. RESULTS

In each of the four policy simulations, the restriction of antibiotics and DES had the impact of increasing prices of beef, pork, broiler and turkey at the wholesale level. The pattern of impact indicated the greatest deviations from the benchmark would occur in late 1974 and early 1975. By this time, the full impact of each policy decision would be felt. The impact then trailed off.

Restriction of antibiotics only, or DES only, is predicted to have a minor impact on the wholesale beef price. For antibiotics, the wholesale beef price is expected to rise less than 1.2 percent at most over the benchmark. For DES, the wholesale beef price is expected to rise less than .5 percent. However, when banning the antibiotics and DES are considered together, the impact on price was significant. The combined impact, in conjunction with other meat industries, produce a greater total impact and wholesale beef prices increased approximately 2.6 percent. At most, per capita consumption is expected to decrease by .3 pounds per capita (1 percent). Cattle feeder net profits are depressed approximately $1.50 per head from withdrawing DES. With antibiotics and DES are considered together, cattle feeder net profits are depressed up to $13.00 per head. However, when replacement technology is considered, cattle feeder net profits rebound from their depressed levels to exceed the benchmark projections by fourth quarter, 1977.

The banning of DES had a very minor impact on pork, broiler, and turkey prices. The banning of antibiotics did have a significant impact on the pork sector. The wholesale pork price increased to $3.90 (4.5 percent) over the benchmark prediction by first quarter, 1975. Per capita consumption is estimated to decrease up to 1/2 pound in the last half 1974, and first half 1975. Hog net profits are increased by banning antibiotics, up to $4.40 per head by first quarter, 1975. The addition of withdrawing DES produced a negligible change to the results of withdrawing antibiotics.

The decision to ban antibiotics is expected to decrease per capita poultry supplies slightly, and produce a minor impact on both broiler

Table 3 Wholesale beef price and comparison with benchmark simulation

Year and Quarter	Benchmark Simulation (1)	Antibiotics only (2)	DES only (3)	Antibiotics plus DES (4)	Antibiotics plus DES with replacement technology (5)
1973-1	62.30	62.30	62.30	62.30	62.30
73-2	69.44	69.44	69.44	69.44	69.44
73-3	73.00	73.00	73.00	73.00	73.00
73-4	66.24	66.25	66.41	67.17	67.17
1974-1	70.84	70.86	71.01	71.78	71.78
74-2	75.17	75.62	75.30	76.55	76.55
74-3	75.89	76.39	76.05	77.48	77.48
74-4	61.78	62.36	61.95	63.47	63.47
1975-1	59.42	60.08	59.56	61.00	61.00
75-2	60.73	61.30	60.84	62.09	62.00
75-3	60.89	61.16	61.00	61.97	61.51
75-4	54.27	54.59	54.42	55.60	54.72
1976-1	55.82	56.22	55.98	57.31	56.04
76-2	59.46	59.77	59.61	60.78	59.40
76-3	60.57	60.64	60.73	61.71	60.48
76-4	58.22	58.21	58.36	59.15	57.79
1977-1	60.96	60.99	61.08	61.83	60.46
77-2	64.66	64.55	64.76	65.28	64.29
77-3	68.64	68.27	68.74	68.97	68.15
77-4	68.30	68.31	68.41	69.13	68.08
1978-1	72.37	72.56	72.49	73.40	72.85
78-2	77.91	77.90	78.02	78.66	77.85
78-3	82.45	82.41	82.57	83.22	82.40
78-4	74.24	74.54	74.37	75.39	74.39
1979-1	75.07	75.46	75.18	76.27	75.30
79-2	80.70	80.88	80.80	81.60	80.99
79-3	83.16	83.32	83.27	84.07	83.46
79-4	71.73	72.17	71.87	73.08	71.88

Table 4 Wholesale pork price and comparison with benchmark simulation

Year and Quarter	Benchmark Simulation (1)	Antibiotics only (2)	DES only (3)	Antibiotics plus DES (4)	Antibiotics plus DES with replacement technology (5)
1973-1	71.02	71.02	71.02	71.02	71.02
73-2	75.00	75.00	75.00	75.00	75.00
73-3	70.14	70.12	70.14	70.12	70.12
73-4	72.55	72.53	72.56	72.60	72.60
1974-1	77.89	77.88	77.90	77.95	77.95
74-2	74.63	76.44	74.64	76.56	76.52
74-3	79.69	82.70	79.70	82.78	82.78
74-4	85.08	88.70	85.11	88.90	88.90
1975-1	86.17	90.08	86.22	90.35	90.36
75-2	78.31	81.87	78.36	82.13	81.58
75-3	81.80	84.11	81.84	84.40	83.13
75-4	81.54	83.19	81.60	83.60	81.07
1976-1	72.97	74.44	73.03	74.84	70.97
76-2	61.95	62.92	61.99	63.23	59.29
76-3	67.91	67.83	67.95	68.12	64.97
76-4	69.71	69.83	69.77	70.20	66.99
1977-1	62.09	62.89	62.14	62.23	60.20
77-2	55.98	56.60	56.01	56.84	55.26
77-3	68.17	67.99	68.21	68.24	68.16
77-4	72.33	72.76	72.39	73.10	72.80
1978-1	64.70	65.82	64.74	66.11	65.57
78-2	62.19	62.60	62.21	62.79	63.34
78-3	77.45	76.89	77.48	77.12	78.20
78-4	78.82	79.13	78.87	79.46	79.08
1979-1	68.17	69.13	68.20	69.38	68.21
79-2	67.69	67.70	67.71	67.87	67.66
79-3	83.59	82.86	83.62	83.10	83.11
79-4	80.41	81.07	80.47	81.41	79.81

Table 5 Wholesale broiler price and comparison with benchmark simulation

Year and Quarter	Benchmark Simulation	Antibiotics only	DES only	Antibiotics plus DES	Antibiotics plus DES with replacement technology
	(1)	(2)	(3)	(4)	(5)
1973-1	32.23	32.23	32.23	32.23	32.23
73-2	40.00	40.00	40.00	40.40	40.00
73-3	37.81	37.87	37.81	37.87	37.87
73-4	34.36	34.43	34.37	34.50	34.50
1974-1	35.81	35.85	35.82	35.92	35.92
74-2	36.71	37.08	36.72	37.15	37.15
74-3	37.52	38.17	37.53	38.25	38.25
74-4	35.50	36.22	35.52	36.33	36.32
1975-1	35.38	36.15	35.39	36.25	36.25
75-2	35.24	35.94	35.26	37.04	35.92
75-3	35.29	35.81	35.30	35.91	35.60
75-4	33.61	33.96	33.63	34.09	33.54
1976-1	32.70	33.03	32.72	33.16	32.36
76-2	31.42	31.66	31.44	31.77	30.96
76-3	32.50	32.61	32.52	32.72	32.08
76-4	31.68	31.76	31.70	31.88	31.23
1977-1	30.93	31.13	30.94	31.24	30.60
77-2	30.58	30.75	30.59	30.83	30.47
77-3	33.45	33.51	33.46	33.59	33.51
77-4	32.90	33.04	32.91	33.15	30.00
1978-1	32.06	32.34	32.07	32.44	32.22
78-2	32.49	32.63	32.50	32.70	32.68
78-3	36.29	36.20	36.30	36.29	36.37
78-4	34.56	34.69	34.58	34.80	34.61
1979-1	32.94	33.21	32.95	33.30	32.96
79-2	33.86	33.96	33.87	34.00	33.87
79-3	37.78	37.69	37.79	37.77	37.96
79-4	34.85	35.06	34.87	35.17	34.76

Table 6 Wholesale turkey price and comparison with benchmark simulation

Year and Quarter	Benchmark Simulation	Antibiotics only	DES only	Antibiotics plus DES	Antibiotics plus DES with replacement technology
	(1)	(2)	(3)	(4)	(5)
1973-1	41.20	41.20	41.20	41.20	41.20
73-2	47.00	47.00	47.00	47.00	47.00
73-3	34.91	35.52	34.91	35.52	35.52
73-4	43.50	43.71	43.51	43.73	43.73
1974-1	42.74	42.83	42.74	42.83	42.83
74-2	34.46	35.00	34.46	34.99	34.99
74-3	36.58	37.99	36.58	37.99	37.99
74-4	45.73	46.87	45.74	46.90	46.90
1975-1	43.90	44.98	43.91	45.02	45.02
75-2	34.47	35.33	34.48	35.37	35.20
75-3	37.04	38.29	37.05	38.35	38.05
75-4	44.45	45.14	44.47	45.23	44.65
1976-1	39.52	40.03	39.54	40.12	39.21
76-2	29.06	29.29	20.06	29.36	28.38
76-3	32.22	32.93	32.23	33.00	32.23
76-4	40.32	40.63	40.33	40.71	39.94
1977-1	35.31	35.65	35.32	35.71	35.01
77-2	28.53	28.75	28.54	28.79	28.40
77-3	32.00	32.63	32.01	32.68	32.65
77-4	39.50	39.89	39.51	39.96	39.92
1978-1	34.11	34.52	34.12	34.58	34.51
78-2	28.47	28.61	28.48	28.64	28.75
78-3	34.00	33.63	34.00	33.68	33.83
78-4	39.58	39.70	39.59	39.77	39.71
1979-1	31.12	33.35	33.13	33.40	33.18
79-2	28.31	28.31	28.31	28.34	28.24
79-3	35.21	34.94	35.22	34.99	34.87
79-4	38.65	38.88	38.66	38.96	38.58

Table 7 Cattle Feeder Net Profits

Year and Quarter	Benchmark Simulation (1)	Antibiotics plus DES (4)	Difference from Benchmark Simulation
1973-1	42.81	42.81	0.00
73-2	56.85	53.89	-2.96
73-3	91.63	82.07	-9.56
73-4	-16.07	-25.91	-9.84
1974-1	-23.81	-37.48	-13.67
74-2	-24.52	-33.11	-8.59
74-3	34.94	24.33	-10.61
74-4	-37.33	-45.46	-8.13
1975-1	-57.56	-66.22	-8.66
75-2	-43.17	-53.00	-9.83
75-3	-0.51	-13.09	-12.58
75-4	-25.49	-37.18	-11.69
1976-1	-18.47	-28.03	-9.56
76-2	8.96	0.06	-8.90
76-3	43.07	32.60	-10.47
76-4	24.79	11.86	-12.93
1977-1	24.23	11.60	-12.63
77-2	43.39	30.38	-13.01
77-3	73.53	59.55	-13.98
77-4	59.56	48.27	-11.29
1978-1	66.21	57.28	-8.93
78-2	85.44	76.38	-9.06
78-3	111.73	101.14	-10.59
78-4	47.53	37.55	-9.98
1979-1	29.01	20.42	-8.59
79-2	45.98	36.09	-9.89
79-3	84.90	73.58	-11.32
79-4	19.21	16.49	-2.72

Table 8 Hog Net Profits

Year and Quarter	Benchmark Simulation (1)	Antibiotics plus DES (4)	Difference from Benchmark Simulation
1973-1	22.86	22.86	0.00
73-2	19.74	19.74	0.00
73-3	2.96	2.95	-0.01
73-4	0.09	0.15	-0.06
1974-1	8.67	8.74	0.07
74-2	7.66	9.66	2.00
74-3	12.52	15.94	3.42
74-4	22.84	27.15	4.31
1975-1	30.41	35.13	4.72
75-2	23.95	28.26	4.31
75-3	24.93	27.69	2.76
75-4	23.85	25.76	1.91
1976-1	17.15	18.75	1.60
76-2	6.75	7.74	0.99
76-3	11.44	11.37	-0.07
76-4	13.72	14.05	0.33
1977-1	7.94	9.08	1.14
77-2	1.85	2.80	0.95
77-3	12.87	13.04	0.17
77-4	17.80	18.72	0.92
1978-1	11.63	13.24	1.61
78-2	8.78	9.52	0.74
78-3	22.51	22.19	-0.32
78-4	23.87	24.52	0.65
1979-1	13.99	15.29	1.30
79-2	13.09	13.30	0.21
79-3	27.54	27.01	0.53
79-4	24.14	25.20	1.06

and turkey wholesale prices. Broiler prices are expected to rise at most by $.72 per hundredweight (1.7 percent). Turkey prices are expected to rise more, up to $1.30 per hundredweight (3.9 percent) by thir quarter, 1974. The additional withdrawal of DES produced negligible impact on prices. However, the result of replacement technology was to drive broiler and turkey wholesale prices below benchmark predictions by fourth quarter, 1975. These results are presented in tables 3-8.

Changes in expenditures on meat at the wholesale level are calculated in undiscounted value terms. The result of banning antibiotics would be to increase expenditures by $500 million over a 7 year period, whole the result of banning DES would increase expenditures by only $150 million over a 7 year period. The combined result of banning both antibiotics and DES would increase meat expenditures by $1.53 billion. However, when replacement technology is assumed, the increase is approximately $170 million, again over a seven year forecast period.

V. CONCLUSIONS

Our conclusions are divided into two categories. First, simulation appears to be a valid tool for environmental impact analysis. It is especially useful in depicting the pattern of impact and adjustment over time. It is a methodology which uses coefficients as estimated from past history. Thus, future projections are based on how producers and consumers reacted in the past. There may be concern that we are just playing a numbers game in the adjustment of regression coefficients. Our only answer is that they were adjusted to explicitly account for the different impacts, and are explicitly reported as such. The answers given appear reasonable and consistent with economic logic.

Second, as with the use of any technology, there is a risk involved. There is a risk in driving on the highways during the Fouth of July holiday - the question is the degree of acceptability of the risk. Congress has delegated to the FDA the responsibility for insuring a clean and pure food supply. The question becomes: how clean? A balance must be struck between the risk of consuming beef produced with DES and the cost of beef produced without the benefit of DES. If this technology is used properly, then no residues are left in either the meat tissue or the liver. Society must decide if beef, produced with a cancer causing agent yet not containing it, is acceptable food, given the alternative of slightly higher beef prices. While banning is one choice, another policy might be the required labeling of DES and non-DES produced beef, and allowing the consumer to choose.

If the problem of using antibiotics is the residual left in meat tissue, then the use of antibiotics as feed additives appears to have the same policy alternatives as with DES. However, if the concern over the transference of resistance between bacteria is indeed well substantiated, then consumer labeling may not be a very rational public policy decision. The very nature of the resistance problem and its transference clasifies the use of antibiotics as a public good. Everyone in society is affected to a degree and there does not appear to be any possibility of exclusion. Hence a collective public policy decision must be made, and certain or all antibiotics banned from use at subtherapeutic levels as feed additives.

The banning of antibiotics and DES is certainly not the last of this type of public policy decision. As it is determined that some technology produces undesirable residual output (e.g., health risks), that technology will either be banned or the residual output taxed. There are no other economic choices. Society will be faced with a continuing decision process of weighing environmental risks against increases in the costs of goods and services. It will have to decide in each case which action increases human welfare in the long run.

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