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Enforcing Food Safety Standards: A Case Study of Antibiotic and Sulfa Drug Residues in Veal

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The current debate over food safety policy has focused on food safety standards while ignoring enforcement issues. However, previous studies show that unless we can assume perfect compliance, this approach may not produce desired results. For example, Viscusi and Zeckhauser conclude that more stringent safety standards may not always result in higher levels of safety because they increase the likelihood of noncompliance by some firms. Jones shows that whether more or less stringent standards produce higher levels of safety depends on the type of penalty structure imposed by enforcement policy.

We cannot always justify assuming perfect compliance with food safety laws. Existing data on violation rates shows that compliance with safety standards is quite high for most, but not all foods. For example, in 1987 the Food and Drug Administration monitored for residues of 253 pesticides in 112 types of domestically produced foods (FDA). They took a total of 6,503 samples or an average of 58 samples per food type. While most of foods showed no violative residues, 33 of the foods had violation rates of two percent or more and 23 foods had violation rates of five percent or more. Similarly, of the 128 imported food types sampled, 43 foods had violation rates of two percent or more and 29 foods had violation rates of five percent or more.

We can observe the same type of result in the case of chemical residues in livestock at slaughter. The Food Safety and Inspection Service (FSIS) samples 13 animal species to monitor for residues of a wide variety of pharmaceuticals, pesticides, environmental contaminants, and heavy metals (National Research Council). In most cases, compliance is very high, but recurring problems have occurred with sulfa residues in swine (Kramer; Shriver) and antibiotic and sulfa residues in veal calves (Bylenga).

This paper examines the problem of reducing violative residues of antibiotic and sulfa residues in veal.¹ We use the case study to illustrate problems encountered in enforcing food safety standards and the importance of understanding economic incentives in dealing with the standards. We evaluate a FSIS program

designed to address a chronic problem of noncompliance using before and after comparisons of violation rates. To determine why the program produced the results it did, we examine how the program changed the penalty structure and, thus, incentives to violate. We use the findings to develop recommendations for the design of food safety enforcement programs and future avenues of research.

Problems in Enforcing Drug Residue Standards

The Food Safety and Inspection Service (FSIS) monitors chemical residues in meat by randomly sampling carcasses at slaughter and performing tests which detect a wide variety of animal drugs, pesticides, heavy metals, and environmental contaminants. They use the monitoring program to establish rates of compliance with food safety standards. When the FSIS observes a compliance problem, special programs for reducing violations and enforcing the law are established.

From 1978 to 1982, FSIS monitoring showed that over five percent of slaughtered veal calves had antibiotic or sulfa drug residues in violation of federal tolerances. They considered these violation rates unacceptable because residues above the tolerance level can cause allergic reaction in sensitive humans.

FSIS determined that the main source of the residue problem was surplus dairy calves (bob calves) which include about 40 percent of the three to four million calves slaughtered annually for veal. Bob calves are marketed before two weeks of age, weighing between 75 and 115 pounds, have low economic value, and are prone to a variety of diseases. When these newborn calves are medicated and sent for immediate slaughter, violative drug residues result because most drug withdrawal periods exceed two weeks.

FSIS initially believed that the violations were due to a lack of producer awareness of the possibility that slaughtering of bob calves could occur within days after leaving the farm. As a result, in 1982, the FSIS allocated nearly one million dollars to improve residue testing methods and to educate dairy producers about the need and procedures for reducing drug residues in surplus dairy calves. However, violation rates remained unchanged. So, in June of 1984, FSIS implemented a program designed to create penalties for marketing medicated calves.

Designing Incentives to Deter Calf Medication

Regulators can deter calf medication by making it more costly to medicate than not. Increasing the expected penalty for violating drug residue tolerances can achieve this result.

The expected penalty is a function of the probability that violations will be detected times the size of the penalty violators must pay (Becker). The probability that a violation is detected is determined by the proportion of calves FSIS samples for residue testing at slaughter. The size of the penalty violators must pay is limited by law. FSIS is only permitted to condemn violative carcasses or to require violators to present subsequent marketings for follow-up testing.²

Whether a detected violator experiences one of these penalties depends on two factors. First is the ability to identify the owner of the animal so penalties can be assessed. Second is the ability to condemn carcasses to punish violators.

Before the new program, FSIS was unable to identify calf producers in 45 percent of the cases of residue violations.³ The new program overcame this problem by providing forms that producers and handlers could voluntarily sign certifying that their calves were not treated with drugs that leave illegal residues. The certification statement would identify the producer and indicate their awareness of the illegality of medicating bob calves sent to slaughter.

Also before to the new program, it was impractical to hold carcasses at the slaughterplant until residue test results were available.⁴ The new program overcame this problem by instituting the Calf Antibiotic and Sulfa Test (CAST) which provided residue results at the slaughterplant within 18 hours of tissue sampling.

FSIS recognized the need for some incentive to encourage producers to certify their calves. So, they decided to CAST test uncertified calves at a significantly higher rate than certified calves. This would give slaughterers an incentive to seek certified calves to avoid the slower line speeds and increased condemnation losses associated with more intensive testing.

What FSIS overlooked, however, was the honest use of certification. Economic theories of market signals and product guarantees say this would require penalties for false certification as well as benefit to sellers (Akerlof, Spence). Since FSIS planned the same penalty for detected violators regardless of certification status, and they planned to sample certified calves at a much lower rate, the new program would appear to have created an incentive to falsely certify medicated calves.

On the other hand, certification gave FSIS the identity of the calf producer. Violations detected in certified calves would be certain to be penalized but violations among uncertified calves might not be if FSIS could not identify the owner. The question then, is whether the testing rate for certified calves, combined with the penalties of carcass condemnation and follow-up testing, was sufficiently high to offset the gains of medicating calves.

Incentives for Violative Drug Use in Treating Sick Dairy Calves

Whether the potential increase in the expected penalty for medicating certified calves would have a significant deterrent effect on violation rates depends on the relative cost of alternative calf treatments. Prior research by FSIS found that adequate colostrum intake is of equal effectiveness to drug therapy in treating calfhood diseases (Bylenga). While the material cost of this method is about the same as that of administering drugs, it is much more labor intensive. The colostrum approach required an average of one and a half hours of additional labor a day for five days. Using the \$4.09 hourly farm wage in 1984 (USDA), medication of sick calves resulted in a cost savings of \$10.23 per calf. We assumed this to be the same before and after the certification program.

Other variables that could affect the expected value of marketing surplus dairy calves did not vary in the period before and after implementation of the new program, so we did not explicitly consider them in the analysis. For example, interviews with FSIS and slaughterplant personnel did not show any unusual disease problems during the period of analysis (January 1983 through March 1985). So we assumed the underlying rate of disease in newborn calves to be constant. Likewise, we assumed production costs other than those associated with alternative health management and marketing strategies constant. Further, since the pre- and post-program periods of analysis both occurred after the producer education programs conducted in 1982, we assumed that information costs associated with drug and nondrug treatments, producer knowledge of human health effects, and the value of obedience to the law were constant both before and after implementation of the new program.

The Probability of Detection

We determined the likelihood that a bob calf is chosen by FSIS for residue testing by dividing the total number of bob calves tested by the total number of bob calves slaughtered per unit of time. Unfortunately, estimates of the number of calves slaughtered are only available on an annual basis, so we could estimate only annual averages of the probability of detection for the pre- and post-program periods. Furthermore, since the program started in mid-year 1984, extrapolation was necessary. This was done by computing the average number of tests conducted monthly in the pre and post-program periods, and then multiplying by 12 to get an estimate of the annual number of tests. We divided these figures by an estimate of annual calf slaughter in 1984 to obtain estimates of the probability of detection.

Before certification, there was no special program for testing bob calves, so testing rates are for all types of calves (bob, veal, fancy, large, and extra large).

Since FSIS testing was based on random sampling, we assumed that the same rate applies equally to all categories of calves, including bob calves. The resulting estimate of the probability of any type of calf being tested was .002.

After certification, FSIS limited testing to bob calves and the testing rate was different depending on the certification (or not) of the calves. To estimate the percentage of bob calves marketed as certified or uncertified, we conducted a survey of the 20 slaughterers making up 50 percent of all plants known to FSIS to slaughter calves. On average, the plants reported that 96 percent of all bob calves purchased were certified following the new program. Applying this to the estimate of annual bob calf slaughter (1,206,774) yielded the estimates of the number of certified and uncertified bob calves.

We determined the number of certified and uncertified calves tested following certification by physically counting the total CAST test outcomes from inspector worksheets. The FSIS conducted over 60,000 CAST tests during the first nine months following certification. The totals we counted were the number of positives (residue detected) and negatives and the corresponding number of certified and uncertified calves within these two categories. The resulting estimates of the probability of a test on a calf were .03 for certified calves and .77 for uncertified calves.

Size of the Penalty

Before and after the certification program, FSIS could impose costs on violators detected through the residue monitoring program by requiring follow-up surveillance testing. The process involves an identified violator having five calves of his/her choice tested by FSIS for residues before marketing another lot of calves. We assumed the cost to a violator to be equal to one and a half hours of labor time required to assemble five non-medicated calves for special testing at the time of her next shipment of calves. We based the cost of labor on the USDA wage rates for hired, hourly wage farm workers in 1984. Since FSIS did not assess any charges for follow-up testing costs, the effective penalty of follow-up testing was \$6.14 (in 1984 dollars).

Before certification, calves tested under the monitoring program were not held at the slaughterplant until the laboratory test results were completed. Therefore violative animals were not condemned and the condemnation penalty to producers was zero.

Following certification, FSIS condemned calves found violative with CAST and slaughterers therefore lost investments on those animals. If the slaughterplant charges the producer for the condemned animal, the producer loses the price of calf. We obtained the average annual price used in our

calculation from the USDA Agricultural Marketing Service. Prices for bob veal (those calves weighing between 75 and 115 pounds) were recorded weekly in sixteen New York stockyards for 1984. We averaged this to obtain a national average annual price of \$56.59 (in 1984 dollars).

To account for the price difference between certified and uncertified calves, we obtained the average difference paid by slaughterers by surveying slaughterplants. The survey showed that uncertified calves were selling at an average price discount of -\$16.98. Thus, we estimated the average annual price of uncertified calves to be \$39.61 (in 1984 dollars).

However, these prices represent only a potential condemnation penalty to producers. The survey of slaughterplants revealed that even after the beginning of the new program, only a third of the plants charged producers for condemned animals.⁵ Consequently, expected penalties of marketing violative calves were different at different plants. We will examine both of these cases, but we illustrate the calculations only for the case of a plant that charged producers.

Did the Program Reduce Violations?

FSIS provided the monthly residue violation rates for each of the five FSIS-designated U.S. regions from January, 1983 through March, 1985. The data show residue rates for antibiotics and sulfonamides separately. We calculated monthly national totals so we could observe overall trends before and after the bob veal program (Figures 1 and 2).

We calculated the Student's *t* test to determine whether there was a significant difference between violation rates before and after the implementation of certification (Table 1). We compared residue rates for the period of June 1983 to May 1984 to residue rates from the period of June 1984 to March 1985 (the first 10

Table 1.

Mean and Standard Deviation of Rates of Residue Detection Before and After Certification

	Mean	Standard Deviation	t Value (20 deg. of fr.)
Antibiotic Residues			
6/83 to 5/84	3.934	1.784	
6/84 to 3/85	3.186	2.533	.81
Sulfonamide Residues			
6/83 to 5/84	2.683	2.480	
6/84 to 3/85	1.933	1.272	.86

Figure 1:
Antibiotic Residue Violation Rate for Calves January 1983 to March 1985

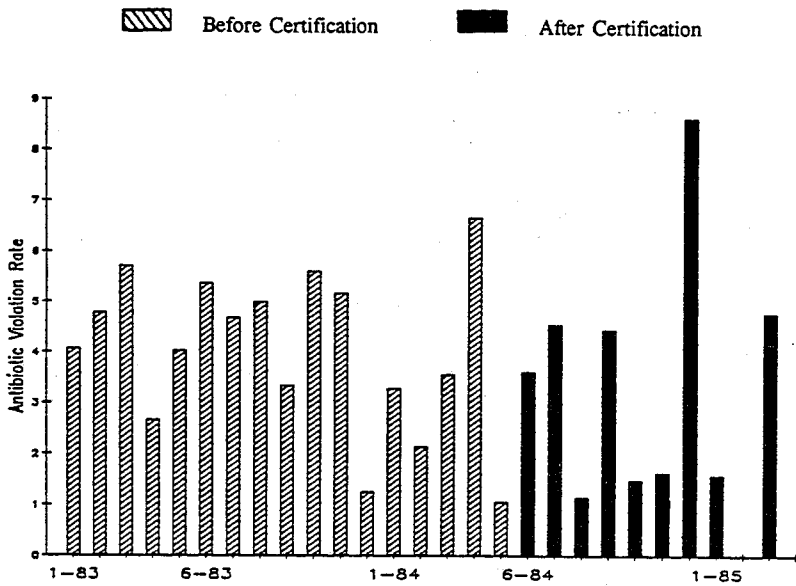
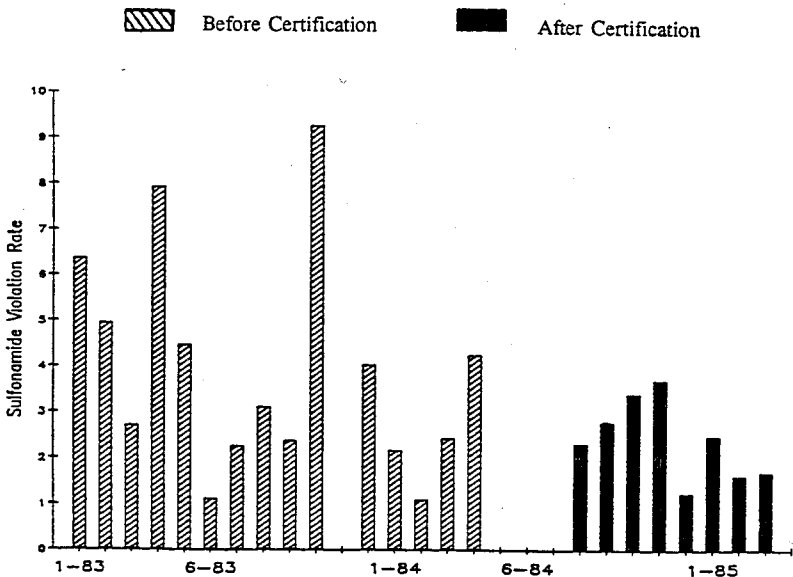


Figure 2:
Sulfonamide Residue Violation Rate for Calves January 1983 to March 1985



months following program implementation). This procedure accounts for monthly or seasonal factors. However, data were unavailable for April and May of 1985.

Table 1 shows there was not a significant difference between rates of drug violation in calves twelve months before and 10 months after certification. We cannot reject the hypothesis there is no significant difference between the groups of residue violation rates at the 10 percent level of significance for both antibiotics and sulfonamides.

Table 1 also shows an interesting reversal in the standard deviations in the two types of drugs before and after certification. The use of antibiotics became more variable following certification but the standard deviation decreased in sulfonamides following certification. A possible explanation is that sulfonamides were more easily detectable in post-mortem inspections (because of green dyes used in boluses) and that producers may have begun using less detectable types of drugs (antibiotics not administered through boluses) as a result of improvements in FSIS testing capabilities.

The main problem is data do not distinguish different types of calves (fancy, bob, feeder). Bob calves represent about 40 percent of total calves slaughtered. We can therefore assume the rate shown by national monitoring data to underestimate the true residue problem in bob calves, based on evidence that the residue problem focused in bob calves. Only CAST data singles out the type of calf sampled. However this test began with the implementation of the certification program. So, we cannot use the data to evaluate whether changes occurred following the program.

However, we can use the CAST data to evaluate whether certification was used honestly by calf sellers. If it were, we would expect the proportion of all positive tests to be significantly lower for certified calves. To test whether there was a relationship between certification status and test outcome, we created a contingency table from CAST data. We estimated Cramer's V, a measure of association, to measure the strength of the relationship between test outcome and certification status.⁶ Table 2 shows that the 63,663 CAST tests conducted during the first nine months of the certification program do not show a clear relationship between certification status and drug use. Cramer's V was .13 which reflects a lack of a statistically significant relationship.

The slaughterplant survey confirms the result that test outcome is not related to certification status. If a penalty existed in bob calf markets following certification for marketing a violative calf, the survey responses would have shown that slaughterers were charging producers who could now be identified for losses due to condemnations.

Table 2.
CAST Test Results June 1984 to February 1985

	% Positive Drug Residues	% Negative Drug Residues
Certified calves	39%	46%
Uncertified calves	46	51
Unknown status calves	15	3

Did the Program Change Incentives?

Both before and after the beginning of the certification program, treating sick calves with the next best non-drug therapy resulted in a cost disadvantage of \$10.23 (in 1984 dollars). Given market prices for surplus dairy calves, the expected value of marketing this calf would, on average, have been \$46.36 (in 1984 dollars) minus normal costs of production (figure 3).

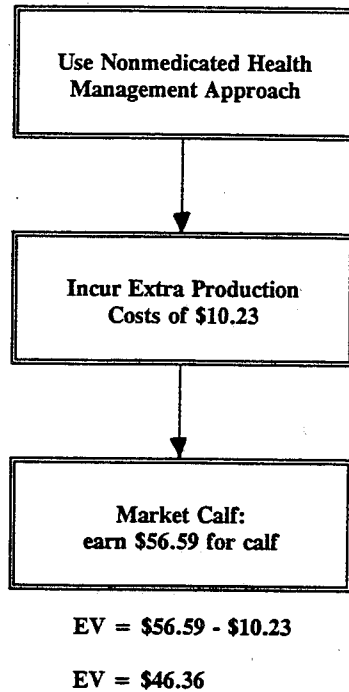
Before certification, there was a clear advantage to using drugs to treat calves because the expected penalty for violating was about a penny (figure 4). This penalty was low for two reasons. First, the testing rate was very low (.002). Second, the penalty was small since carcasses could not be held at slaughter. The only penalty a violator would face would be the cost of arranging for follow-up testing when next marketing calves or \$6.14 (in 1984 dollars). In fact, in many cases, the expected penalty was zero because producers could not be identified for about 45 percent of violations.⁷

The low expected penalty before the certification program reflects that unless we observe high rates of violation during random monitoring, FSIS does not undertake special enforcement actions.⁸ The key question is whether the certification significantly changed the expected penalty.

As figure 5 illustrates, the new program reduced, but did not eliminate the net benefit of drug use. Furthermore, the new program created an incentive for producers to falsely certify medicated calves. The figure shows that producers who certified medicated calves could expect to save \$8.35 (in 1984 dollars) on average by using drugs if they marketed them at a slaughterplant that was known to charge producers for condemned animals. By not certifying a medicated calf, producers faced a net loss of over \$40 per calf. Even if the animal were unidentifiable, the net benefit would still be negative (-\$6.75). For producers marketing calves to slaughterplants that did not charge for condemned animals, producers could expect to save \$10.05 if they medicated and certified their calves and to lose \$11.48 if they sold a medicated calf uncertified.

Figure 3:

Expected Value (EV) of Not Medicating Calves Before and After Implementation of the Certification Program

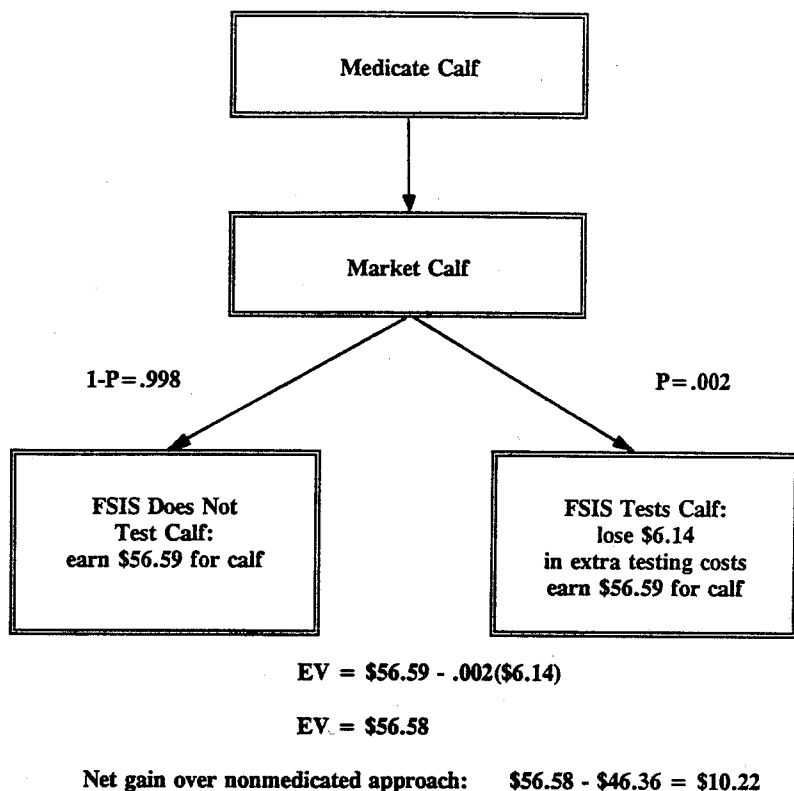


Actually, one wonders why there were any uncertified calves remaining in the market since the expected net benefit was negative. In fact, the survey of slaughterplants revealed that only a small percentage were uncertified and suggested that some of these were simply unhealthy calves for which the certification status was irrelevant.

Enforcement Policy Implications

For certification to have been effective in reducing violations, false certification would have to have been penalized. This would have required an expected penalty for certified calves which deterred violations. We can use the analysis above to calculate the testing rate or size of penalty that would have been needed to achieve deterrence for identifiable calves.

Figure 4:
Expected Value (EV) of Medicating Calves Before Implementation of the
Certification Program



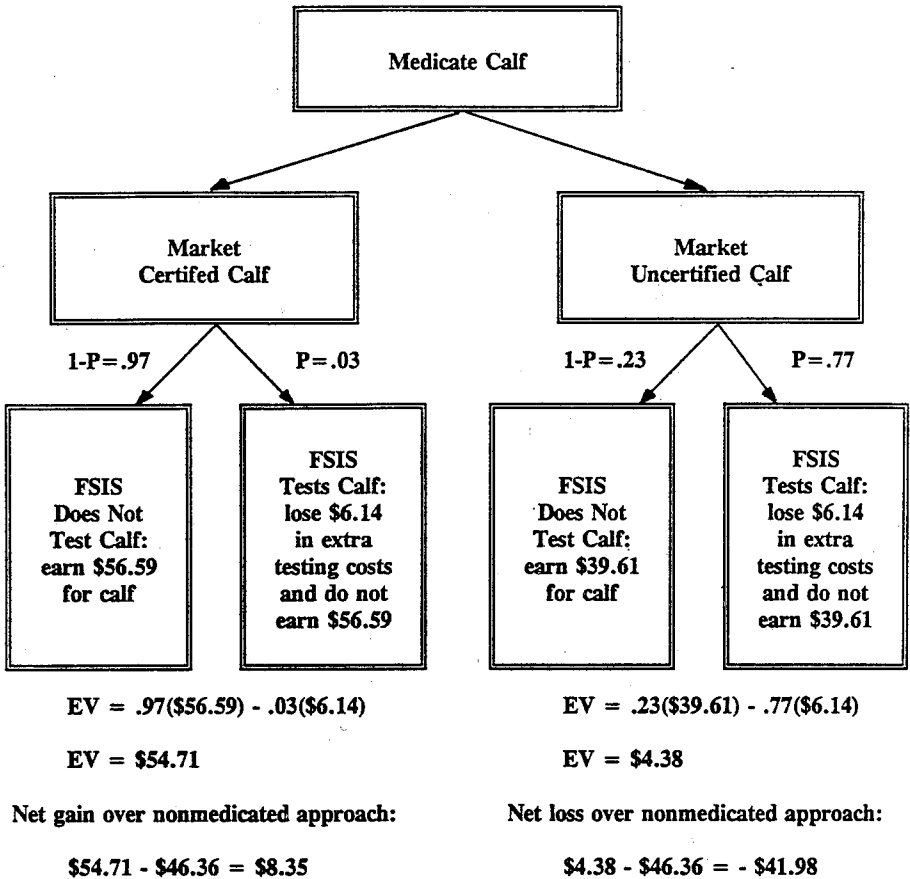
The required testing rate is obtained by setting the EV of medicating and certifying calves (figure 5) equal to the EV of nonmedicated calves (figure 3) and solving for P. For the case of a plant that charged producers for condemned animals, the calculation is:

$$(1-P) (\$56.59) + P (-\$6.14) = \$46.36$$

which gives a testing rate of .163. For a plant that did not charge back, there is no testing rate which penalizes illegal drug use.

We use the same formula to determine the level of penalty needed to deter violations in certified calves, however, instead of solving for P, we solved for the

Figure 5:
Expected Value (EV) of Medicating Calves After Implementation of the Certification Program



penalty level. If testing rates had remained as shown in figure 5 for the certified animals, the penalty of \$6.14 would have to have been increased to \$284 (in 1984 dollars) if the plant charged for condemned animals $(.97(\$56.59) + .03(\text{penalty}) = \$46.36)$ and \$341 if the plant did not charge.

Survey evidence showed large disincentives to slaughterplants to charge for condemned animals. That means condemnations created little or no penalty for producers. That means the only way that FSIS could have enlarged the penalty would have been through surveillance testing. The expected cost of this testing

would have had to increase to \$334.86 (\$341 minus the existing FSIS expected cost of \$6.14). This could have been achieved by requiring violators to not only present animals for special testing before marketing another lot but to also require them to pay the laboratory cost for those tests. We estimated that the cost of FSIS follow-up surveillance testing of five calves was \$269.40 (in 1984 dollars). FSIS could have created negative net benefits for sellers to market violative, certified calves by having increased the number of calves required for follow-up surveillance testing to six and charged producers for the cost. Alternatively, the required number of calves tested could have been kept at five and violators could have also been charged for material and shipping costs as well as laboratory labor costs.

An advantage of raising penalties rather than testing rates is that testing is very costly to FSIS. Furthermore, having larger penalties would eliminate the cost of developing rapid testing methods such as CAST.

Larger penalties for violative certified calves would also represent a potential cost savings to calf producers who do not use drugs. Recall that FSIS hoped rapid testing would allow carcasses to be held at the plant, thus creating condemnation losses for slaughterers. However, according to our survey evidence, slaughterers usually did not pass this cost on to violators. It is cheaper for them to offer a lower price for all calves or to charge a higher price for the veal products they sell than to penalize violators. The result is that a higher testing rate potentially penalizes all calf producers whether they have violated the law or not.

Under a voluntary system, it is necessary to maintain the incentive for producers to certify animals, while imposing a penalty on false certification. This could only have been achieved by creating an incentive for slaughterers to buy certified calves. FSIS created this incentive by having a higher rate of testing for uncertified calves than for certified calves. However, the minimum rate of testing needed depends on the relative testing costs of certified and uncertified animals imposed on the slaughterer. These costs would have to be high enough to result in a price differential between certified and uncertified calves greater than the cost savings to producers of medicating sick calves (\$10.23). The differential level of testing of certified and uncertified calves shown in figure 4 was more than sufficient to guarantee this since the price differential for calves was \$16.98.

The higher testing rate for uncertified calves would be unnecessary if an effective demand for non-violative calves created a premium which offset the cost advantage of medicating calves. Without this effective demand, producer identification requires either a mandatory identification program or a voluntary program that maintains economic incentives to certify.

Conclusions

The certification program did not produce a statistically significant reduction in drug residue violations calves in the 10 months following its implementation. This result is not surprising since the incentive to use drugs continued to exist. Rather than discouraging drug use, the program actually created economic incentives for producers to certify violative calves.

The problems that faced FSIS in the bob veal calf case—namely, slow tests and difficulty in identifying violators—are common to other food safety contexts. Chemical tests are costly and difficult to perform. Commodity markets often obscure the identity of producers.

Research on causes of enforcement problems in both domestic and imported foods could provide useful information for improving food safety enforcement programs and targeting limited resources. This research could also have important implications for examining the consequences of increasing the stringency of safety standards. However, to develop more refined analyses than the one presented here, better data on violation rates, detection probabilities, and penalties over time needs to be maintained by enforcement agencies.

Finally, the bob veal case offers an interesting illustration of the operating of a voluntary certification program. The case study shows that honest certification cannot be assumed. Appropriate economic incentives to discourage dishonest certification are necessary. This conclusion has important implications for the design of voluntary certification programs such as those proposed for organic food.

Notes

This research was supported by Cooperative Agreement No. 58-3523-1-0334X with the Economic Research Service, USDA. The authors gratefully acknowledge the helpful comments from anonymous referees.

1. This paper is based on research reported in greater detail in an M.S. thesis by Bylenga.
2. Additional monetary penalties require referral to, and investigation by, the Food and Drug Administration and prosecution by the Justice Department. This is rarely done.
3. In some cases, the lack of identification was due to errors in the ear and back tag system used to identify calves. In other cases, producers acted to prevent identification by using an assumed name or marketing at different locations over time.
4. It often took days or weeks for FSIS to obtain test results because sample tissues had to be sent to a laboratory for analysis and the analytical testing methods were slow.

5. Plants gave several reasons for not charging for condemned animals. First, the administrative cost may exceed the amount paid for the calf because, for example, payment of a charge-back may require taking a producer to small claims court. Second, skins from condemned calves are marketable. A bob calf slaughterer does not realize a one-hundred percent loss on calves condemned by FSIS for violation of chemical residue standards.
6. Cramer's V was chosen because it allows an uneven number of rows and columns in the contingency table.
7. Since the producer could control the probability of being identified by choosing not to identify a calf or by using an assumed name, this aspect of detection of violations is not treated as being probabilistic.
8. The exception is when a carcass is found to have noticeable injection sites or when drugs with dyes are used. Both of these types of evidence of drug use can be avoided by producers.

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