



# Economic Incentives, Public Policies, and Private Strategies to Control Foodborne Pathogens

By Tanya Roberts

New scientific and management knowledge in both public and private sectors is improving economic incentives for food safety. New threats, such as bovine spongiform encephalopathy (BSE, popularly known as “mad cow disease”) are altering global markets. Market incentives for food safety are relatively weak, however, because food safety is a credence good. Even after food has been consumed, the lag between consumption and illness hinders identification of the contaminated food. Food safety information is improving because of new testing and surveillance methods as well as new public and private control initiatives. Better supply chain control systems are being invented and used from farm to fork. Recent food safety innovations have been spurred by stringent standards demanded by large buyers—domestic and overseas—and by regulatory agencies.

The public and private sectors are in a food safety dance. Hazard Analysis and Critical Control Point (HACCP) systems started as a private-public partnership to develop safer food for US astronauts. Some firms were early adopters of HACCP to prevent pathogens from entering, surviving, and growing in their production processes. Starting in the mid-1990s, the Food and Drug Administration and the United States Department of Agriculture Food Safety and Inspection Service required HACCP for seafood, meat and poultry, juice, and shell eggs. Regulatory HACCP system requirements differ, and each plant has to develop and monitor its own HACCP system for the foods it produces. HACCP systems are evolving as regulators, scientists, corporate managers, and economists apply new scientific information, innovative equipment, and new pathogen tests and management strategies. Some companies are using continuous food safety innovation as a competitive strategy.

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In this issue of *Choices*, we explore the complex world of global food safety and the evolving economic incentives. The economics of food safety is a relatively new area of research. New models and improved understanding of the public policy/private strategy interface are bridging scientific disciplines and bringing new understanding to food safety issues. Not only are global markets at stake, but foodborne pathogens cause acute illness in 76 million US consumers, 5,000 deaths, and an unknown number of chronic complications annually.

Throughout the United States, consumers rely on local health authorities to regulate and inspect restaurants in an attempt to assure that high-quality hygiene standards are maintained. How effective are the regulations and inspections by public health authorities at assuring good-quality restaurant hygiene? Jin and Leslie study restaurant hygiene and the role played by health inspections. In January 1998, Los Angeles implemented a critical change in their regulations leading to a dramatic improvement in restaurant hygiene—restaurants are required to prominently display in their window a letter-grade card (A, B, or C)

corresponding to the result of their most recent hygiene inspection. They analyze a variety of different data to assess the effects of these grade cards on restaurant hygiene, restaurant revenue, restaurant prices and output, behavior of inspectors, and, most importantly, the occurrence of food-related illnesses.

Prior to the December 2003 discovery of a cow with BSE in Washington State, the United States implemented measures to prevent the disease from entering the country and to prevent its spread if it were found. Following that discovery, additional measures were introduced both to safeguard public health and reassure domestic and foreign consumers about the safety of US beef. Fox et al. review the various measures that have been taken and additional measures that have been proposed

and discuss the efficiency of the US response to the disease.

Fearne and Garcia Martinez note that growing concern about food safety is pressuring government agencies to be more prescriptive and proactive in their regulation of the food industry. Given the scarcity of public sector resources and the scale of the task at hand, however, there is growing interest in the notion of coregulation, with public and private sectors working hand in hand to deliver safer food at lower (regulatory) cost. This paper explores the opportunities for and some of the barriers to coregulation of food safety from a UK perspective.

To maintain a reputation or to meet contractual or regulatory requirements, firms choose different target levels of pathogen control for various meat and poultry products.

Roberts finds that private strategies to control pathogens are diverse and that supply chain control is crucial. Public information and regulations strengthen private incentives for pathogen control. Starbird uses a principal agent model to examine the design of supply chain contracts and improve the safety of purchased inputs. The opportunity to use supply chain contracts to improve food safety exists even when food safety is difficult to measure.

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# The Case in Support of Restaurant Hygiene Grade Cards

By Ginger Zhe Jin and Phillip Leslie

Throughout the United States, consumers rely on local health authorities to regulate and inspect restaurants in an attempt to assure that high-quality hygiene standards are maintained. Few people would argue that this is unimportant. If hygiene were left unregulated and unmonitored, it is likely that restaurant workers would shirk in their efforts to maintain good hygiene, and customers would generally have little idea that their meals may have been prepared without meeting appropriate health standards. Of course, not all restaurants would be irresponsible in this way, but it only takes one shirking restaurant to give rise to a public health emergency.

How effective are the regulations and inspections by public health authorities at assuring good-quality restaurant hygiene? We have studied restaurant hygiene and the role played by health inspections in Los Angeles County over a three-year period (1996–1998). Our research indicates that restaurant hygiene regulations and inspections are a fairly imperfect device for assuring good-quality hygiene. However, in January 1998 the Department of Health Services (DHS) in Los Angeles implemented a critical change in their regulations that led to a dramatic improvement in restaurant hygiene—restaurants were henceforth required to display prominently in their window a letter-grade card (A, B, or C) corresponding to the result of their most recent DHS hygiene inspection. We analyzed a variety of different data to assess the effects of these grade cards on restaurant hygiene, restaurant revenue, restaurant prices and output, behavior of DHS inspectors, and, most importantly, the occurrence of food-related illnesses. We also explored the differential effects of the grade cards on different types of restaurants.

## Weak Incentives for Good Hygiene in the Absence of Grade Cards

Before the grade cards were introduced in Los Angeles, DHS inspectors would randomly inspect restaurants about twice a year. During these inspections, the inspector would explain to the restaurant staff where violations occurred, tell them to fix these problems, and offer general advice on how to maintain good hygiene. Restaurants were given a score out of 100, with prespecified points being deducted for each violation. For example, a food temperature violation results in a five-point deduction, and evidence of cockroaches results in a three-point deduction. However, there are no fines for these violations, and a restaurant is only closed in severe cases such as an infestation, or if a restaurant received two consecutive scores below 60. Even then, it would be closed only for the time it took to fix the problems. Hence, a restaurant could consistently have many violations and incur little penalty. Furthermore, the assigned hygiene scores were not made available to the public.

It would be wrong to argue that restaurants had zero incentives to maintain good hygiene in the absence of grade cards. On the regulatory side, inspectors provide education about safe food-handling practices and require at least one certified food handler be present in each restaurant. This probably causes some hygiene improvements. On the consumer side, consumers are not completely ignorant about restaurants' hygiene qualities. Consumers may observe some aspects of restaurant hygiene (such as bathroom cleanliness). Consumers may also learn from experience and form beliefs over time about the hygiene at certain restaurants. These consumer beliefs may provide incentives for restaurants to form and maintain reputations for providing good hygiene.

In search of evidence of reputational incentives for restaurant hygiene, we measured a restaurant's hygiene condi-

tion by the average hygiene scores across all the inspections that restaurant received before graded cards. We found that chain-affiliated restaurants develop reputations for good hygiene quality, which provides an incentive to maintain good hygiene, leading to better hygiene than non-chain restaurants on average (Jin & Leslie, 2005). We also showed that franchised chain restaurants tend to have lower hygiene quality than company-owned chain restaurants, indicating that franchised units tend to free-ride on the chain reputation to some extent.

There is also variation across neighborhoods in the degree of repeat customers at restaurants, which affects the ability of restaurants to form reputations. For example, in locations with many tourists (who are not repeat customers), restaurants may be less able to develop reputations for good hygiene; hence, these restaurants tend to have worse hygiene. Our analysis showed that regional variation in the degree of repeat business has a significant effect on restaurant hygiene quality.

We concluded that hygiene regulations and inspections (without posted grade cards), as well as free-market reputation mechanisms, provide some degree of incentives for restaurants to maintain good-quality hygiene. However, these incentives are likely weak, as many aspects of restaurant hygiene are unobservable to consumers, and inspectors cannot punish a restaurant for violations if the restaurant's hygiene score is above 60. This may be why only 25% of restaurants in Los Angeles had the equivalent of A-grade hygiene before the grade cards were introduced in 1998.

### **Grade Cards Lead to a Reduction in Food-Related Illnesses**

By posting grade cards in restaurant windows in 1998 in Los Angeles, the DHS increased the provision of information to consumers about restaurant hygiene quality. From a public health point of view, the key question is whether the increased information generates any improvement in health outcomes. An ideal answer to this question requires data on the number of people who get sick from eating at restaurants. But, obviously, most people get sick and spend an unpleasant day at home without this being recorded by any kind of authority. Even when there is a visit to a doctor, it is not recorded in a central database of such incidents.

However, in California we have access to data on people who are admitted to hospitals. This data comes from the California Office of Statewide Health and Planning Development. Using this data, we observed the number of people admitted to hospitals with specific diagnoses each month in each three-digit zip code for the period January 1993 to 2000. We determined which diagnoses were almost certainly due to unsafe food by following the criteria of a prior study (Mead et al., 1999) and independently with the help of medical specialists.

We used the data for all periods before and after the grade cards were introduced. We compared the number of food-related hospitalizations in the zip codes in Los Angeles to (a) the number of hospitalizations for non-food-related digestive disorders in zip codes in Los Angeles and (b) the number of hospitalizations for food-related illnesses in zip codes in the rest of California. Our approach was to estimate a regression model in

which the dependent variable was the log of the number of people admitted to hospital with a particular kind of diagnosis in a particular month and zip code. The independent variables were binary indicators for each zip code and illness-type combination, binary indicators for year and month, and a binary variable equal to one for zip codes in Los Angeles after the introduction of grade cards.

Estimating this regression model, we found that the introduction of grade cards in January 1998 in Los Angeles corresponded to a 20% decrease in the number of people admitted to hospitals with food-related illnesses. The estimate is significantly different from zero with 99% confidence. This was a discrete change exactly at the time of the grade cards, leading us to suspect strongly that this reduction in food-borne illnesses was because of the grade cards.

Remember, this finding was based on data for hospitalizations. These were very sick people that needed to spend at least one night in hospital. It is unclear whether grade cards affected less severe cases of food-related illness. It is conceivable this broader effect may be either larger or smaller than 20%. We do not know the answer to this.

There are two ways the grade cards may lead to improved health outcomes. First, the grade cards may cause restaurants to make actual hygiene improvements. Second, they enable consumers to substitute demand away from poor-hygiene restaurants in favor of good-hygiene restaurants. Under the second mechanism, even if restaurants make no actual improvements, we could still find a decrease in the incidence of food-related illnesses. We refer to this as a *sorting effect*, because consumers sort themselves across restau-

rants with different hygiene grades. From the point of view public health, it does not matter if only the sorting effect applies. However, it would be interesting to know whether the grade cards cause restaurants to make actual improvements, which also contribute to the apparent improvement in health outcomes.

We developed a model of consumer sorting, which we estimated using the combined revenue and inspection grades data. Specifically, we obtained permission from the California State Board of Equalization to access confidential sales-tax data for all restaurants in Los Angeles county in 1996, 1997, and 1998. This data allowed us to infer each restaurant's quarterly revenues during this period. We matched this data to the DHS hygiene inspection scores of each restaurant over the same period of time.

In order to disentangle consumer sorting effects from actual hygiene improvements by restaurants, we separated restaurants into three groups—A, B, and C or below—according to their hygiene scores before grade cards. Suppose each group represents a specific risk of food-borne illnesses, and restaurant revenue is a good proxy for consumer flows to these restaurants. If posted grade cards generated no actual improvement in restaurant hygiene, but motivated consumers to sort into better restaurants, the improvement in foodborne hospitalization should follow a specific pattern, given restaurant revenues and the risk of food-borne illnesses in each type of restaurant. If the actual health improvement exceeds the predicted sorting effects, it is likely due to actual hygiene improvement by restaurants. Using econometric techniques, we showed that both effects do in fact contribute to the decrease

in food-related-illness hospitalizations. Full details are available in Jin and Leslie (2003).

### **Grade Cards Magnify Economic Incentives for Good-Quality Hygiene**

The above analysis suggests that restaurant owners have made efforts to improve hygiene after the introduction of grade cards. We argue that this is because grade cards magnify economic incentives for good-quality hygiene.

The 1996–1998 revenue data allowed us to analyze whether consumers are responsive to the grade cards. We found that before the grade cards, changes in restaurants' hygiene quality (as measured by the DHS inspection scores) had no impact on restaurant revenue. This is consistent with consumers having limited ability to assess restaurant hygiene. After the grade cards were implemented, if a restaurant received an A grade, their revenue increased by 5.7% relative to their revenue when there were no grade cards. For restaurants that received a B grade, revenue increased by 0.7%. For a C grade, revenue decreased by 1%.

The analysis of the revenue data verifies that after grade cards, consumers become sensitive to restaurant hygiene when choosing which restaurants to patronize. Critics of the grade cards argue that consumers may be misled—the fact that a restaurant obtained an A during an inspection does not ensure the restaurant has A-grade hygiene at other times. This is true. However, before the grade-card system was implemented in Los Angeles, the average difference in DHS inspection scores between two randomly chosen restaurants was 13.5. Meanwhile, the average difference in scores between

two randomly chosen inspections at a single randomly chosen restaurant was only 8.8. The point is that there tends to be much greater variation in hygiene across different restaurants than there is at any individual restaurant over time. Hence, although grade cards don't assure consumers that the restaurant has the posted grade at other times, they provide valuable information about which restaurants are more likely to have better hygiene. Grade cards are an informative, although imperfect, signal.

The revenue analysis also suggests that restaurants may actually benefit from the grade cards. The impact on revenue varies according to the grade and is positive for A and B-grade restaurants. Revenue is not the same thing as profit, and we have no information on the cost for restaurants to obtain an A or B. As noted above, about 25% of restaurants already had the equivalent of A-grade hygiene, so for these restaurants there was only upside to the grade cards. Some restaurants will incur significant costs to improve hygiene to become an A or B, and in these cases it is conceivable the grade cards have reduced their profits. However, these are the worst hygiene offenders, so policymakers may be unsympathetic with these restaurants.

The grade cards stimulate demand for good-hygiene restaurants, raising the possibility that restaurants may also increase prices, which would be bad for consumers. Revenue equals price times quantity, and so the fact that revenue has increased at good restaurants implies we can only rule out the possibility that both price and quantity have fallen. It could be that price has increased and quantity has fallen, with a net positive impact on revenue.

We are unaware of restaurant-level data on prices. To shed light on the possible impact of the grade cards on prices, we examined price indices constructed by the Bureau of Labor Statistics. Specifically, we looked at the monthly price index for “food away from home” in the combined region of Los Angeles, Riverside, and Orange counties (LRO). This is the least aggregated price index available that includes Los Angeles restaurant prices. Note that Los Angeles has more than twice the combined population of Riverside and Orange counties. We compared this index with the same product category in regions other than LRO<sup>1</sup> and with other consumer price indices<sup>2</sup> within LRO. The data cover the time period January 1991 to February 2001.

In separate regressions we examine the dependent variables: (a) prices over time for food away from home in various regions and (b) prices over time for various goods categories within LRO. Explanatory variables were a grade-card dummy (1 for food away from home in LRO in all months after January 1998) and binary indicators for year, month, region, and goods category. The level of the price index for food away from home in LRO in December 1997 is 171.1. In the cross-region regression, the coefficient on grade cards was estimated to be -2.14, suggesting a 1.25% price drop in LRO after 1998 as compared to non-LRO regions. In

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1. *Comparison regions include San Francisco-Oakland-San Jose counties, Chicago-Gary-Kenosha counties, and New York-Northern New Jersey-Long Island counties.*
  2. *Comparison industries include food at home, alcoholic beverages, and all items.*

the cross-categories regression, the coefficient on grade cards was estimated to be -5.78, suggesting a 3.38% drop in the price of food away from home as compared to other industries within LRO. In both cases, the estimates are statistically different from zero with 99% confidence.

Because revenue is equal to price times quantity, an overall increase in restaurant revenue and a decrease in the price index suggests that output may have increased after grade cards. This conjecture is confirmed when we compare the total number of people employed in the food industry in and out of Los Angeles county, as well as before and after graded cards within Los Angeles county. (More details are available at Jin and Leslie, 2003). Decreased price and increased output may be explained by the grade cards lowering search costs for consumers, leading to more intense competition among restaurants. In other words, the grade cards make consumers more confident about trying restaurants they have not experienced before and make them less captive to the restaurants they have had good experiences at.

### **Grade Cards Make Inspectors Slightly More Lenient**

The revenue analysis verified that the restaurant hygiene grade cards create an economic incentive for restaurants to obtain an A grade. However, these incentives may also affect the behavior of inspectors, probably because the grade cards cause restaurant managers to pressure inspectors during an inspection. In our conversations with DHS inspectors, it was clear that inspectors feel much more pressure from restaurants than they did before the grade cards. For example, an unhappy restaurant manager may complain of discrimination by the

inspector. This is of course not surprising—restaurants will do what they can to obtain an A; this includes improving hygiene as well as pressuring inspectors.

Some evidence is highly suggestive that the grade cards cause inspectors to become more lenient in their inspections. Before the grade cards, the distribution of inspection scores was a smooth bell-shaped distribution. After the introduction of grade cards, there is a dramatic upward spike in the distribution at the score of 90, which is the cut-off score for obtaining an A grade. There is also a downward spike at 89. A similar pattern occurs around the cut-off for a B grade.

One interpretation of this pattern, which is also consistent with the anecdotal evidence from inspectors, is that inspectors choose to “bump up” a score of 89 to 90 so that the restaurant is not punished because of one point. As long as inspectors do not bump up restaurants which deserve even lower scores, this is a mild form of grade inflation. However, monitoring from the DHS is needed to ensure that the grade inflation does not become worse over time.

A final point of interest: Before the grade cards, the average DHS inspection score for restaurants in locations where residents have income below the Los Angeles median was 74.5. For restaurants in locations with income above the median, the average score was 78.8. In the first year after the grade cards, the averages increased to 89.8 and 89.5, respectively. Hence, grade cards appear to be particularly effective at improving restaurant hygiene in low-income areas.

## Conclusion and Further Thoughts

In conclusion, the use of restaurant hygiene grade cards in Los Angeles has been a great success. By increasing the provision of information to consumers, powerful economic incentives are created for restaurants to improve hygiene, leading to a significant improvement in public health outcomes. Moreover, because the DHS already perform inspections, the grade cards create negligible additional cost for the government.

Three factors seem to have contributed to the successful implementation of the grade cards in Los Angeles County. First, the grade-card policy was adopted in response to a three-part report aired on CBS 2 News on the Los Angeles-based Channel 2000 on November 16–18, 1997. The report, “Behind the Kitchen Door,” used hidden cameras to show viewers unsanitary restaurant kitchens. The TV exposé had an immediate influence—it raised consumer awareness about restaurant hygiene, highlighted the weakness of the existing system, and added political pressure for regulatory change.

A second key factor is the format of the grade cards. There are many ways to disseminate hygiene inspection results. Rather than issue a grade card to be displayed in the front window of a restaurant, Los Angeles County government could publicize the inspection reports online (which has been adopted recently in New York City) or require every restaurant owner to provide the most recent hygiene report if a consumer asks for it (which is the state law of California). The policy of “available upon request” was apparently insufficient for maintaining good restaurant hygiene. This was confirmed by Tribbey (2005), who reported a very

low degree of compliance with the state law in Napa, CA. As for internet posting, we are not aware of any study examining the impact of publicizing inspection reports in an online database. Arguably, grade cards reach more consumers and are more readily available to consumers than an internet database. According to what we have seen in Los Angeles County, wide access to the inspection results plays a critical role in enhancing consumer awareness of restaurant hygiene, thus reinforcing the economic incentives for restaurants to improve hygiene quality.

Within the format of grade cards, the DHS could print the numerical inspection score instead of a simple letter grade on the card. In fact, some counties in North Carolina have adopted a “Know the Score” program, which indicates that grade cards must show the letter grade and numeric score in the same size type, side by side (Pytko, 2005). Posting the numerical score may give more information to consumers and alleviate inspector bias around the cutoff of the letter grades. However, it may also entail more education efforts to ensure that consumers understand the details behind the numerical scores. We are not aware of any study evaluating the “Know the Score” program, but the experience in Los Angeles County suggests that letter grades have a clear interpretation to consumers, which is essential for consumers to pay attention to grade cards. Nevertheless, it would be useful future research to examine the issue of what is the ideal form of information to provide consumers.

A third factor contributing to the success of grade cards is the assessment criteria. In Los Angeles, inspectors follow rigid codes that relate specific violations to carefully defined numerical point deductions. By min-

imizing the subjective component in hygiene inspections, the criteria help standardize evaluations across restaurants and inspectors, helping to encourage consumer confidence in the grade cards. Of course, this does not mean the Los Angeles assessment criteria are perfect. There have been concerns that the current criteria in Los Angeles may not reflect the true hygiene conditions and may not give appropriate weights to certain aspects of restaurant hygiene. Although we are unaware of any specific evidence indicating the inspection criteria in Los Angeles may be imperfect, this is surely a topic for ongoing evaluation by public health specialists in Los Angeles as well as the rest of the United States.

Finally, restaurant hygiene regulations fall within the jurisdiction of local governments (to the best of our knowledge). In the case of Los Angeles, the inspections are carried out by county health inspectors, but at least some of the regulations are at the discretion of each city government. For example, the policy of mandatory posting of grade cards that we have studied was a decision made separately by each city government in Los Angeles County. At the other end of the spectrum, the federal government provides guidelines for retail food handling, which are voluntary for local governments to adopt (Food and Drug Administration, 2001). Our research suggests that standardized assessment criterion and mandatory posting of grade cards for every city in the United States would provide significant public health benefits. We cannot help but wonder if the federal government could play a more active role in this respect.

## For More Information

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# The Response to BSE in the United States

By John Fox, Brian Coffey, James Mintert, Ted Schroeder, and Luc Valentin

Since the emergence of bovine spongiform encephalopathy (BSE) in the United Kingdom in the late 1980s, the United States has implemented various measures to prevent the disease from entering the country, to prevent its spread if discovered here, and to safeguard human health. Regulatory actions included import restrictions, a ban on certain ruminant tissues in ruminant feed, and a surveillance program. Additional measures, aimed at reassuring domestic and foreign consumers about the safety of US beef, were implemented following the December 23, 2003 announcement that a dairy cow in Washington State had tested positive for BSE. In the sections that follow, we discuss the US response to BSE under three broad categories—trade policy, food and feed restrictions, and surveillance. Our analysis focuses on the costs associated with various regulatory actions and less so on potential benefits that are more difficult to quantify.

## Trade Policy

Following the announcement of the first US case, 53 countries, including major markets such as Japan, Mexico, South Korea, and Canada, banned imports of US cattle and beef products. This came as no surprise—automatic border closure following such announcements had become standard procedure. The United States itself blocked imports of Canadian beef and cattle following the announcement of the first Canadian case in May 2003.

Border closure in response to a very low BSE incidence in an exporting country is not endorsed by the World Organization for Animal Health (OIE), particularly when control measures are in place. Moreover, although the United States itself had not adhered to OIE guidance on trade, the United States Department of Agriculture (USDA) did initiate regulations to allow imports from countries, specifically Canada, that presented a “minimal risk” of introducing BSE. This minimal risk region (MRR) rule that would reopen the border to imports of Canadian cattle less than 30 months old was to become effective

March 7, 2005. However, in response to a motion filed by the Ranchers-Cattlemen Action Legal Fund (R-CALF), a federal court in Montana granted a preliminary injunction blocking the measure. A hearing to determine whether a permanent injunction should be granted is scheduled for July 27, 2005.

The controversy surrounding the reopening of the Canadian border illustrates the potential gains and losses from any change in trade policy. Although R-CALF may indeed be concerned about the human health risk from Canadian cattle (though some might doubt it), it is clear that US cattle producers, particularly those in the northwestern US, would lose from import competition in the short run. Marsh, Brester, and Smith (2005) estimate that Canadian imports would reduce US feeder cattle prices by \$4.57/cwt. However, in the long run, if adequate cattle supplies are not available locally to keep US packing plants in the region open, producers in the Northwest will lose local cattle markets. Similarly, US producers are losing from the current restrictions on US exports. In 2003, beef exports were valued at \$3.95 billion and accounted for 9.6% of US commercial production. Although some important markets, including Mexico and Canada, did partially reopen during 2004, exports for the year were 82% below 2003. Coffey, Mintert, Fox, Schroeder, and Valentin (2005), in an analysis performed for the Kansas Department of Agriculture, suggest that US beef industry losses from export restrictions during 2004 ranged from \$3.2 billion to \$4.7 billion.

The question we might ask here is whether these trade disruptions and associated welfare losses could have been avoided. Caswell and Sparling (in press) emphasize the importance of an internationally coordinated response to managing risks from diseases such as BSE, and Caswell (in press) argues that the potential trade impacts of BSE discovery were not sufficiently weighted in the BSE risk management process. Thus, if MRR legislation had been enacted prior to the recent discoveries of BSE outside of

Europe, we may never have banned imports of Japanese beef when they discovered their first case in September 2001, nor vice versa. Of course, with the benefit of hindsight, it is easy to point out what might have been. Nevertheless, both Canada and the United States had been warned by the European Union in July 2000 that they were at risk for discovering the disease (Scientific Steering Committee, 2000).

## Surveillance

In 2003, the USDA tested approximately 20,000 cattle for BSE. Countries in which the disease is established have more intensive surveillance—for example, the EU has tested around 8 million head per year since 2001 (Fox & Peterson, 2004). Following the Washington State case, the USDA announced a one-year enhanced surveillance program. The objective was to test as many cattle as possible from high-risk categories—those exhibiting signs of central nervous system disorders, nonambulatory cattle, and those that die on farms—in addition to a random sample of healthy older animals. In various news releases, the USDA stated that a sample size of 268,000 animals would allow for the detection of BSE at a rate of one positive in 10 million adult cattle with a 99% confidence level. That claim, however, is based on the assumption that all cases occur in the targeted high-risk group and that the incidence in nontargeted categories is zero. As of April 2005, 314,000 cattle had been tested under the new protocol with no positive cases identified. Table 1 provides an excerpt from the test results.

The surveillance program has been a source of controversy in areas related to testing protocol, announcement of inconclusive results,

and an incident in Texas in May 2004 in which an animal exhibiting central nervous system symptoms was not tested for the disease. Inconclusive (or false positive) test results are expected with the Bio-Rad rapid screening test used by USDA. The false positive rate is variously estimated at between one in 50,000 to as little as one in 300,000 tests. Thus far, the USDA has announced three inconclusive results—two in June 2004 and one in November 2004—all of which, upon confirmatory testing using immunohistochemistry (IHC), were found to be negative. The initial announcements of inconclusive cases were controversial and led the Animal and Plant Health Inspection Service (APHIS) to revise their announcement procedure—delaying announcement until a sample produced two inconclusive results with the rapid test. Concern about potential market disruption due to false positives is one reason cited by opponents of wider scale or voluntary testing. For example, following the announcement of the third inconclusive test result on the morning of November 18, 2004, most live cattle futures contracts opened around \$2/cwt lower than the previous day's close, and many moved limit down that day. Very light sales in the cash market in the following days were likely the short-run cash market reaction to the news.

At the same time, there has been speculation that the USDA deliberately chose a test with a relatively high rate of inconclusive results as a means of desensitizing markets to the possible discovery of true positive cases (Mitchell, 2004). Also controversial is the USDA's choice of IHC as their "gold standard" test. In February 2005, Consumers Union called on the USDA to retest inconclusive samples using the Western Blot test,

which, they argued, was more sensitive and more objective. According to the Consumers Union, the Western Blot test is used as the confirmatory test in Japan and Europe and had been used previously by the USDA to confirm the December 2003 Washington State case. (See Pruisner, 2004, for more information on BSE testing.)

The future of the surveillance program has not yet been decided. Industry officials have called for it to be scaled back. Not surprisingly, some consumer advocacy groups favor wider scale testing. For example, a March 16, 2005 editorial in *The New York Times* proposed that "the only responsible way to resume international trade in beef is to ensure the health of the cattle. And the only way to do that is to test the cattle—all of them, if need be."

In what turned out to be a particularly thorny issue for the USDA, in July 2004 the agency denied an application by a small Kansas beef processor, Creekstone Farms, for permission to voluntarily test slaughter cattle in an attempt to regain access to the Japanese export market. The beef industry is sharply divided on the issue of voluntary testing. Proponents tend to view it in terms of a marketing decision with expected benefits outweighing costs, at least in the short run. Indeed, our analysis for the Kansas Department of Agriculture (Coffey et al., 2005) suggests a potential net benefit ranging from \$27.50 to \$48.50 per head (before fixed costs) if voluntary testing restored full access to the Japanese and South Korean markets. Opponents argue that BSE testing is unnecessary and costly, that it sets a dangerous precedent in terms of acquiescing to an unreasonable customer demand, and that it is not scientifically valid and provides no risk-

reduction benefit to consumers. Large US meat processor stances regarding BSE testing suggest that the investments and logistics of large-scale testing, in addition to the potential impact on demand of a positive case, are such that it is a losing proposition for bigger firms—perhaps in particular for those diversified either internationally or across meat products. For a single small firm, on the other hand—especially one more heavily reliant on export sales to high-quality foreign markets than the major packers—the situation is different. If voluntary testing provided export market access, it could produce substantial monopoly-type benefits in the short run. Creekstone officials have stated that their increased revenue from regaining access to the Japanese market would far exceed the testing cost of \$20 or less per head. Thus, for Creekstone, the private incentive to pursue testing was fairly clear. It is worth noting however, that this scenario would produce no benefit for producers, because increased demand from a single small firm would have a negligible impact on cattle prices. However, if testing did provide market access, more firms would be attracted to testing, and domestic cattle prices would increase.

Finally, regarding the current surveillance effort, it is not yet clear how successful the USDA has been in its efforts to sample the targeted high-risk groups. The APHIS website provides no breakdown of samples by animal categories (Table 1), in contrast to the UK, where detailed breakdowns for various risk categories in the active surveillance programs are provided (Table 2). Clearly, no one associated with the US beef industry wants to find this disease. However, the perception that officials may have latitude in terms of sample

**Table 1.** Excerpts from the USDA's BSE test results report.

Date	Negative	Inconclusive	Inconclusive result	Positive	Total
<b>Week 45</b> <b>(4/4/05–4/10/05)</b>	9,138	0	—	0	9,138
<b>Week 44</b> <b>(3/28/05–4/3/05)</b>	10,663	0	—	0	10,663
<b>Week 25</b> <b>(11/15/04–11/21/04)</b>	7,900	1	Negative	0	7,901

Note. Data from USDA Animal and Plant Health Inspection Service (2005).

**Table 2.** Excerpts from the UK BSE test results report—2005.

Ongoing surveys (cattle)	Tested	Results pending	BSE not confirmed	BSE confirmed
<b>Fallen stock</b>	18,574	3	18,558	13
<b>Casualties on farm</b>	30,825	11	30,788	26
<b>Casualties at OTMS abattoirs</b>	3,165	0	3,164	1
<b>24–30 month casualty cattle at fresh meat abattoirs</b>	211	0	211	0
<b>Over thirty months (OTM) scheme—random animals (born before August 1996) (before feed ban)</b>	2420	0	2417	3
<b>OTM scheme—animals born after July 1997</b>	28,613	0	28,613	0
<b>Animals sampled as 96/97 cohort (excluding fallen stock, casualties, etc.)</b>	26,726	0	26,726	0
<b>Birth cohorts of BSE cases</b>	380	0	380	0
<b>BSE offspring</b>	43	0	43	0
<b>Animals slaughtered for human consumption: OTM (beef assurance scheme)</b>	22	0	22	0

Note. Data from Defra UK (2005).

selection, rumors about animals not sampled, and allegations by at least one former USDA employee about the mishandling of potentially positive test samples, does not help engender confidence among foreign buyers or policy decision makers. Critics have commented that Germany did not begin to find BSE until it allowed private testing. If the disease is truly not present in the US herd, then the industry has little to fear from allowing expanded private testing. However, what are the odds that the surveillance program in place during 2003 managed to detect the

only BSE-infected cow in a herd of 100 million?

### Food and Feed Restrictions

In January 2004, the Food Safety Inspection Service (FSIS) banned nonambulatory animals and certain tissues designated as specified risk material (SRM) from the human food supply. The new regulations require firms to age animals using postmortem dentition, to deal with nonambulatory animals, and to segregate SRM material. Using data from a survey of meat processors, Coffey et al. (2005) estimated the

additional labor costs of these tasks at approximately \$0.45 per head of plant capacity.

As currently defined, SRM includes the brain, skull, eyes, trigeminal ganglia, dorsal root ganglia, spinal cord, and vertebral column from cattle 30 months of age and older, and the tonsils and the distal ileum of all cattle. In order to ensure complete removal of the distal ileum, the rules required that the entire small intestine be disposed of as inedible. The small intestine rule has been the most controversial aspect of the SRM regulation because for some firms it was a valuable by-product, particularly in some export markets. Coffey et al. (2005) estimated that on average, firms that previously sold small intestines were losing from \$3.23 to \$4.13 per head because of the rule. Other products condemned as a result of BSE regulations include bone-in cuts from over-thirty-month (OTM) animals that contain vertebral column (i.e., T-bone steaks) and product obtained from advanced meat recovery (AMR) using OTM vertebral columns. Coffey et al. (2005) estimated that restrictions on bone-in cuts and AMR reduce per-head revenues by approximately \$8.50 and \$9.36, respectively, on affected OTM animals, while the ban on nonambulatory (downer) cattle resulted in an aggregate loss of approximately \$63 million.

On February 2, 2004, a panel of experts (the International Review Team or IRT) commissioned by the USDA provided recommendations for future actions for managing BSE risk. With regard to feed regulations, the IRT recommended that (a) unless aggressive surveillance showed BSE risk to be minimal, SRM should include the brains and spinal cords of all animals over 12 months and the

entire intestine of all animals; (b) SRM should be excluded from all animal feed including pet food; and (c) all meat and bone meal (MBM), including avian, be excluded from ruminant feed. Earlier, on January 26, the Food and Drug Administration (FDA) announced plans to strengthen the ruminant feed ban that had been in place since 1997. In particular, the FDA said it would eliminate exemptions for bovine blood and plate waste and ban the feeding of poultry litter. In July 2004, the FDA published an Advance Notice of Proposed Rule-making (ANPR) with an invitation to comment on several aspects of the ruminant feed ban, including the recommendations of the IRT. The comment period for this notice ended on September 13, 2004, but as of April 2005, the FDA had not implemented any of its proposed actions, and the exemptions for plate waste and bovine blood products in the 1997 feed ban remained in place.

Additional restrictions on SRM or ruminant feed would hurt the cattle sector by eliminating markets for certain products or increasing feed costs. Ruminant blood meal, for example, is widely used in cattle feed, particularly for dairy cows and in milk replacement rations for calves. When FDA announced plans to eliminate the blood exemption, the values of ruminant and porcine blood meal, which had been similar, diverged. During 2004, ruminant blood meal traded at an average discount of \$250 per ton compared to the porcine product. Coffey et al. (2005) estimated that if the blood exemption were eliminated, the value of ruminant blood meal would fall by an additional \$225 per ton, resulting in a combined loss of approximately \$1.43 for an average steer. Similarly, the cost of banning currently defined

SRM from all animal feed was estimated at \$2.16 per head, and if the SRM definition were extended (as recommended by the IRT), the cost would be \$6.77 per head.

If additional cases of BSE are found in the United States, it seems likely that some of the changes proposed by the FDA will become law. The benefits of implementing those measures are more difficult to quantify than their costs. The Harvard/Tuskegee risk analysis (Cohen et al., 2001) estimated that a ban on SRM in both human and animal feed would reduce the predicted number of BSE cases (in the event it is present) by 80% and the potential human exposure by 95%. However, the baseline level of exposure is so low that further reductions appear to have minimal value. As testing technologies develop and testing costs fall, it may be more efficient to test animals for the disease instead of condemning their products. Testing, even at current prices, appears preferable to a total ban on feeding any ruminant derived proteins to animals—a measure currently in place in the EU and Japan. Coffey et al. (2005) estimated the cost of such a ban at \$14.00 per head in lost revenue plus \$4.50 per head in additional feed costs. However, for reasons that are not clear to us, the testing option is not currently applied to nonambulatory animals—even in cases in which an animal sustains an injury in transport.

## Conclusions

Although the US response to BSE can be critiqued in some areas, the overall response appears to be far more efficient than, for example, that of Japan, which removed all cattle over 30 months from the food chain, instituted universal BSE testing, and banned meat and bone meal for all

uses. US policy makers appear to have considered the costs and benefits of various approaches and recognized that the risk to human health is extremely low.

How low is the risk? In the United Kingdom, the human version of BSE has claimed around 150 victims. However, they have had more than 180,000 BSE infected cows, most of which were found before the connection to human disease was recognized. Estimates of the total number of animals infected in the United Kingdom run to as high as two million. Had Canadian and US authorities taken no precautions to eliminate SRM tissues from food, four Canadian BSE cases might have led to 0.004 human cases in the next 10–15 years. The human health risk from BSE is probably far lower than the risk of choking on a toothbrush. Thus, to suggest, as did Judge Richard Cebull in granting the injunction blocking imports of Canadian cattle, that BSE poses a “genuine risk of death for US customers” is a complete distortion of the concept of what is really risky.

Beef, like any other food, is not and never can be 100% risk free. However, today’s salient risk is not mad cow disease. Instead, it is the more familiar bacterial pathogens like *Salmonella* and *E. coli*, the incidences of which have dropped significantly in recent years. By refusing to implement drastic measures in response to a virtually nonexistent threat, policy makers may foster a more rational perception of the risk associated with the disease. Not permitting voluntary testing of young animals, because it provides no useful information for consumers, could well be viewed as part of that strategy. The wider impact of such a measured response may be one of enhancing the overall stability of food demand and making

it less responsive to food scares that occur from time to time.

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# Opportunities for the Coregulation of Food Safety: Insights from the United Kingdom

By Andrew Fearne and Marian Garcia Martinez

## Introduction

The increase in the recorded incidence of foodborne illness and the recent history of high-profile outbreaks of illness that have been linked to food have created both political and economic demands for more effective controls. Consequently, government regulation of food safety has increased substantially in the last decade, including the introduction of *ex ante* direct regulations as well as *ex post* indirect controls. Alongside public intervention, private mechanisms of food safety control have also developed substantially and now play an important role in the supply of higher quality, safer food.

In reality, the distinction between public and private regulations and standards is less discrete than often assumed; in practice, there is a continuum between the two (Gunningham, Grabosky, & Sinclair, 1998). In most markets public and private safety regulations coexist, and there can be considerable interrelationships and dependencies between them. On the one hand, private regulations and standards can evolve as a mechanism to facilitate compliance with regulatory requirements. On the other, regulations can reference private standards as part of their requirements. Moreover, the interaction between self-regulation and public regulation could provide a superior outcome, as industry and firms are often more knowledgeable regarding product quality, and public regulation can generate reputation-based incentives to monitor quality, in the form of public exposure (Nuñez, 2001).

This paper explores opportunities for coregulation of food safety as an alternative to traditional direct government intervention. It aims to contribute to the current debate on the role that government and industry should play in providing for an optimal food safety system while ensuring that all actors in the chain, from producers to consumers, benefit from the efficiency gains that are possible when the responsibility for protecting consumers from

foodborne illnesses is shared between the public and private sectors.

The potential benefits of coregulation of food safety are self-evident—coercion breeds minimal compliance, resulting in suboptimal improvements to public health, and often comes with a significant bill for enforcement and monitoring—but coregulation remains a relatively a new concept in most parts of the world. The lack of trust among actors in the food chain and the perceived risk associated with allowing market forces to play a role in the regulatory process are, in our opinion, key limiting factors for closer coordination of private and public resources in the regulation of food safety. However, the view of food safety responsibilities (and liabilities) from farm to table brings about a new paradigm in stakeholder relationships characterized by complex interaction between public and private modes of regulation (Fearne et al., 2004a). This shift of responsibilities towards the private sector has created a more complex and demanding “policy space” involving public and private sector incentives and controls (Garcia Martinez & Poole, 2004), hence the need to explore the opportunities for greater public-private coordination in the effective and efficient regulation of food safety.

In the United Kingdom, food safety regulation and standards are articulated through a central coordination standard-setting system headed by the Food Standards Agency (FSA) with implementation and enforcement delivered by its own agents (the Meat Hygiene Service) or others (Environmental Health Practitioners [EHPs] employed by the local authorities). Although the majority of food law is derived from the European Union (EU), there remains scope for the FSA to propose new direct regulations or alternative approaches aimed at improving public health and protecting consumers in policy areas not regulated by EU law. Moreover, current EU regulatory

developments towards more flexible risk-based approaches to food safety, with greater responsibility lying more explicitly with the private sector, are opening new opportunities for government and industry to work together to deliver a socially optimum level of food safety.

### **Coordinated Approach to Food Safety**

For any given policy issue, the options for public intervention range from doing nothing to direct prescriptive regulation (Better Regulation Task Force, 2003). In between, there is a wide range of options available, ranging from information and education campaigns where people change their behavior of their own accord, to incentive-based structures, private regulation, and coregulation.

Though probably unpopular among consumer lobby groups, there may be circumstances where it could be better for the government not to intervene. A careful analysis of the benefits and costs of alternative regulatory options could advise policy makers that no intervention is the best course of action, in particular when the costs of preventing a highly improvable food safety failure outweigh the estimated benefits. Moreover, there could be issues of equality on the incidence of costs and/or benefits placed upon, or derived by, a particular section of society as a direct result of public intervention, which could advise governments not to exercise their powers. In addition, the difficulty or impossibility of enforcing new legislation could also prevent governments from intervening.

At the other extreme, command-and-control intervention would be required when the market fails to deliver the level of safety necessary to

meet public health requirements. Within this hierarchy of public intervention, there are a number of possibilities to coordinate public and private resources in the regulation of food safety. The question is what form should this coregulation take, and under what circumstances might private regulations and standards be the most efficient and effective mechanisms to manage food safety, either in combination with or as an alternative to public intervention?

*Coregulation* is an approach in which a mixture of instruments is brought to bear on a specific problem, typically involving both primary legislation and self-regulation or at least some form of direct participation of bodies representing stakeholders in the regulatory process (Eijlander, 2005). Coregulation aims to combine the advantages of the predictability and binding nature of legislation on the one hand and the more flexible self-regulatory approach on the other. Coregulation thus involves self-regulation and regulation working together, mutually reinforcing each other.

Hence, an essential aspect of a cooperative approach to governance is the cooperation between the public and private sectors in the process of creating new rules. This cooperation in the field of regulation may, however, result in various forms, such as agreements, conventions, and even regular legislation (Eijlander, 2005). In the last case, this government regulation is the result of a process of negotiating between the public and the private parties involved. However, the key to the coregulation debate is the distinction between private and public motives for the use of coregulation and the possible relationship between private and social benefits and costs emerging under a coregulatory framework. In the field

of food safety economics, the public-interest and private-interest approaches in the regulation theory are well documented (Fearne et al., 2004a). The public food safety policies focus on the regulation of markets to increase social welfare (improvements in public health), whereas the private-interest approach is concerned with the study of the position of interest groups in the process of regulation. An element in the latter approach is the concern that the relationships between the regulators and the regulated may become too close and thus lead to capture, that is, the pursuit of the regulated businesses' interests rather than those of the public at large.

Within this context, the analysis of coregulation of food safety presented in this paper will focus on four stages in the regulatory process where greater coordination of public and private efforts may be justified: (a) setting the standards; (b) process implementation; (c) enforcement; and (d) monitoring.

### **Setting Standards**

#### ***Early-Stage Coordination: Impact on the Quality of Regulation***

In recent years, governments have turned to the use of risk assessment methodologies to provide fairly standardized evaluations of specific risks. On the risk management side, careful analysis of the benefits and costs of alternative regulatory interventions can play a similar role in disciplining decision making and providing solid support for the regulatory options chosen (Caswell, 1998, 2004). Precise forecasts of economic benefits and costs can rarely be made, but systematic analysis can differentiate between policy options that are promising and those that are not.

Regulatory impact assessment (RIA) for all new legislation is a common feature in developed countries, including the United Kingdom, where existing legislation is also subject to periodic assessment every three years (post-implementation reviews). RIAs have the potential benefit of allowing for comparative analysis of different policy options, which may inform the policy decision-making process. However, the widespread perception within the UK food industry is that RIAs are generally undertaken too late in the decision-making process to have any significant influence on the legislation, and there is inadequate consultation with industry over the scale and incidence of likely compliance costs (Fearne et al., 2004b). This is of particular concern, as previous research has revealed little evidence to enable conclusions to be drawn about the effectiveness of RIAs to produce better food safety legislation (Fearne et al., 2004a).

Greater and earlier engagement of stakeholders would lead to better regulation by taking account of industry/sector-specific requirements and characteristics while facilitating implementation and enforcement. The possibility of using the industry as a sounding board is particularly important in the process of evaluating compliance costs and potential impacts on the competitiveness of UK food businesses of emerging legislation at an early stage in the regulatory decision-making process. Closer cooperation is particularly relevant when legislation is developed at EU levels in order to ensure that emerging regulations can be properly and simply implemented and enforced. However, early work on RIAs before the relevant legislation is fixed brings its own problems. If the legislation has not been decided, or

the guidelines to regulators written, then how can the interpretation of those guidelines be understood in terms of its effect on businesses? If the legislation and its interpretation cannot be described, how can stakeholders estimate the cost implications?

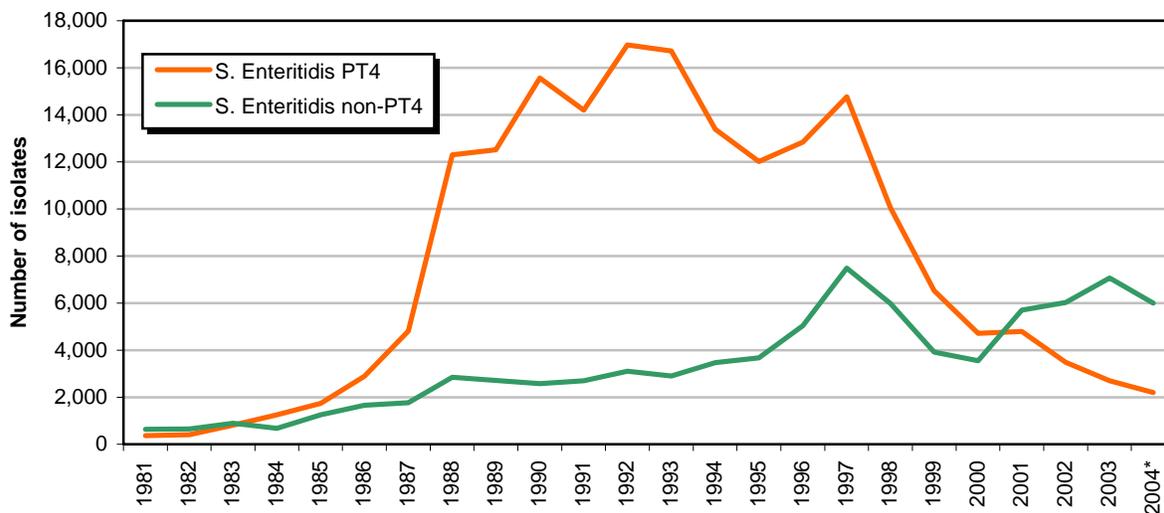
### **Development of Baseline Standards**

Governments can produce and/or stimulate the generation of codes of practice (COPs), which industry can comply with voluntarily. These codes are a form of information and set standards of good practice. For example, in the UK, a plethora of private farm assurance schemes (primarily driven by UK supermarkets seeking to comply with the due diligence requirements of the 1990 Food Safety Act and subsequent public and private demands for traceability back to the farm) that incorporate official COPs have evolved over the past decade. All schemes require their members to be aware of and to implement COPs. Some scheme assessors have specific questions aimed at checking that members understand and are applying them (Food Standards Agency, 2002).

However, should the industry move beyond the legal and official guidance by setting stringent standards? This debate is at the heart of the development of farm assurance schemes in the UK. Baseline schemes have an implicit inclusive approach by aiming at majority participation and an increase in standards across all producers while avoiding “gold plating”—increasing standards (and thus compliance costs) without justification from a public health perspective. In the UK, baseline schemes cover over 85% of production in the milk, eggs, chicken, pork, and combinable crop sector and over 65% for beef and lamb and horticultural produce

(Food Standards Agency, 2002). However, the value of schemes that do little more than repeating the basic legal position by focusing primarily on greater uptake is questionable. Yet, if by doing so, the scheme raises standards across the whole sector, consumers and the society in general would benefit. This argument touches on the issue of the development (or lack thereof) of food safety baseline standards among UK farm assurance schemes aimed at improving public health compared to the “success” of proprietary quality-assurance schemes developed by UK food retailers.

Two examples in the UK—the Lion quality scheme and the ZAP Salmonella Monitoring Programme—illustrate how the progressive development of assurance schemes towards stringent standards are seen as beneficial in providing socially optimum levels of food safety. Between 1981 and 1991, the number of cases of salmonellosis in humans in the UK rose by approximately 170% and remained high throughout most of the 1990s. In March 1991, the Advisory Committee on the Microbiological Safety of Food (ACMSF) agreed to set up a working group to consider the extent to which eggs were responsible for this problem. Their report, published in 1993, concluded that much of the rise in human salmonellosis was due to *Salmonella enteritidis*, mostly phage type 4 (PT4), which can invade the reproductive tract of chickens (ACMSF, 1993). In an attempt to restore consumer confidence, the British Egg Industry Council (BEIC) developed in 1993 the Lion Code of Practice to reduce *Salmonella* in eggs throughout the food chain. It was substantially amended in 1998 to provide for a major *Salmonella* vaccination pro-



**Figure 1.** Salmonella Enteritidis infections, England and Wales, 1981–2004.

\*Provisional data.

Note. Data from UK Health Protection Agency, 2005 ([http://www.hpa.org.uk/infections/topics\\_az/salmonella/data\\_human\\_se.htm](http://www.hpa.org.uk/infections/topics_az/salmonella/data_human_se.htm)).

gram. Because of the life cycle of a laying hen, this means that since the end of 1999, the Lion scheme considers it has effectively eliminated *Salmonella* from Lion eggs. The scheme sets standards for the production of eggs to significantly higher levels than required by UK and EU law in areas including food safety, product quality, labelling, and animal welfare. All major retailers specify Lion eggs and display the Lion logo. It is UK-wide in coverage. It calculates that it covers over 85% of UK egg production (i.e., 95% of free range, organic, and barn egg production and 75% of cage egg production). Vaccination is reinforced by extensive cleaning and monitoring. Hatcheries, pullet rearing, and laying hen flocks are regularly tested. Feed is UFAS assured. Strict on-farm rodent and biosecurity controls are enforced; other controls ensure that the “best before” date on the egg and pack does not exceed 21 days from the date of packing and that the egg is kept at a temperature below 20°C. The scheme has a detailed passport system for birds, eggs, and feed. It

requires on-shell date marking to prevent eggs removed from packs from losing their age mark.

The results of the scheme are encouraging. Official data shows there has been a substantial decrease in human illness caused by *Salmonella enteritidis* since 1997 (Figure 1). A study carried out by the FSA in 2003 (Food Standards Agency, 2004c) shows that only one in every 290 boxes of six eggs on retail sale in 2003 had any *Salmonella* contamination, compared with one in 100 boxes in a survey carried out in 1995/96. This equates to an almost three-fold reduction in the level of *Salmonella* contamination since 1995/96. The FSA recognises that this is likely to reflect the measures introduced by the UK egg industry to control *Salmonella*.

The Assured British Pig (ABP) scheme has moved in similar direction with the introduction in June 2002 of the Zoonoses Action Plan (ZAP) Salmonella Monitoring Programme. ZAP was introduced following a report published in 2000, which indicated that a proportion of

pigs arriving at abattoirs carried *Salmonella* and presented a significant risk of meat contamination. The ZAP program is voluntary but operates in all British assured abattoirs collecting samples from all assured pigs, which represent 90% of British pig meat production. Meat samples are collected from slaughter pigs by abattoir staff and despatched to the laboratory once weekly at the abattoirs' expense. Three samples are collected from each batch of farm assured pigs that arrive at the abattoir. Farms with excessive levels of positive results will usually have their assured status suspended, and meat from their pigs would no longer be eligible for the Quality Standard or Special Selected Scotch Marks. Pigs from these holdings could still be slaughtered as nonassured pigs in abattoirs that process these animals, but the number and market share of these is in sharp decline. The results to date are impressive (Table 1); the target is to reduce the level of positive results by 25% by the end of 2005.

The above examples illustrate how the progressive development of

**Table 1.** Positive results from ZAP salmonella program, July 2003 through June 2004 (%).

	Jul-Sep 2003	Oct-Dec 2003	Jan-Mar 2004	Apr-Jun 2004
<b>Total</b>	25.0	24.8	24.0	20.7
<b>England</b>	28.2	28.1	27.8	24.5
<b>Scotland</b>	14.0	14.3	11.7	10.1
<b>N. Ireland assured</b>	14.1	13.7	11.3	10.2
<b>Total samples reported</b>	31,851	33,095	36,542	34,212

Note. Data from Zoonoses Action Plan Salmonella Programme Annual Report, 2004 (<http://www.bpex.org/technical/zap/zapannualreport04.pdf>). Milton Keynes, UK: British Pig Executive.

assurance schemes towards stringent standards are seen as beneficial in providing socially optimum levels of food safety. However, this development seems to be uneven across UK farm assurance schemes (Food Standards Agency, 2002). It has been easier for schemes to raise standards more rapidly where industries are more integrated or where a smaller number of suppliers or processors account for a large percentage of the market, as in the case of eggs, poultry, and pigs. In the beef and lamb sector, conversely, progress has been hampered due to the complexity and length of the red meat chain. There is a tension between the scheme owners' desire to keep the majority of producers loyal to the scheme and their recognition that consumers expect standards to improve throughout the chain.

### Process Implementation

Following the application of new EU Food Hygiene Regulations beginning January 1, 2006, the responsibility for the production of safe food will lie more explicitly with the food business operator, a requirement that is contained in current legislation and is underpinned in General Food Law. All food business operators will be required to put in place appropriate controls that demonstrate they are managing food safety within their business. This legislative framework

represents a move from a prescriptive *command-and-control* approach towards an *enforced self-regulatory* approach (Braithwaite, 1982) with the regulator imposing a requirement on businesses to determine and implement their own internal rules and procedures in order to fulfill the regulator's policy objectives. The more risk-based and flexible procedures are better matched to the needs of individual businesses and to enforcement. They will provide better opportunities for businesses to demonstrate that they have effective risk management systems, and therefore their products present lower risk to consumers.

The three main EU regulations that make up the package will be directly applicable and therefore constitute the law in each member state of the EU. This means that national legislation is not required (or indeed allowed) to give effect to the EU regulations, beyond providing for their enforcement in the UK. However, there are a number of areas in the EU regulations that either require or allow member states to adopt certain provisions as appropriate in their national law, and these regulations address these aspects too.

The FSA has produced draft guidance on the requirements of the food hygiene legislation applying in the UK. The aim is to help food businesses to understand what provisions apply to them and to guide

them through the legislation. Where necessary, the guidance points food businesses to other guidance and sources of advice that will help them to understand how to comply with the relevant legal requirements.

However, the move from a prescriptive approach towards an enforced self-regulatory approach raises a number of concerns regarding the delivery of a socially optimum level of food safety. Though by law, individual food sectors can develop and implement their own guidance, is this level of self-regulation acceptable by all stakeholders, particularly consumers and other watchdog groups? To what extent can individual food sectors involved in developing this guidance ensure compliance by their members? Some form of inspection system will still be necessary.

### Enforcement

Effective regulation depends on effective and consistent enforcement to ensure compliance. Therefore, it is important to determine the type of inspection policies most appropriate for motivating food businesses to achieve target levels. Different inspection regimes influence behavior in different ways. If the aim is to win the hearts and minds of food business operators and their employees to encourage well-embedded and lasting changes to practices, enforcement officers may concentrate on promoting good practice through advice and education rather than enforcement action. Conversely, the speed of action needed may drive the decision regarding the best approach in some cases. For example, where food products on sale are known to pose an acute and serious health risk, enforcement officers discovering them may seek to have the foods vol-

untarily surrendered by the food business operators or seize them with a view to their subsequent destruction (Food Standards Agency, 2004b).

Good advice is important, particularly in the case of small and medium enterprises (SMEs) to help them to comply with existing and emerging legislation. A recent study by Yapp and Fairman (2004) on enforcement approaches for food safety in SMEs shows that local authority education activity has significant effects upon inspection ratings scores and compliance levels of SMEs. The survey results show that 62% of proprietors in food SMEs demonstrated a lack of knowledge throughout the compliance decision process and that interventions that increase specific food safety knowledge within businesses were the most effective at improving conditions. Generic written information was frequently misinterpreted and misunderstood, thus limiting its effectiveness in improving food safety compliance within SMEs. Formal enforcement was a vital component of the compliance process. It acted as a last-resort action for the enforcer and maintained the general fear of enforcement presence in SMEs.

As well as good advice and support, and an effective inspection regime, the right incentives need to be in place to encourage compliance (Hampton, 2004). Regulatory incentives may be positive, resulting in the voluntary adoption of appropriate food safety controls, or negative, either purposive (in the form of policy-mediated sanctions for noncompliance, such as fines) or consequential (in the form of declining market share and exclusion from the market). In general, incentives to enhance food safety have been largely negative, often focused on warnings

backed up by the threat of financial penalties in the magistrates' courts, whereas a more positive approach, aimed at helping farms and businesses comply with food safety legislation, has been largely overlooked.

Regulators can use incentives to encourage compliance. Good performance can be rewarded, most obviously through lighter inspections when risk profiling has taken place (see below). The role of reputational mechanisms as drivers for investments in food safety, whereby consumers "discipline" firms by switching to rival firms when quality is below certain tolerance levels, has been found as having a positive effect for instance on hygiene levels in restaurants (Jin & Leslie, 2003).

Finally, effective penalties are an essential last resort in the regulatory system. They deter businesses from breaching regulations and provide assurance to law-abiding businesses that those who do try to gain competitive advantage by breaking the law are properly punished (Hampton, 2004). Moreover, an effective penalty regime could help to build consumer confidence in food and food regulation (Cragg Ross Dawson, 2005).

### **Monitoring**

Compliance with food safety regulations and standards requires ongoing monitoring and evaluation of business performance to ensure continued conformity. There is increasing recognition that inspections could be inefficient (in terms of use of limited resources), particularly in the case of low-risk or high-performing businesses, and that many objectives of inspection can be achieved through means other than inspection, particularly through giving advice (Hampton, 2004). Hence, many regulators

are starting to use risk profiling to try to concentrate limited resources where they are of most use. However, visiting high risk businesses more frequently must not be at the expense of the quality and consistency of inspection (Griffith, 2005).

In the United Kingdom, the FSA determines how regulation should be enforced through a statutory code of practice that directs and advises local authority EHPs. Until very recently, the food safety code of practice required all businesses to be inspected at least every five years. The new code of practice for local authorities, issued by the FSA in October 2004, allows alternative (non-inspection-based) enforcement strategies to be used with the lowest-risk premises (Food Standards Agency, 2004a). Moreover, following the application of the new EU Food Hygiene Regulations beginning January 2006, food business operators would be required to implement procedures based on Hazard Analysis and Critical Control Point (HACCP) principles. The universal adoption of HACCP will move the focus of food safety inspections from prescriptive rules to an auditing of HACCP procedures.

There are opportunities for government agencies to rely more on private mechanism of food safety control (i.e., ISO 9000, HACCP) to assist their enforcement and monitoring process in terms of inspection frequency ratings. The implementation of the new EU Food Hygiene Regulations in January 2006 will offer an opportunity for the FSA to move away from physical inspections of food businesses that have good systems and a demonstrably good record through formal recognition of the level of consumer protection that is delivered through independently audited industry standards and assur-

ance schemes. This level of cooperation between the public and private sectors would allow local authorities to concentrate limited resources on food enforcement in businesses with high and poorly controlled risk.

However, the opportunity to use private industry schemes to assist the enforcement process could, in turn, bring equity problems that need to be considered. For instance, farm assurance schemes are voluntary, and thereby nonmembership should not be considered by the FSA as a failure by businesses to comply with legislation (the scope and level of private and public standards could differ significantly). There is a danger that the issue of “voluntariness,” which is at the heart of private standards, could be undermined by government interference.

Moreover, the role of the enforcer would change as inspections of good performers could eventually become a “checking a box” exercise. However, this would mean little if the quality and time for inspections are inadequate and if the process is target-driven rather than outcome-driven (Griffith, 2005). Achieving consistency and ensuring minimum standards of food safety, at a time when inspections move towards a more audit-based approach with possibly less-trained EHPs, may become more difficult. This would eventually raise concerns as to the ability of the system to be a strong deterrent for free riders and the kind of private standards the FSA should recognize.

## Conclusions

The potential benefits of coregulation of food safety are self-evident—coercion breeds minimal compliance, resulting in suboptimal improvements to public health, and invariably comes with a significant heavy

monitoring cost. Coordination of activities, public and private, at different stages in the regulatory process (from standard setting to enforcement and monitoring) *should* result in safer food at lower (regulatory) cost as a result of a more effective allocation of scarce resources. The fact that we see relatively little coregulation in practice is, we believe, a reflection of the lack of trust in the food chain and the perceived risk associated with allowing market forces to play a role in the regulatory process.

However, change is afoot in the UK and throughout the EU, where the principles of coregulation are being embraced as a mechanism for moving faster, with greater effect, and/or at lower cost in certain circumstances, where risk assessment and industry structure provide the right prognosis.

It is perhaps a little early to claim there are lessons to be learned for the United States from these recent developments in the UK, but the implications of a more widespread adoption of coregulatory principles and practices for countries outside of the EU are significant, not least from the perspective of international trade. Food safety is widely regarded as a regulatory burden that inhibits the ability of commercial stakeholders (particularly the smaller ones) to compete, yet the clamor for more regulation increases with every new food scare. Coregulation provides a mechanism for moving quicker, in a more targeted (risk-based) way, at lower cost to both the taxpayer and private enterprise. Yet the tension between public and private incentives, the lack of trust, and the challenge of imperfect information represent significant hurdles to be overcome. Thus, any insights that trigger discussion of how this

approach might develop in other countries and how these tensions might be reduced should be encouraged, however different the institutional and political approach to regulation might be.

The work in which we are currently engaged aims to identify which combination of public and private regulation is appropriate for different regulatory objectives at different stages in the regulatory process. The challenge now is to find case studies of best practice, which we will be doing in conjunction with our research partners in the United States, Canada, and Australia. The hope is that these case studies will give pointers to the incentive structures and regulatory contexts in which coregulation is most likely to succeed. It will then rest with the government agencies and industry organizations to decide what, if anything, needs to be changed to the regulatory processes and incentive structures to facilitate the more widespread consideration of coregulation as a more efficient and effective way of improving the safety of our food supplies.

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# Economics of Private Strategies to Control Foodborne Pathogens

By Tanya Roberts

**F**oodborne pathogens are naturally occurring contaminants that public policies and private strategies target for control. In the 1990s, both the Food and Drug Administration (FDA; US Department of Health and Human Services) and the Food Safety and Inspection Service (FSIS; Department of Agriculture) required a new system for many regulated food plants. Hazard Analysis and Critical Control Points (HACCP) is based on preventing pathogens from entering the food supply chain and controlling this contamination after it occurs. The new federal HACCP regulations have not automatically solved the pathogen-contamination problem, and foodborne illness outbreaks and product recalls continue.

This paper examines the role of public and private economic incentives in the market for food safety, how pathogen information influences this market, the variety of strategies firms use to control foodborne pathogens, and the firm's package of choices: Are inputs sold for a cooked or raw product? What are the safety requirements of buyers? What is the risk a firm is willing to bear of a foodborne disease outbreak or product recall? In evaluating economic incentives for pathogen control, the food safety externalities caused by joint production of quality attributes are often overlooked but may alter the willingness of a firm to adopt food safety controls. This paper focuses on the supply chain for meat and poultry products, estimated to cause more than 40% of human illnesses associated with common pathogens. Case studies are examined for economic incentives for achieving pathogen control.

## Role of Information in Economic Models

Although neoclassical economics assumed zero information and transaction costs, Akerlof's seminal article on the used car market (1970) created awareness of how missing information about quality alters the marketplace. In

today's knowledge economy, the role of information has become even more central (Metcalf, 1995). Firms do not have equal access to information; this asymmetry is a driving force in the economic selection process, in how different technologies change over time, and in core policy-making behavior within a firm that can hinder or enhance the creative process. Competition is a process of change in an inefficient world. On the empirical front, Metcalf reports that firms in the United Kingdom's manufacturing industries have "substantial unit cost deviations from best practice" (p. 472), even in very competitive environments. As evolutionary economists predicted, the range of firm efficiencies was most diverse in rapidly growing industries. New shocks, such as changes in demand and development of new technologies, add to the inefficiency of old behaviors in the framework of evolutionary economics and give firms new opportunities for creating profit.

## HACCP Regulations and New Tests Shock Food Safety Markets

Firms used to talk of testing for pathogens as looking for a needle in a haystack—lingo that is no longer heard. Improved tests and pathogen surveillance systems have undergone a sea change in the past decade (Unnevehr, Roberts, & Custer, 2004). The problem of false positives caused by DNA from killed pathogens has been solved. Tests are faster, cheaper, and much more highly automated with standardized results. Most significantly, new information revealed by better pathogen tests allows firms to develop new control strategies, because the tests are reliable enough to document the impact of alternative control strategies on pathogens. Both the public and private sectors are reacting around the globe, tightening pathogen control with new regulations or contract provisions.

To comply with the FSIS HACCP regulations, meat and poultry plants have to follow standard sanitation oper-

ating procedures, test for generic *E. coli*, and develop a seven-point HACCP plan to monitor and control production operations: (a) identify food safety hazards; (b) identify critical control points (CCP); (c) set critical limits for each CCP; (d) develop CCP monitoring procedures; (e) perform corrective actions; (f) establish recordkeeping systems; and (g) verify the system is working as planned. Under the HACCP regulations, FSIS tests for *Salmonella* on raw meat and poultry products. If the plant fails *Salmonella* tests, their HACCP plan is subject to an in-depth review by FSIS.

### **Joint Production Functions Reduce Costs**

One factor complicating economic analysis is the joint production function between pathogen control and other economic benefits. McDonald's clamshell cookers were put into use in 1984 to meet three objectives: to cook patties faster, to reduce labor costs, and to enhance food safety. More uniform cooking was achieved by simultaneously heating the patty from both sides in the clamshell cooker. Cost savings and pathogen control were complementary objectives for McDonald's. The American Meat Institute reports that companies find shelf-life extension to be a benefit from pathogen control in combination with new packaging systems. Economic analyses of the marginal costs of pathogen control, then, are more complete if they include estimates of the savings derived from these joint-production-function benefits.

Mazzocco (1996) reports that the business management literature on quality control and innovation reveals that "the cost of poor quality exceeds the cost of developing pro-

cesses which produce high-quality products" (p. 770). The characteristics of internally driven quality management systems include heavy reliance on employee involvement, development of new measurement methods (e.g., new pathogen tests), and continual change in processes. The private application of process control complements FDA and FSIS HACCP regulations to control pathogens in the food supply chain.

### **Firm Strategies for Pathogen Control**

Traditional methods of pathogen control in foods include drying, curing, salting, sugaring, heating, and cooling. A "kill step," such as pasteurizing food in cans or cooking meat well-done just before serving, can effectively control pathogens. A kill step, however, can create quality tradeoffs, such as changes in flavor and texture (Ralston, Brent, Starke, Riggins, & Lin, 2002). The food industry typically designs new food products with multiple hurdles that either kill pathogens or minimize pathogen growth. Some meat and poultry producers now use multiple hurdles to control pathogens in their production processes for raw products. Other firms, however, may choose to ignore pathogen contamination of the foods they produce. These firms are then faced with an increased risk of legal liability when consumers become ill, when the CDC reports an outbreak associated with their product, or when the FSIS requests a recall of product that has failed a pathogen test. Ollinger and Ballenger (2003) report that badly managed meat and poultry plants tend to go out of business.

A firm's choice of a pathogen control strategy is influenced by how strictly it chooses to control patho-

gens in specific raw meat products. Within a meat company, the target level for pathogen control can vary by plant and/or product. For example, plants slaughtering bulls and cows used in breeding and milk production sell in three markets with differing levels of pathogen risk in their final marketplace products: high-risk raw ground beef market (grinding mixes pathogens throughout), medium-risk roast market (pathogens remain on the exterior and are killed by conventional cooking), and low-risk processed products, such as soup that is cooked thoroughly. Different requirements for pathogen control exist in each of these three markets. Different requirements also exist in the international marketplace. A firm must analyze its competitive advantage: Is it competing today on low price, high safety, or high quality (tenderness or a product sold in the organic market)? What is the firm competing on tomorrow in this dynamic environment of improving food safety knowledge?

Based on implementation of HACCP, industry literature, and risk assessment models, meat and poultry firms use seven generic strategies to control pathogens in their products. Combinations of the strategies are often used. The strategies are arranged from least complex to most complex. In general, the level of pathogen control increases from Strategy 1 to Strategy 7.

**Strategy 1: sanitation control.** Cross-contamination of meat and poultry is minimized by regular sanitation of the conveyor belts and other equipment in the plant. Systematic cleaning of the plant's walls, drains, and air ventilation at regular intervals further reduces risk. Although HACCP requires certain sanitation practices,

firms may choose to comply minimally (or do nothing) until receiving notice of a regulatory violation.

**Strategy 2: kill step for pathogens.** A firm decontaminates food at the end of the production line, for example pasteurizing milk, canning fruits, or irradiating hamburger patties in case-ready packages for sale in supermarkets.

**Strategy 3: pathogen prevention.** A firm prevents pathogens from entering the plant at one or more locations, keeps pathogens from growing on food through control over temperature and shelf-life, and minimizes cross-contamination between food products and between the plant environment and food products.

**Strategy 4: multiple-hurdle approach.** A firm improves control over all operations in the plant, or at least at several prevention and decontamination steps. This is similar to the standard practice in food companies for designing new foods with several barriers or hurdles to keep pathogens from surviving or growing in foods.

**Strategy 5: key risk locations.** A firm uses microbial testing at various locations in the plant to determine where the highest probability of pathogen contamination occurs. Pathogen data are used to identify key risk locations, where managers improve pathogen control using new processes and employee training. Or, the data can be put into a risk model and various control scenarios evaluated to determine key risk locations and effective control strategies.

**Strategy 6: compare risk/cost tradeoffs.** A firm adds explicit consideration of the costs of alternative control options to Strategy 5 and evaluates

the risk/cost tradeoffs of different control options.

**Strategy 7: invest in R&D.** A firm adopts a long-run strategy to invest in research and development and invent new control options, either by adapting management systems or processes used in a related industry or by inventing a new management system or process (complete with new equipment) to control pathogens.

What empirical evidence exists about the pathogen-control strategies used by firms? Case studies reveal what strategies are used and present evidence of the high information costs of pathogen control, joint production functions, and incentives for innovation.

#### ***New Testing and Management System***

The Bacterial Pathogen Sampling and Testing Program (BPSTP) was invented by the Texas American Foodservice Corporation (Golan et al., 2004). Developed in collaboration with four other partners, the BPSTP demonstrates the evolving market incentives for pathogen control. In the early 1990s, Texas American tightened its quality-control procedures in response to increased product returns and customer complaints about hamburgers contaminated with fragments of plastic or metal.

In 1993, Jack in the Box was hit with a major outbreak associated with *E. coli* O157:H7 in its hamburger patties. For Texas American, Jack in the Box's offer of a negotiated contract for successful pathogen control in hamburger patties offered the opportunity to intensify the company's new commitment to safety and quality assurance. With the contract, Texas American was able to reduce its sales in the spot market. The contract permitted more effi-

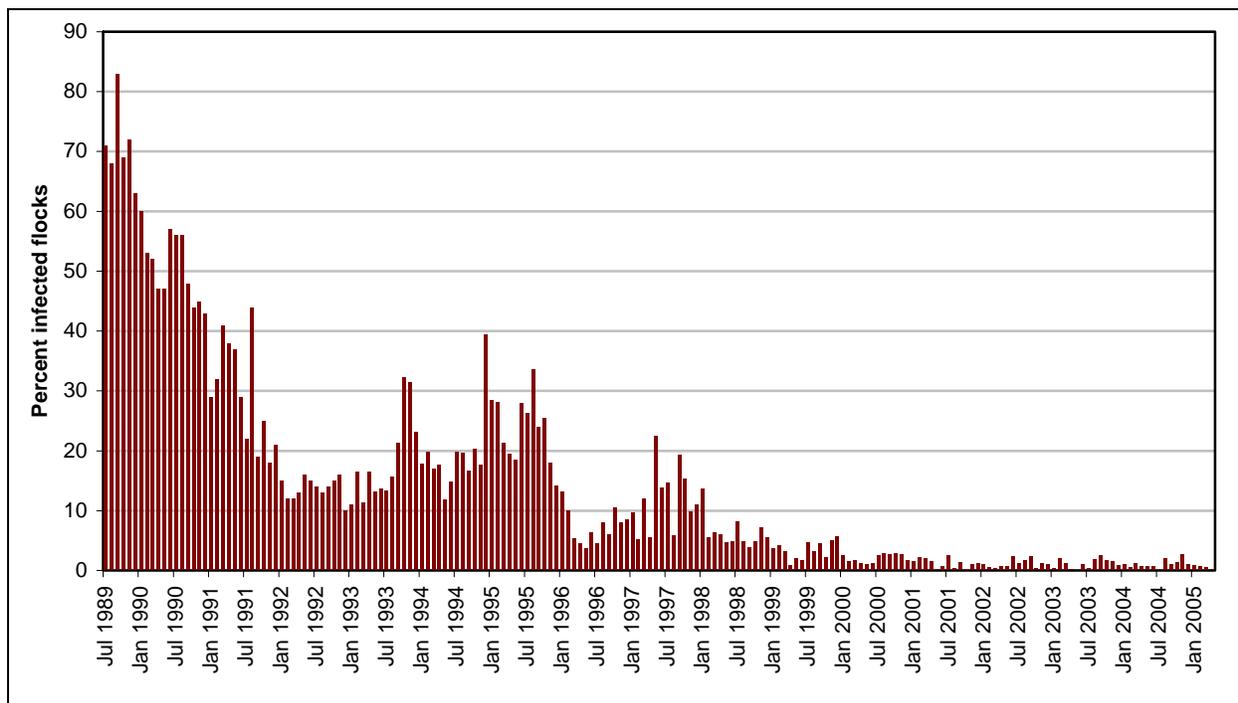
cient use of equipment and more efficient scheduling of the workforce as well as reduced product spoilage and product returns due to spot market sales. These production cost savings were transferred into development of the BPSTP pathogen control program.

The BPSTP is a process innovation combining a new sampling protocol/management system for *E. coli* O157:H7, *Listeria monocytogenes*, and *Salmonella* and a new application of a patented testing technology to hamburger patty processing lines. The process innovation has resulted in a product innovation: hamburger patties with consistently low levels of pathogen contamination. Both companies were first motivated by the need for risk management to limit or eliminate the damage in reputation, sales, and liability stemming from inadequate quality control. Both companies have found that leadership in pathogen control has been a foundation for growth.

The food-safety strategy used in this example was Strategy 5 (control at key risk locations) in combination with Strategy 7 (invest in R&D to develop a new management system). The joint production function for economic efficiency and pathogen control were also exhibited. The inaccuracy of pathogen information drove Texas American to collaborate with Qualicon, a company developing a superior test (BAX) for detecting *E. coli* O157:H7 in beef.

#### ***Innovative Equipment***

Frigoscandia Equipment invented the Beef Steam Pasteurization System (BSPS) to sterilize the exterior of beef carcasses in collaboration with beef industry and academic partners (Golan et al., 2004). The BSPS technology uses steam to kill pathogens on beef carcasses. The BSPS unit is in



**Figure 1.** *Salmonella* in Danish broiler flocks as determined by bacteriologic testing of every flock 2–3 weeks before slaughter ( $N > 4,000$  flocks/year).

Note. Data from Wegner et al. (2003).

a stainless steel cabinet at the end of the slaughter line before the sides of beef (hanging from an overhead rail) enter the chiller. The BSPS can be purchased with automatic record-keeping capabilities for carcass identification, steam temperature, steam exposure time, and deviations. For companies selling equipment to meat processors, a central information question is validating the ability of the equipment to kill pathogens. Efficacy, however, is linked to other downstream actions; for example, a poorly run chilling procedure can negate the benefits of the BSPS, as cross-contamination and pathogen recovery and growth can occur. Other issues in equipment sales are the uncertainty about the level of safety required by the marketplace or government regulations.

In inventing the BSPS, Frigoscandia Equipment was using Strategy 6—invest in R&D for sales to other companies. The BSPS illustrates

Strategy 2—the kill step for pathogens (if the steam temperature is high enough and the steam time is 20–30 seconds). The joint production function problem occurs in two ways: (a) if the steam is applied for too short a time, perhaps to save money, efficacy in killing pathogens can be compromised, or (b) if the steam is applied long enough to kill virtually all pathogens, the tradeoff is some cooking on the carcass exterior. Information uncertainty is a large issue, especially because downstream controls must be rigorous to maintain the high level of pathogen control.

#### ***Employee-Run Electronic Continuous Monitoring***

By turning over monitoring of the the production line to employees, Hatfield Quality Meats in Pennsylvania reduced the defect levels on pork carcasses from 8% to 1% over four years (Bolton, Oser, Cocoma, Palumbo, & Miller, 1999). The pro-

gram first enforced job pride—a strong factor in the success of the system. The on-line monitoring was able to identify when intensive training was needed to improve evisceration practices, when engineering problems called for redesign of operating practices, and when feed-withdrawal practices for hogs needed modification. Implementation resulted in less trimming and less product waste and required fewer employees. The plant may have saved money, even though there were training and equipment costs. Food safety increased dramatically: Microbial contamination levels decreased 99.8% to less than half the US national average level for pork.

This case study illustrates the benefit of improved information in food safety. Joint production function issues were exhibited. Hatfield Quality Meats used Strategy 5—monitoring and identification of key risk locations on the slaughter line.

### **Hog Total Confinement Production System**

Using data from the National Animal Health Monitoring System survey, Wang et al. (2002) compared traditional US hog production systems (barns, sheds, and access to the outdoors) to total confinement systems. They found traditional production had slightly higher long-run production costs: \$0.31/cwt for hogs. Although the confinement buildings were more expensive, costs were more than offset by greater feed and bedding costs in nonconfinement production. Analysis of blood samples found that total confinement market hogs had a statistically significant lower level of contamination with the parasite *Toxoplasma gondii*, a human pathogen.

This case study illustrates three points: (a) the joint production function of economic efficiency and parasite control in a total confinement production; (b) the information problem in linking the human illness (toxoplasmosis) to pork consumption that causes weak economic incentives to switch to confinement systems for pathogen control; and (c) use of Strategy 4 (the multiple-hurdle approach) to use a combination of methods to limit cat and rodent access to hogs and reduce contamination of hogs with *Toxoplasma gondii*.

### **Salmonella Control in Danish Broilers**

Wegener et al. (2004) found that government-mandated *Salmonella* control programs of broiler chickens were successful five years after implementation (Figure 1). The control strategy used extensive pathogen testing of feed supplies and of birds in quarantine, in the hatchery, on the farm, and in the slaughterhouse. The pathogen test data were used to identify *Salmonella*-control problems and

execute changes in the production chain, such as destruction of all *Salmonella*-contaminated birds and feed.

Farmers were initially indemnified for contaminated broilers, but private insurance is required now, and high-risk farmers pay increased premiums—a strong incentive for *Salmonella* control. An economic incentive available to retailers is a “*Salmonella*-free” label for broilers sold in Denmark. This study illustrates how a combination of government regulations and private requirements for pathogen-insurance coverage can overcome the information problem related to pathogen control.

The primary strategies used were a combination of Strategies 3, 4, and 5. Pathogens are prevented when *Salmonella* tests are required throughout the supply chain. When contamination is detected, immediate actions are taken, such as destruction of *Salmonella*-contaminated birds and feed and effective cleaning of all contaminated facilities documented by environmental testing. This case study also reveals the importance of strong regulatory controls that are enforced.

### **Choices About Achieving Greater Pathogen Control**

Food safety is an example where weak market incentives are changing with new information about pathogen risks and controls. In the last decade, foodborne disease outbreaks and surveillance, new pathogen tests, and new regulations have strengthened private incentives for pathogen control. Supply chain managers face a steep learning curve to control bacteria that can multiply in the food chain. Public policy makers have been challenged by how to get the economic incentives right. Innovation has occurred in both public and

private management strategies, resulting in positive change in both sectors. HACCP and its enforcement procedures are a step toward new pathogen control policies. The focus of this paper, however, is the strategies used by private companies to control foodborne pathogens.

The five case studies displayed an array of innovative management systems (e.g., the hamburger patty plant), superb supply chain control that extended back to the grandparents of broilers, and employee empowerment to control pathogens (e.g., the pork plant). Although weaker incentives to control pathogens were exhibited in hog confinement production and the beef carcass steam pasteurization equipment case studies, significant pathogen control was nonetheless within economic reach of private firms.

The strong role that public policies play in providing incentives to firms is illustrated by the Danish requirements for *Salmonella* control in broilers. Especially noteworthy is the system of initially compensating farmers for contaminated broilers, then phasing this system out and replacing it with private insurance. In the last decade, there has been continuous improvement by both public regulators and private companies in pathogen control. Some private companies are taking the concept one step further to create continuous innovation in pathogen control and using this as a marketing strategy.

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*Without implicating them for the paper's shortcomings, the author appreciates insightful comments from Mike Doyle, Andrew Starbird, and two anonymous reviewers. Tanya Roberts is with the Diet, Safety and Health Economics Branch in the Economic Research Service, United States Department of Agriculture. The views expressed in this article are not necessarily those of the USDA.*



# Supply Chain Contracts and Food Safety

By S. Andrew Starbird

As this issue of *Choices* attests, food safety has become one of the most important issues facing the food industry. Unnevehr (2003) gives four reasons why food safety is more important than ever to consumers: Improved diagnostic techniques make it easier to trace illnesses to food-borne pathogens; increasing consumer affluence has led to increased demand for safer, higher quality foods; new sources of food and new production practices have introduced new risks into the food supply chain; and consumers are purchasing more prepared food and food away from home than ever before. The food industry is well aware of the market's demand for food safety, and it continues to develop methods and adapt operations to meet this demand (Golan et al., 2004).

In this issue of *Choices*, Roberts defines seven generic strategies employed by food companies to reduce the contamination that leads to food safety failures. Her second strategy, pathogen prevention, includes efforts to keep pathogens out of a processing facility, destroying pathogens or limiting their growth if they are already in a facility, and minimizing cross-contamination. The best way for a consumer or processor to prevent food safety failures is to make sure that inputs, ingredients, and raw materials are safe when they are purchased.

In this article, I examine how supply chain contracts can be designed to improve the safety of purchased inputs. Contracts are frequently used to govern the exchange of goods, services, information, and money between supply chain participants. Even when sellers have more information about the product safety than buyers do, contracts can be used to enhance food safety.

## Safe or Unsafe?

Two critical problems associated with ensuring food safety is defining *safe* and figuring out how to measure it. Although advances in public health have made it possible to link illness to specific pathogens, the definition of a safe level of pathogen contamination remains imprecise. The

involvement of the government in establishing food safety standards has not resolved the issue. The lack of resolution is due in part to the incompatible interests of producers, processors, and consumers, and in part to the shortage of scientific evidence relating contamination rates to illness.

When the definition of safety is imprecise, firms participating in the supply chain face uncertainty with respect to the economic consequences of their actions. A firm may be able to calculate the cost of a lot failing a safety inspection or the cost of a lot being recalled because it is unsafe; however, without a precise definition of safety, the firm cannot compute the probability of these events. Without knowing the probability of these events, managers cannot measure the return on investments that improve safety, the value of food safety insurance (if it is available), or the value of testing the safety of raw materials and ingredients.

Even if the definition of safe is unambiguous, measuring safety is subject to significant error. Two sources of measurement error are *diagnostic error* and *sampling error*. Diagnostic error is the error associated with false positive and false negative test results. A *false positive* is a test that indicates that a pathogen is present when it is not; a *false negative* is a test that indicates that a pathogen is not present when it is. Recent developments in diagnostic technology have reduced the false positive and false negative rates to less than 1% (Qualicon, 2005). In economic jargon, the rate of false positives is the producer's (or in our case supplier's) risk—the risk that an uncontaminated lot will be classified as contaminated. The rate of false negatives is the consumer's (or in our case buyer's) risk—the risk that a contaminated lot will be classified as uncontaminated.

Some food safety inspection procedures include a sequence of tests in order to reduce the rate of false positives. A positive first test is called a *presumptive positive* until it is confirmed with a second test. This practice is common in drug screening of employees and athletes. In the case of drug screening, the double sampling procedure

is designed to protect the person being tested from false accusations of drug use. In food safety, the double sampling procedure is designed to protect companies from false accusations of contaminated food. Unfortunately, double sampling does not reduce the buyer's risk associated with contaminated food passing inspection (false negatives). The rate of false negatives is influenced by the accuracy of the test for pathogens, the frequency of sampling, and by sampling at multiple places in the production process.

The other source of error in food safety testing is sampling error. The enormous volumes of food that move through the supply chain on a daily basis make it impossible to test every gram, square centimeter, or milliliter of food for the presence of pathogens. Buyers are forced to take samples in order to test the safety of purchased lots. Sampling error occurs when the characteristics of the sample are different from the characteristics of the lot from which the sample is drawn. Random sampling is a means of controlling this error, but establishing random sampling techniques and making sure they are followed everywhere in the supply chain is a daunting task.

The existence of diagnostic and sampling error means that buyers know less than suppliers about the safety of the product they are buying. It also means that unsafe product will sometimes pass inspection and that safe product will sometimes fail inspection. The risk associated with these events influences the behavior of both suppliers and buyers, because it influences supplier and buyer profitability.

## Measurement Error and Imperfect Information About Safety

Measurement error leads to what economists call *imperfect* or *asymmetric* information about food safety. One of the assumptions behind neo-classical economic analysis is that market participants have perfect information about quality and price. Safety is an attribute of food that is not immediately observable, also called a *credence attribute*, so information about safety is imperfectly distributed among supply chain participants.

When suppliers have better information about quality than buyers do, the market is subject to two rather unpleasant economic phenomena: *moral hazard* and *adverse selection*. Moral hazard occurs when a supplier promises to exert effort to enhance safety but does not do so. Because safety measurement is subject to significant diagnostic and sampling error, a buyer cannot be sure that a supplier has fulfilled its promise to deliver safe food ingredients. Adverse selection occurs when suppliers can be divided into different categories or types based on the safety of their product. The supplier's type is imperfectly observable when safety is imperfectly observable. If the supplier's type is unobservable, buyers offer a price that reflects the "average" quality or safety they get from suppliers. The average price is too low for the highest quality suppliers to make money, so they leave the market. Of course, this outcome is undesirable from the point of view of policy makers and consumers.

Under certain conditions, however, we can use the uncertainty associated with food safety to motivate suppliers to deliver safer food. We are assuming, of course, that the buyer

wants safer inputs because the profitability of safer food is higher. This assumption implies that the buyer faces high safety failure costs or high inspection failure costs that can be partially allocated to the supplier responsible for the unsafe food. The objectionable effects of an imperfect allocation of information can be partially corrected by an equitable allocation of cost.

## Correcting Problems Associated with Imperfect Information

Several strategies exist for correcting the problems associated with imperfect safety information. The most obvious strategy is to get more information about the supplier and the quality of the supplier's product. This strategy will correct some of the asymmetry in the distribution of information, but acquiring accurate information is expensive and may be infeasible. Another strategy is vertical integration. If the buyer cannot segregate safe and unsafe suppliers, the buyer can acquire or merge with a supplier and make it safe. A third strategy is to make revealing information valuable, thereby encouraging the supplier to "signal" its safety level in some fashion. Safety and quality signals include the adoption of process standards (ISO 9000 or HACCP compliance, for example), guarantees, warranties, and third-party certifications. A fourth strategy is to design contracts that appeal to safe suppliers but not to unsafe suppliers. A contract, consisting of a bid price, specifications, and inspection protocols, may exist that segregates safe and unsafe suppliers.

## A Safe Contract

A safe contract is a contract that will be accepted by safe suppliers and rejected by unsafe suppliers. To

**Table 1.** The influence of contamination rate on the supplier's return per lot and buyer's cost per lot.

Contamination rate	Probability that a lot passes inspection	Probability that a contaminated lot passes inspection	Production cost per lot (\$)	Supplier's return per lot (\$) <sup>a</sup>	Buyer's cost per lot (\$) <sup>b</sup>
0.00	0.99	0.000000	1.000	0.0046	1.0300
0.02	0.97	0.000206	0.942	0.0043	1.0403
0.04	0.95	0.000421	0.887	0.0020	1.0510
0.06	0.93	0.000644	0.835	-0.0024	1.0622
0.08	0.91	0.000878	0.787	-0.0090	1.0739
0.10	0.89	0.001121	0.741	-0.0177	1.0861

<sup>a</sup> Supplier's return per lot is net of inspection failure costs and the allocated portion of safety failure costs.

<sup>b</sup> Buyer's cost per lot includes the portion of safety failure costs that could not be allocated to the supplier.

design a safe contract, the buyer selects contract parameters that persuade the safe supplier to participate in the transaction, but deter the unsafe supplier. Contract parameters related to safety include the bid price, the safety standard (definition), premiums or discounts associated with deviation from the standard, the sampling plan, the diagnostic test used to measure safety, and provisions for sharing the cost of food safety failures. Of course, supply chain contracts include many other provisions in addition to those that influence safety.

These contract provisions influence safety because they influence the cost of delivering contaminated food. The supplier of contaminated food faces two kinds of costs. First, if a contaminated lot is delivered and fails inspection, the supplier faces an *inspection failure cost*. Inspection failure cost includes the cost of disposing of the contaminated food, penalties and fines that might be levied against the supplier, and the cost of the additional production that will be needed to replace the rejected lots. Second, if a contaminated lot is delivered and passes inspection, the supplier faces a *safety failure cost*. Safety failure cost is the cost associated with contaminated food entering the buyer's production system and, perhaps, causing an illness when

it reaches the consumer. Estimates of the safety failure cost are difficult to come by (see Buzby, Frenzen, & Rasco, 2001) and are different for private firms that seek to maximize profit and public agencies that seek to maximize consumer welfare and public health. Safety failure costs affect suppliers only if the supplier responsible for the failure can be identified and made to pay a portion of the cost associated with the safety failure.

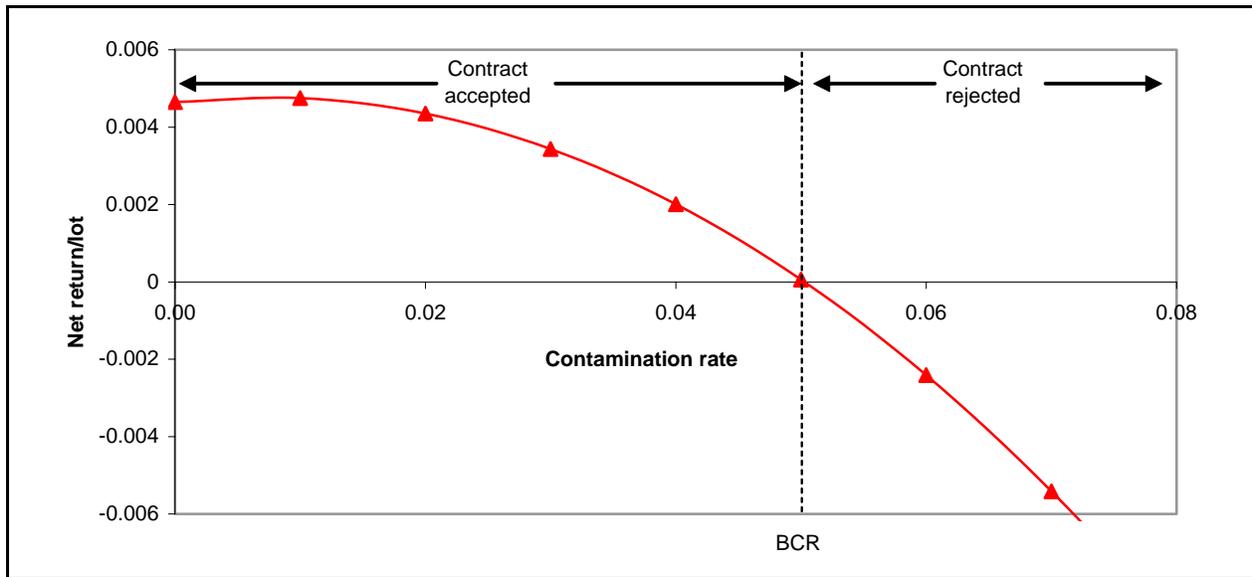
The probability that a supplier will have to pay an inspection failure cost or a safety failure cost depends on the accuracy of the inspection procedure. The probability of a false positive test result contributes to the probability that a supplier has to pay the inspection failure cost. The probability of a false negative test result influences the probability that a contaminated lot passes inspection. If a lot that passes inspection is contaminated, then the supplier may have to pay a portion of the safety failure costs.

### Segregating Safe and Unsafe Suppliers

A safe contract appeals to safe suppliers and does not appeal to unsafe suppliers. The appeal of a contract depends on the supplier's production cost, the probability of inspection failure, the probability of a safety fail-

ure, and the costs of inspection and safety failures. To illustrate this relationship, we examine the hypothetical case of a buyer offering to buy a product for \$1.03 per lot. (This price can be scaled up and down without changing the results.) The contract requires inspection with a pathogen test that exhibits 99% sensitivity and 99% specificity, and the buyer only pays for lots that pass inspection. The production cost is \$1.00 per lot for suppliers with no contamination. Suppliers with higher contamination rates have lower production costs. If the product fails inspection, the supplier pays \$0.50 per lot to dispose of the contaminated product, and if a contaminated lot passes inspection, the buyer must pay \$100 in safety failure costs. The buyer can allocate half of this cost to the supplier responsible for the failure.

Table 1 shows how contamination rate influences supplier return per lot in this hypothetical case. Suppliers break even at a contamination rate between 4% and 6%. This threshold is called the *breakeven contamination rate* (BCR) in Figure 1. Suppliers with a contamination rate below the BCR will accept the contract because their return is positive, and suppliers with a contamination rate above this threshold will not because their return is negative. The



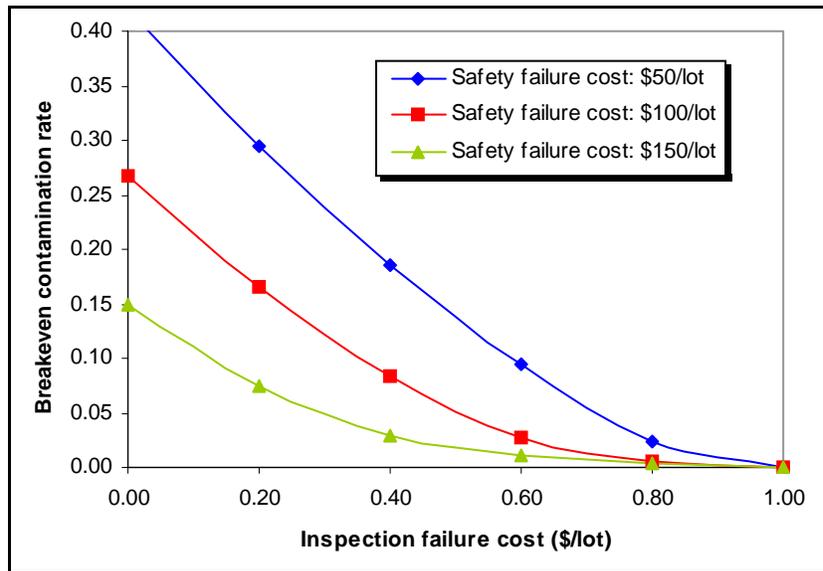
**Figure 1.** The breakeven contamination rate (BCR).

lower the BCR, the safer the ingredients entering the food supply chain.

Buyers and policy makers can influence the BCR by changing the parameters of the contract: the inspection and safety failure costs, the type and accuracy of the inspection procedure, or the bid price. Figure 2 shows the influence of inspection and safety failure costs on the BCR in our hypothetical case. As the inspection failure cost increases, the threshold declines. The threshold also declines when the safety failure cost increases. Suppliers who have a contamination rate above the threshold are dissuaded from participating unless, of course, they make the investment or exert the effort required to reduce their contamination rate.

### An Opportunity for Buyers and Policy Makers

Private firms and public agencies often use contracts to regulate transactions with suppliers. Prudent contract design can segregate safe and unsafe suppliers and lead to an improvement in the safety of food



**Figure 2.** The effect of inspection and safety failure costs on the BCR.

purchased for school lunch programs, the military, food service, and other distribution channels. This opportunity exists even if suppliers know more about product safety than buyers do. Imperfect information about safety exposes both suppliers and buyers to significant financial risks. In a carefully designed contract, these financial risks can be used to deter unsafe suppliers from delivering harmful product.

However, poor contract design can lead to problems. First, if the safety failure and inspection failure costs are too high, the market will fail because no suppliers will participate. Second, if the safety failure and inspection failure costs are too low, then segregation is infeasible because all suppliers will accept the contract. Third, even if a contract effectively segregates suppliers, adverse selection can exist for the set of suppliers below the threshold. When the buyer

cannot tell the difference between suppliers with nearly zero contamination and suppliers with contamination near the BCR, the buyer will offer a price that the safest suppliers find unsatisfactory. If this happens, the safest suppliers are likely to relax their efforts directed toward food safety. Finally, if suppliers have the option of avoiding inspection (because of a third-party certification of safety, for instance), perverse incentives that lead to cheating and less safe food can enter the supply chain (see van Ravenswaay & Bylenga, 1991, for an example).

Buyers have several strategies available for ensuring that suppliers deliver safe food ingredients. These strategies include reducing measurement error through improved diagnosis, vertical integration, and motivating suppliers to provide safety signals. These strategies are not possible in all supply chains, and even when they are possible, they can be expensive. Careful contract design is a relative inexpensive alternative that has promising potential for improving food safety.

### For More Information

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