Three essays on livestock biosecurity and traceability

by

James L. Mitchell

B.S., Oklahoma State University, 2014

M.S., Oklahoma State University, 2016

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the
requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

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Abstract

Chapter 1: The Effects of Production Contracts on Biosecurity Adoption by United States Hog Producers

Production contracts play an important role in U.S. livestock production. As their use has grown, so has the need to understand their influence on production practices. Understanding the link between production contracts and health management practices, for example, is crucial to policies and analysis of the preparation for, and potential consequences of larger scale animal disease outbreaks in the United States. The benefits and costs, as well as tolerance for disease risks, are likely different among independent producers and operations utilizing some form of production contracts. Using results from a 2017 survey of U.S. hog producers, we estimate the effects of production contract use on adoption of enhanced biosecurity practices. The main result of this chapter is that contracting producers are more likely to adopt biosecurity. We find evidence that the effect of production contracts is heterogeneous across enterprise types.

Chapter 2: The Market for Traceability with Applications to U.S. Feeder Cattle

For voluntary traceability programs, a key interest for program designers and policymakers is how to encourage participation. We contend that participating in voluntary traceability can be viewed as a product characteristic, and thus serves as a source of product differentiation. We study the implicit market for traceability systems for the first known time. In our empirical example, we use stated choice experiments to link feeder cattle sellers and buyers through premiums and discounts for cattle traceability systems. Using results from discrete choice models, we simulate changes in traceability supply and demand in response

to prices and policies. We find that cost-share policies might be an effective way of encouraging participation for feeder cattle sellers and could serve as an alternative to mandating traceability.

Chapter 3: Cow-Calf Producer Willingness to Report Disease: A Test of Adverse Selection

Animal health agencies' efforts to prevent and control foreign animal disease outbreaks depend on, among other factors, timely livestock producer self-reporting of disease suspicions. Adverse selection applies to disease reporting because livestock producers have private information about their disease status. Policymakers want to know how to set policy variables such that producers reveal private information about disease status, early, before the disease spreads. In this chapter, we study the effects of disease prevalence and indemnity payments on cow-calf producer willingness to report foot-and-mouth disease (FMD) suspicions. A novel test of adverse selection arises because we can determine how the rate of disease reporting adjusts to policy variables evaluated at different disease prevalence rates. Producers that report FMD suspicions do so early such that the effects of policy variables diminish at high prevalence rates.

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Approved by:

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Dedication

To Mauresa.

Chapter 1

The Effects of Production Contracts on Biosecurity Adoption by United States Hog Producers

1.1 Introduction

Livestock biosecurity is a set of on-farm practices designed for infectious disease prevention and control. Biosecurity also includes disease surveillance, risk assessments, and practices used to limit production losses following exposure. Together, these practices form an operation's biosecurity plan. Isolating and determining the effectiveness of a single biosecurity practice or a combination of practices is challenging. Biosecurity practices range in complexity and efficacy, and adoption occurs at the intersection of several factors.

Today, biosecurity is at the forefront of larger animal health and food safety concerns. The coronavirus (COVID-19) outbreak is an example where a disease was transferred from animals (bats) to humans (zoonotic disease) (World Health Organization-China Joint Mission, 2020).[1] The U.S. Center for Disease Control and Prevention (CDC) estimates that 3

[1] It is still not known which intermediate hosts were associated with the transmission of the disease to humans (World Health Organization-China Joint Mission, 2020).

out of every 5 diseases in humans are zoonotic (Center for Disease Control and Prevention, 2019). Beyond human health, contageous diseases also have important agricultural productivity and economic implications. The 2013 U.S. porcine epidemic diarrhea virus (PEDV) outbreak resulted in average annual economic losses ranging from $900 million to $1.8 billion for the 2013-2018 period (Paarlberg, 2014). The 2014 U.S. highly pathogenic avian influenza (HPAI) outbreak resulted in the death of more than 50 million chickens and turkeys (Ramos et al., 2017). The 165 detected cases of African swine fever (ASF) in China have resulted in the culling of 1.19 million pigs (Food and Agriculture Organization, 2020). While these examples have widely different implications and consequences, they highlight the importance of biosecurity in animal agriculture.

Central to broader biosecurity discussion is determining what role economic incentives play in biosecurity adoption. In recent years, the literature on the incentives to adopt biosecurity has grown substantially. Research has focused on policy (Gramig et al., 2009; Mitchell et al., 2020; Reeling and Horan, 2015), strategic interaction (Hennessy et al., 2005; Reeling and Horan, 2015), market prices (Tonsor and Schulz, 2020), and disease risk reductions (Gramig et al., 2010) as the main instruments to incentivize biosecurity adoption. An incentive that is ignored is the business arrangements characterizing the livestock operation under consideration.[2] The benefits and costs from biosecurity are likely different among independent producers and operations utilizing some form of production contracts.

The objective of this chapter is to determine the effects of production contracts on biosecurity adoption. We consider three components of a operations's biosecurity plan, 1) conducting biosecurity risk assessments, 2) providing written biosecurity procedures to employees, and 3) adopting specific biosecurity practices. Using data from a 2017 survey of U.S. hog producers, we estimate differences in biosecurity adoption between contracting and independent producers. An empirical problem that potentially hinders our ability to draw conclusions about the effects of production contracts is selection bias. We overcome possible selection bias by jointly estimating biosecurity adoption and production contract participation with

[2]Dong et al. (2010) show that contracting results in higher levels of a business protection input and Hennessy et al. (2019) note that contracting is an important consideration that is omitted from their model.

a bivariate probit model.

For the three components of biosecurity that we consider, results show a significant increase in the probability of adoption when the producer is a contract grower (contractee). Estimates for the effects of contracting on biosecurity adoption are also heterogenous. The key source of heterogeneity that we consider is the type of operation (e.g., wean-to-finish versus finishing operation). Among the operations we consider, we find a heterogenous effect for finishing operations.

1.2 Production Contracts and Biosecurity

A hog production contract is an agreement where a contractee or grower raises or grows pigs that are owned by a contactor or integrator.[3][4] The use and structure of production contracts in U.S. livestock production have evolved. From 1992 to 2009, the percent of U.S. hog operations using production contracts grew from 3% to 48%, and the percent of hogs grown under contract grew from 5% to 71% (Mcbride and Key, 2013). More recently, 11.5% of U.S. hog operations are contract growers, and hogs grown under contract represent 43.0% of total production (National Agricultural Statistics Service, 2019).[5]

The structure of livestock production contracts changes the types of price, production, financial, and disease risks that producers face. Broadly, a standard production contract involves a base payment with bonuses or premiums built into the contract. The design of production contracts allow for solutions to the classic economic problems of moral hazard and adverse selection. Moral hazard might arise if producers take less care at raising or growing animals that they do not own. Adverse selection might arise if a producer has private information about which type of operation they are (e.g., efficient versus inefficient). Contract designs to solve adverse selection and moral hazard can take many forms which might include a tournament contract or premiums based on predetermined performance

[3] Langemeier (1993) provides a more detailed description of livestock production contracts.

[4] Throughout the chapter we will use the terms contractor, integrator, firm, and principal interchangeability. Likewise, we will use contracting producer, contracting operation, and agent interchangeability.

[5] The calculation is a percent of total U.S. hog operations with inventory, which include contract growers, contractor or integrator, and independent grower.

measures. Performance measures typically include feed efficiency and/or death loss which are easily measured and verifiable by the producer and the contractor firm.

Contract terms list the duties of the grower and the firm. Duties include general management responsibilities, animal handling, and environmental practices, among many others. Grower duties also include health management and biosecurity, which are part of the firm's best management practices. Best management practices are private actions taken by the producer. These private actions might be difficult for a firm to observe and verify. The question then arises, what mechanisms act through production contracts to result in different biosecurity actions than what a producer would take otherwise?

We argue that there are two potential mechanisms that act through production contracts to result in different levels of biosecurity practice adoption. First, to verify that producers are compliant with biosecurity, contractors subject all operations to internal audits. In practice, auditing takes the form of firm production managers performing routine standard site visits and verifying that all processes are being completed correctly following the guidelines that have been established through the contract. The prospect of on-farm assessments increases the likelihood of biosecurity adoption by contracting operations. Failure to comply with biosecurity standards could result in penalties or contract termination. Second, contractors or integrators provide pigs for growing (inputs) and serve as sellers, and in many cases packers, for finished hogs (outputs). Firms also provide feed, veterinary services, supplies and when a mortgage exists on the contracting producer's facilities provide a long-term contract that will match the length of the loan. Thus, losing a production contract would result in a loss of market access for inputs, outputs, and sources of credit. Another benefit to raising hogs on contract is access to manure which is often a big driver, especially in the Midwest. Hog manure offers a opportunity to offset fertilizer costs. Third, while biosecurity adoption is not observable by the firm, outcomes that biosecurity adoption are associated with are observable. Namely, performance which could vary depending upon feed efficiency, morbidity, and mortality. A firm could simply make compensation conditional on or a function of herd health and productivity.

1.3 Conceptual Framework

This section provides a simple model of biosecurity adoption to illustrate key differences that arise between contracting and independent growers. To do this, we bring together the literature on biosecurity and damage control inputs (Chi et al., 2002; Gramig et al., 2010) and the literature on livestock production contracts (Dong et al., 2010; Dubois and Vukina, 2004; Muth et al., 2007). In the livestock production contract literature, researchers model grower effort as a broad collection of production actions. Grower effort is related to output through the effects of effort on feed conversion (Dubois and Vukina, 2004). However, the biosecurity literature makes a distinction between productive and biosecurity inputs, which have different effects on output, and thus grower incentives. We model this distinction for independent and contract growers.

There are three types of producers $i \in \{I, C, A\}$ where I denotes an independent grower, C denotes a contract grower that does not face auditing, and A denotes a contract grower facing auditing. We assume that there is a representative grower for each type. Throughout, let us assume that growers operate in isolation so that there are no strategic interactions or livestock disease externalities. At the beginning of a feeding period, growers decide on biosecurity practices $b^i = (b^i_1, b^i_2, ..., b^i_K)$ to adopt and grower effort $e^i = (e^i_1, e^i_2, ..., e^i_N)$. Like Gramig et al. (2010) we will focus on discrete biosecurity practices so that $b^i_K \in \{0, 1\}$ and regard them as practices functioning to prevent disease during the feeding period. Likewise, we consider the discrete case of producer effort so that $e^i_k \in \{0, 1\}$. Biosecurity adoption and effort are costly and have price vectors $c_b = (c_{b1}, c_{b2}, ..., c_{bK})$ and $c_e = (c_{e1}, c_{e2}, ..., c_{eN})$, respectively, which implies that all pay the same price.[6]

During the feeding period some level of disease $D = D(b^i) \in [0, 1]$ is realized after b^i is adopted. Here $D(b^i) = 1$ implies that b^i has no effect on the prevalence of the disease and $D(b^i) = 0$ implies that b^i completely prevents that disease. We maintain the assumption of Gramig et al. (2010) that $D(0) \geq D(b^i)$ when b^i includes at least one nonzero element. By not indexing disease by producer type, we are assuming that biosecurity efficacy is the same

[6] Relaxing this assumption is not crucial to the main result.

for all producers.[7]

Disease has a destructive effect on output. Specifically, the share of output destroyed by disease is $G(D) \in [0, 1]$ where $G(\cdot)$ is the damage function (Lichtenberg and Zilberman, 1986). Alternatively, $G(D)$ can be thought of as the mortality rate. Output is defined as total pounds of live weight produced $N^i W_L^i$ where N^i is the number of pigs and W_L^i is live weight.[8] Feeder pigs weigh W_F^i. Thus, the total amount of output that survives the production process is $N^i W_L^i [1 - G(D(b^I))]$. Disease and effort have production efficiency effects. We write the grower-specific feed conversion rate $F^i(e^i, D(b^i)) \in [0, \infty]$ and assume $\partial F(\cdot)/\partial D(\cdot) > 0$. The feed conversion rate is the pounds of feed per pound of gain. $D(0) \geq D(b^i)$ implies $F^i(D(0)) \geq F^i(D(b^i))$ when b^i includes at least one nonzero element.

1.3.1 Adoption for an Independent Producer

At the beginning of the feeding period, the independent grower purchases feeder pigs N^I at weight W_F^I and pays market price P_F in dollars per pound. The independent grower owns and can sell the output at price P_L in dollars per pound. Finally, feed costs are c_F in dollars per pound. The independent grower's profit for the feeding period is

$$\pi^I = P_L N^I W_L^I \Big[1 - G\Big(D(b^I)\Big)\Big] - P_F N_F^I W_F^I - c_F F^I\Big(e^I, D(b^I)\Big) N^I \times \\ \Big[W_L^I \Big[1 - G\Big(D(b^I)\Big)\Big] - W_F^I\Big] - c_b \cdot b^I - c_e \cdot e^I \tag{1.1}$$

The usual decision rule applies for the adoption of discrete practices. An independent producer will adopt biosecurity practice b_k^I if $\pi_{k=1}^I - \pi_{k=0}^I > 0$ where $\pi_{k=1}^I$ is profit from adoption and $\pi_{k=0}^I$ is profit from non-adoption.

[7]There are several specific examples where this is not true. However, we have no way of definitively arguing how efficacy from collective biosecurity adoption varies between independent and contract growers. That is, differences in efficacy will be practice-specific.

[8]Alternatively, N^i can be viewed as the amount of pig space measured in number of pigs or size of production facilities.

1.3.2 Adoption for a Contracting Producer

In this section, we model producer decisions for a given set of contract terms. We are not interested in the contractor-contractee relationship or the design of contracts.

The first difference between independent and contract growers is recognizing that a contract grower does not own the output produced, and thus compensation is not equal to the market price. Likewise, contract growers do not pay for variable inputs and feeder pigs. Payment can take many forms. We will use a variant of the payment scheme developed in Dubois and Vukina (2004). The second difference is that contracting producers might be required to use a certain combination or amount of inputs to produce outputs, as described in the contract terms. For example, a contractee might have to adopt specific animal welfare practices or manage water and waste according to a contractor's guidelines. In our context, a contracting producer might be required to adopt certain biosecurity practices. In what follows, we will consider these two key differences.

Without Auditing. Suppose that a contractor would like to encourage adoption of biosecurity b^C. However, during a feeding period, a contractor cannot perfectly observe a contractee's biosecurity adoption. The contractor knows there is a relationship between biosecurity and disease. Moreover, the contractor knows that disease influences mortality and feed efficiency. As such, the contractor structures bonuses around feed efficiency and mortality. For the contractee, compensation takes the form $P^C = base + bonus$. The contract grower receives a base payment that is determined by pig space, $base = \beta_1 N^C$. bonus is determined by the grower's feed conversion relative to a benchmark feed conversion. That is,

$$bonus = \beta_2\Big(\bar{F} - F^C\Big(e^C, D(b^C)\Big)\Big)N^C\Big[W_L^C\Big[1 - G\Big(D(b^C)\Big)\Big] - W_F^C\Big]. \quad (1.2)$$

The contract grower's wealth for the period is

$$R^C = \beta_1 N^C + \beta_2 \Big(\bar{F} - F^C\Big(e^C, D(b^C)\Big)\Big) N^C \Bigg[W_L^C \Big[1 - G\Big(D(b^C)\Big)\Big] - W_F^C\Bigg] - \tag{1.3}$$
$$c_b \cdot b^C - c_e \cdot e^C$$

and adoption occurs if $R^C_{k=1} - R^C_{k=0} > 0$, for practice b^C_k.

With Auditing. In this scenario, a contractor would like to incentivize a grower to adopt a specific set of biosecurity practices, defined by $\bar{b} = (\bar{b}_1, \bar{b}_2, ..., \bar{b}_K)$. However, during a feeding period, a contractor cannot observe a contractree's choice of b^A. Instead, a contractor can audit growers with auditing probability $\alpha \in [0, 1]$. A penalty is applied $\beta_3 \cdot max(0, \bar{b} - b^A)$ when the producer is audited where β_3 is an exogenously determined parameter measuring the severity of the penalty.

In this scenario, given the payment scheme in equation 1.2, grower wealth is

$$R^A = \beta_1 N^A + \beta_2 \Big(\bar{F} - F^A\Big(e^A, D(b^A)\Big)\Big) N^A \Bigg[W_L^A \Big[1 - G\Big(D(b^A)\Big)\Big] - W_F^A\Bigg] - \tag{1.4}$$
$$c_b \cdot b^A - c_e \cdot e^A - \alpha\beta_3 \cdot max(0, \bar{b} - b^A)$$

and adoption occurs if $R^A_{k=1} - R^A_{k=0} > 0$, for practice b^A_k.

1.3.3 Comparisons

Recall, we care about determining which producer is more likely to adopt biosecurity. We can do this by comparing adoption decision rules across producers. The idea is to compare $\pi^I_{k=1} - \pi^I_{k=0}$, $R^C_{k=1} - R^C_{k=0}$, and $R^A_{k=1} - R^A_{k=0}$ which will determine which grower is more likely to comply with b_k. Comparisons are made easier through normalization of several terms. Let $N^I = N^C = N^A = 1$, $W^I_L = W^C_L = W^A_L = 1$, and $W^I_F = W^C_F = W^A_F = 0$. Thus, we are evaluating growers of similar size with similar live hog and feeder pig weights. Further, assume that we are evaluating growers at constant effort so that $e^I = e^C = e^A = e$. Given equations 1.1, 1.3, and 1.4, grower I, C, and A will adopt practice b_k if

$$P_L\left[G\big(D(0)\big) - G\Big(D(b_k^I)\Big)\right] - c_{bk} > \tag{1.5}$$
$$c_F\left\{F^I\Big(e, D(b_k^I)\Big)\Big[1 - G\Big(D(b_k^I)\Big)\Big] - F^I\big(e, D(0)\big)\Big[1 - G\big(D(0)\big)\Big]\right\}\ \forall b_K^I = 1,$$

$$\beta_2\bar{F}\left[G\big(D(0)\big) - G\Big(D(b_k^C)\Big)\right] - c_{bk} > \tag{1.6}$$
$$\beta_2\left\{F^C\Big(e, D(b_k^C)\Big)\Big[1 - G\Big(D(b_k^C)\Big)\Big] - F^C\big(e, D(0)\big)\Big[1 - G\big(D(0)\big)\Big]\right\}\ \forall b_K^C = 1, \text{ and}$$

$$\beta_2\bar{F}\left[G\big(D(0)\big) - G\Big(D(b_k^A)\Big)\right] - c_{bk} + \alpha\beta_3 \cdot max(0, \bar{b}_k - 0) > \tag{1.7}$$
$$\beta_2\left\{F^A\Big(e, D(b_k^A)\Big)\Big[1 - G\Big(D(b_k^A)\Big)\Big] - F^A\big(e, D(0)\big)\Big[1 - G\big(D(0)\big)\Big]\right\}\ \forall b_K^A = 1,$$

respectively. For each grower, equations 1.5-1.7 show that three main effects are driving the adoption decision. The first term in each equation is the difference in returns from adoption. The second term in each equation is the unit cost of adoption. Finally, the third term in each equation is the cost differential that arises from changes in feed conversion and death loss. Equation 1.7 includes an additional term for the effects of auditing.

A type C contract grower is more likely to adopt b_k relative to an independent grower if $R_{k=1}^C - R_{k=1}^C > \pi_{k=1}^I - \pi_{k=1}^i\ \forall\ b_k^C = b_k^I = 1$. A visual inspection of equations 1.5 and 1.6 reveal that the likelihood that contract growers will have a higher rate of adoption will depend on how the benchmark feed conversion rate and bonus parameter are set relative to costs and market prices for the independent grower. A higher rate of adoption by contract growers also depends on the relative functional relationship between feed conversion, effort, and disease, i.e., grower production efficiency. To see this, assume that we are comparing growers with similar production efficiency, $F^I(\cdot) = F^C(\cdot)$. Combining equations 1.5 and 1.6

shows that a contract grower is more likely to adopt biosecurity practice b_K if:

$$\beta_2 \bar{F} > P_L. \tag{1.8}$$

$\beta_2 \bar{F}$ can be viewed as the maximum bonus payment, i.e., a feed conversion rate of zero. Equation 1.8 says that a contract grower will be more likely to adopt b_k if contract terms are set such that the maximum bonus is greater than market prices received by the independent grower.

A type A contract grower is more likely to adopt b_k relative to an independent grower if $R^A_{k=1} - R^A_{k=1} > \pi^I_{k=1} - \pi^i_{k=1} \; \forall \; b^C_k = b^I_k = 1$. From equations 1.5 and 1.7, relative adoption between type grower types A and I depends on how the benchmark feed conversion rate, bonus parameters, auditing probability, and auditing penalty are set for the contract grower relative to costs and market prices for the type I grower. Again, the functional relationship between feed conversion, effort, and disease will play an important role. Assuming that $F^I(\cdot) = F^A(\cdot)$ and combining equations 1.5 and 1.7 shows that a contract grower facing auditing is more likely to adopt biosecurity practice b_K if:

$$\beta_2 \bar{F} + \alpha\beta_3 \cdot max(0, \bar{b}_k - 0) > P_L. \tag{1.9}$$

Equation 1.9 says that a contract grower will be more likely to adopt b_k if contract terms are set such that the maximum bonus is greater than market prices received by the independent grower, adjusted by the prospect of auditing.

Equations 1.8 and 1.9 provide evidence that contract grower compensation and auditing might result in a contracting producer being more likely to adopt a biosecurity practice relative to an independent producer. This finding depends on how the contractor sets contract parameters. An assumption that might not be appropriate is that biosecurity adoption costs are the same across producer types. A likely alternative is that contractors cover or supply all the inputs associated with complying with biosecurity protocols so that $c^I > c^A = c^C$. Another simplifying assumption that abstracts from the nuances of hog production is that independent producers face output and input price risk whereas contracting producers do not in most cases. Finally, we have only considered one payment scheme for one type of hog producer. There are several different types of business arrangements that vary among enterprise types.

To conclude, the main prediction that we seek to test is that contracting producers are more likely to comply with biosecurity. This section also provides insights on which variables should be controlled for empirically to isolate the effects of production contracts. We have no way of knowing which contracting producers are subject to audits or face compensation based on mortality and feed efficiency. Thus, a significant finding for the effects of contracting does not mean that audits or compensation based on the disease are the reason for higher adoption. However, the lack of such a finding would suggest that audits or conditional compensation based on disease have no effect on a contracting producer's decision to adopt biosecurity practices.

1.4 Data

This chapter uses data from a 2017 survey of U.S. hog producers. The survey instrument was developed and tested in collaboration with university faculty, extension specialists, and other professionals with knowledge of U.S. hog production. The final survey instrument was granted exemption status by the Iowa State University Institutional Review Board and administered by the Iowa State University Center for Survey Statistics and Methodology (CSSM). CSSM developed survey cover letters and questions for web application using Qualtrics software.

Hog producers from Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, South Dakota, and Wisconsin received surveys electronically from March to April 2017. These 13 states were selected as they represent 60% of inventory and 90% of sales in the United States (National Agricultural Statistics Service, 2019). Producers were sampled from membership lists, and invitations to complete the survey were sent from respective state pork producers' associations.[9] Final data collection resulted in 371 complete or partially complete surveys.

The survey instrument collected information on producer demographics, current management questions, biosecurity investment and adoption, feasibility of implementation of specific biosecurity practices, and experiences with and perceptions of swine disease. The survey asked producers, "Which business arrangement best describes the agreement under which you are presently producing hogs?" and options included independent producer, contractor or integrator, contract grower (contractee), or other. For comparison, we limit the sample to producers that either identifies their business arrangements as an independent producer or contractee.

Determining how best to measure biosecurity has proven difficult in the literature, and there is no clear consensus. A farm's biosecurity plan is comprised of several protocols, procedures, and investments that range in complexity, efficacy, and cost. In the literature, biosecurity has been measured as a share of total investment (Mitchell et al., 2020), hypothetical annualized costs in stated choice questions (Tonsor and Schulz, 2020), biosecurity protocol adoption with adoption costs in experimental games (Merrill et al., 2019), and discrete adoption (Gramig et al., 2010; Pudenz et al., 2019). We consider a subset of the discrete biosecurity practices in Pudenz et al. (2019).

Collectively, the Center for Food Security and Public Health, Iowa State University, University of Minnesota, swine industry expert, and state and national government officials developed the Secure Pork Supply (SPS). SPS provides educational material, checklists, templates, and training for producers to enhance their preparedness for disease outbreaks. Central to SPS is enhanced biosecurity. The SPS provides enhanced biosecurity checklists and plans for each sector of the U.S. swine industry.

Here, we consider the adoption of three separate and distinct biosecurity practices from SPS that were included in the survey: biosecurity risk assessment ($BioRisk$), always providing a written site-specific biosecurity plan to employees ($BioPlan$), and clearly defining a perimeter buffer area (PBA). A site-specific biosecurity plan is a collection of protocols

[9] Similar producer sampling procedures were used by Roe et al. (2004).

that range from entry/exit guidance from the site to feed and manure management. Biosecurity risk assessments evaluate a farm's biosecurity and identify risk factors for disease and herd health that can be mitigated through changes to an operation's biosecurity. Providing site-specific biosecurity procedures to employees helps ensure that everyone entering and on the production site is compliant with biosecurity procedures.[10] A PBA functions to keep potentially pathogen contaminated personnel, vehicles, and equipment from contaminating swine production areas. The PBA is the first line of defense to protect the pigs housed within its perimeter.Together, these three practices serve as key components to protecting from endemic and foreign animal diseases (Secure Pork Supply, 2017).

The final sample includes 223 observations after omitting incomplete survey responses. Table 1.1 provides variable abbreviations and definitions of all variables used in the analysis. In Table 1.2, we provide a summary of the data, difference in mean tests, and a comparison with data from the 2017 Census of Agriculture (Ag Census) when available. To make better comparisons, we only use Ag Census data for the 13 states surveyed. In our sample, 40% of producers are contracting produces, and 22.5% of producers (operations with inventory) from the Ag Census sample are contract growers. Producers are similar in operation type and PRRSV infection. PRRSV statistics are from the 2012 National Animal Health Monitoring System swine study. Differences between the data used in this chapter and Ag census data are expected. Producers in our sample have larger inventories relative to Ag Census data.

Contract producers have a higher adoption rate of all biosecurity practices considered (Table 1.2). The largest difference in adoption is for providing biosecurity procedures to employees ($BioPlan$). While this finding could be a function of production contracts, it is also likely that inventory is a determinant of differences in $BioPlan$ adoption. Larger operations require more employees, and thus providing biosecurity procedures becomes an important step in ensuring biosecurity compliance. Similarly, inventory could be a confounding factor in determining the effects of contracts on PBA adoption. Table 1.2 shows that 48% of contracting producers and 28% of independent producers adopt PBA. PBA helps

[10] The SPS provides an example of a site-specific biosecurity plan that can be accessed at: https://www.securepork.org/Resources/SPS-Biosecurity-Plan-Example-W-F-Indoor-Production.pdf.

prevent pathogens from entering production sites. As the number of of production sites (unique premise ID, unique address) in an operation increases, to house larger hog and pig inventories, PBA becomes important in preventing pathogen spread between sites where animals are raised.

Table 1.1: *Variables and Definitions*

Variables	Definition
Dependent Variables:	
BioRisk (0,1)	1 if the operation has conducted a self-administered biosecurity risk assessment
BioPlan (0,1)	1 if written site-specific biosecurity procedures are provided to employees
PBA (0,1)	1 if a perimeter buffer area is clearly defined for the operation
Independent Variables:	
Contract (0,1)	1 if currently a contract grower/contractee
Age (years)	Producer age
*Exp*30 (0,1)	1 if experience in hog production is greater than or equal to 30 years
College (0,1)	1 if college education or more
IA (0,1)	1 if operation is in Iowa
PRRSV (0,1)	1 if PRRSV outbreak on operation in the last 3 years
PEDV (0,1)	1 if PEDV outbreak on operation in the last 3 years
Operation (0,1)	1 if operation is farrow to finish (FarrowFinish); 2 if operation is wean to finish (WeanFinish); 3 if operation is finishing only (Finishing); 4 if operation is other.
MgmtPigs (0,1)	1 if growing pigs are managed other (other); 2 if growing pigs are managed continual flow (ContFlow); 3 if growing pigs are managed all-in/all-out by room (AllByRoom); 4 if growing pigs are managed all-in/all-out by building (AllByBuilding); 5 if growing pigs are managed all-in/all-out by site (AllBySite)
Inventory (0,1)	1 if hog and pig inventory is 1-999 head; 2 if hog and pig inventory is 1000-4999 head; 3 if hog and pig inventory is 5000-9999 head; 5 if hog and pig inventory is >10000 head
FacilityAge	Number of buildings in which hogs are raised are 10 years old or greater

Table 1.2: *Survey means for dependent and independent variables*

	All Operations N=223	Contract N=89	Independent N=134	Difference	2017[a] Ag Census
Dependent Variables:					
BioRisk (0,1)	0.52	0.60	0.46	-0.13*	
BioPlan (0,1)	0.57	0.76	0.45	-0.32***	
PBA (0,1)	0.36	0.48	0.28	-0.21***	
Independent Variables:					
Age	53.04	54.28	52.21	-2.072	49.20
FacilityAge	7.04	3.49	9.40	5.90**	
*Exp*30 (0,1)	0.63	0.57	0.67	0.10	
College (0,1)	0.57	0.55	0.59	0.04	
IA (0,1)	0.71	0.63	0.76	0.13**	0.09
PRRSV (0,1)	0.53	0.43	0.60	0.18***	0.46[b]
PEDV (0,1)	0.40	0.43	0.39	-0.039	
Operation (0,1)					
FarrowFinish	0.32	0.02	0.51	0.49***	0.29
WeanFinish	0.43	0.53	0.36	-0.17**	
Finishing	0.13	0.26	0.04	-0.21***	0.40[c]
Other	0.13	0.19	0.08	-0.11**	0.17
MgmtPigs (0,1)					
Other	0.05	0.02	0.07	0.04	
ContFlow	0.07	0.02	0.10	0.08**	
AllByRoom	0.19	0.12	0.24	0.12**	
AllByBuilding	0.34	0.34	0.34	0.00	
AllBySite	0.35	0.49	0.25	-0.24***	
Inventory (0,1)					
1-999	0.09	0.00	0.14	0.14***	0.69
1000-4999	0.14	0.11	0.16	0.04	0.20
5000-9999	0.22	0.29	0.17	-0.12**	0.11[d]
>10000	0.48	0.49	0.48	-0.02	

[a]Only for operations in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, South Dakota, and Wisconsin.
[b]From the 2012 National Animal Health Monitoring System swine study USDA–APHIS–VS–NAHMS (2012).
[c]The USDA's definition of a finishing hog operation is such that it does separate wean to finish from finishing operations.
[d]5,000 or more in hog and pig inventory.

1.5 Empirical Framework

The theoretical model predicts that contracting producers are more likely to adopt biosecurity. We test this prediction by exploiting cross-sectional variation in biosecurity adoption in survey data among contracting and independent producers. To start, we assume that binary biosecurity adoption Bio_i is determined by

$$Bio_i = 1[\boldsymbol{x_i}'\boldsymbol{\beta} + \gamma Contract_i + \varepsilon_i > 0] \tag{1.10}$$

where $1[\cdot]$ is the indicator function equal to one if $\boldsymbol{x_i}'\boldsymbol{\beta} + \gamma Contract_i + \varepsilon_i > 0$, $\boldsymbol{x_i}$ is a vector of controls, $\boldsymbol{\beta}$ is a parameter vector, $Contract_i$ is the business arrangement for producer i that equals one if the producer operates under production contracts and zero if the producer operates independently, γ is the effect of interest, and ε_i is the error term. With normally distributed errors, we would like to know the effects of production contracts on the response probability:

$$P(Bio_i|Contract_i, \boldsymbol{x_i}) = \Phi(\boldsymbol{x_i}'\boldsymbol{\beta} + \gamma Contract_i) \tag{1.11}$$

where Φ is the standard normal cumulative distribution function.

One problem with the model in equation 1.10 is that $Contract_i$ is not randomly assigned. As a result, MLE for the probit model will be inconsistent for $\boldsymbol{\beta}$ and γ. Non-random assignment is a result of producers' self-selecting into different business arrangements. Selection bias becomes less of a problem if one can provide a convincing argument for selection on observables and control for all observable differences between contracting and independent producers. However, in our context, there are several reasons why unobservables potentially play an important role in determining contract participation and biosecurity adoption. A specific example in the hog production contract literature is management ability (Key and McBride, 2003). Like Key and McBride (2003), it is easy to see how management ability might be positively correlated with production contracts and biosecurity adoption.

One way to account for selection on unobservables is the bivariate probit model:

$$
\begin{aligned}
&Bio_i = 1[\boldsymbol{x_i}'\boldsymbol{\beta} + \gamma Contract_i + \varepsilon_i > 0] \\
&Contract_i = 1[\boldsymbol{z_i}'\boldsymbol{\alpha} + \upsilon_i > 0] \\
&(\varepsilon_i, \upsilon_i) \sim N\left(0, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}\right).
\end{aligned}
\tag{1.12}
$$

In equation 1.12, $\rho \neq 0$ implies that a single probit estimation would produce biased estimates because of correlation between $Contract_i$ and ε_i.

There are two ways through which the bivariate probit model in equation 1.12 is identified. The first is the case where $\boldsymbol{x_i} = \boldsymbol{z_i}$ and identification is driven by functional form assumptions. In particular, the model is identified from parametric assumptions made about the joint distribution of the error terms. While this approach might be appealing, many in the literature are critical and argue that results can be fragile (Altonji et al., 2005; Maddala, 1983; Mourifié and Méango, 2014).

The second approach is well known and uses exclusion restrictions to identify the parameters in the model. In our model, we use the exclusion restriction that the number of facilities that are greater than 10-years-old ($FacilityAge$) enters the contracting equation but has no direct channel through which it determines the adoption of the types of biosecurity that we consider. Integrators and contractors can offer contract growers loans for buildings, facility improvements, and equipment, as well as help build facilities (Langemeier, 1993). Thus, it is hypothesized that contracting producers will have fewer old buildings. Recent estimates support the hypothesis. According to Eric Haveman, an ag lending vice president for the Sioux Center American Savings Bank, "more than 80 percent of hog buildings constructed in the last few years have come attached to a contract from a large producer." (DeYoung, 2019)

The types of biosecurity practices that we consider are low investment practices that require a high level of adoption to be effective. We cannot think of a plausible reason why

$FacilityAge$ would directly determine adoption of the three practices that we consider. As an example, there is no reason why producers with fewer old buildings would be more/less compliant with providing employees with biosecurity procedures relative to producers with more older buildings. This exclusion restriction would be hard to justify for practices that require a high investment. For example, producers with more older buildings would be reluctant to invest in new air filtration systems that improve air quality and prevent the introduction and spread of disease.

The next obvious problem with our exclusion restriction is determining whether $FacilityAge$ is correlated with management ability and ε. $FacilityAge$ captures the age of the production technology used in hog production (McBride, 2003). In general, managerial skill is a broad term related to several production decisions that go beyond biosecurity. To purge any correlation that $FacilityAge$ has with ε, we include as many observables in $\mathbf{x}$ that are likely predictors of management skill and biosecurity adoption. For example, experience, age, education are likely highly correlated with overall management skills. We also include past outbreaks of PEDV and PRRSV as controls in $\mathbf{x}$. PEDV and PRRSV outbreaks are likely correlated with the portion variation in management ability that is correlated with production contracts and biosecurity adoption.

1.6 Results

This section focuses on the empirical results of the chapter. We begin the section by presenting baseline results from probit models that ignore selection bias and consider the importance of different sets of confounding factors. As a robustness check, we estimate the effects of production contracts for a more homogeneous subsample of the data. Next, we provide results from bivariate probit models to control for selection bias. Finally, we consider heterogeneity and use model predictions to determine the number of operations adopting biosecurity under different business arrangement scenarios.

Results in Table 1.3 are from probit estimations that consider different sets of control variables. Results in Column (1) are from the regression of biosecurity on production contracts without controls. Without controls, the average marginal effect ranges from 0.13 for biosecurity risk assessment ($BioRisk$) to 0.32 for providing biosecurity procedures to employees ($BioPlan$) and is equivalent to a raw difference in means. Column (2) controls for operation type. Different operation types have different contractual obligations and tolerances for disease risks. For example, the implications for a disease outbreak in a gilt developer unit, which supplies genetics (breeding stock), are drastically different from those for an operation growing hogs for marketing. A feature of the swine industry is the development of production pyrmids (Ramirez and Zaabel, 2012). As part of production pyramids, the health pyramid concept, which seeks to minimize the downstream effects of disease by controllingfor disease toward the top of the pyramid and thus prioritizes the health of animals in the genetic nucleus and multiplication population, followed by farrowing and gestation, nursery, and lastly finishing animals (Ramirez and Zaabel, 2012). When we control for operation type, we see a slight change in marginal effect estimates, relative to Column (1). The average marginal effect for $Contract$ ranges from 0.198 for $BioRisk$ to 0.30 for $BioPlan$, and all are statistically significant (Table 1.3 Column 2).

Together, controlling for operation type and inventory in Column (3) have an impact on estimated marginal effects and appear to be important predictors of biosecurity adoption. Relative to Column (1), controlling for operation type and inventory decreases the marginal effect 9.8 percentage points for $BioPlan$ and increases the marginal effect 4.2 and 2.6 percentage points for $BioRisk$ and PBA, respectively. Column (4) includes the full set of controls. Relative to Column (3), including additional controls has a small impact on estimated average partial effects. However, relative to Column (1), the direction of change in the average marginal effects from including all controls reduces the range across biosecurity practices. In Column (4), the average marginal effect ranges from 0.19 to 0.23, whereas the range of the effect is 0.13 to 0.32 in Column (1).

As a robustness check, we conduct a similar assessment for a subsample of the data. The last four Columns in Table 1.3 are from data that only include wean to finish, farrow to finish, and finishing sample, which allows for comparisons among a more homogenous group of producers. The full sample includes additional (Other) operations such as gilt

Table 1.3: *Maximum likelihood estimates and average partial effects (APE) from probit models for the effects of production contracts on biosecurity adoption*

	Full Sample N=223				Sub Sample N=195			
BioRisk	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.34*	0.52**	0.47**	0.51**	0.273	0.55**	0.53**	0.53**
	(0.17)	(0.21)	(0.22)	(0.23)	(0.19)	(0.23)	(0.24)	(0.25)
APE	0.13**	0.20***	0.18**	0.19**	0.11	0.21**	0.20**	0.20**
	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)
R-squared	0.01	0.04	0.05	0.07	0.01	0.03	0.04	0.06
BioPlan								
Estimate	0.85***	0.80***	0.64***	0.69***	0.90***	0.84***	0.72***	0.70***
	(0.18)	(0.21)	(0.23)	(0.24)	(0.20)	(0.24)	(0.25)	(0.26)
APE	0.32***	0.30***	0.22***	0.23***	0.33***	0.31***	0.25***	0.23***
	(0.06)	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)
R-squared	0.07	0.09	0.16	0.18	0.08	0.09	0.15	0.18
PBA								
Estimate	0.55***	0.72***	0.66***	0.69***	0.48**	0.72***	0.70***	0.70**
	(0.18)	(0.15)	(0.23)	(0.25)	(0.19)	(0.25)	(0.25)	(0.28)
APE	0.21***	0.26***	0.23***	0.23***	0.18**	0.26***	0.24***	0.22***
	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)
R-squared	0.03	0.07	0.09	0.15	0.03	0.05	0.07	0.14

Notes: The full sample includes operation types and the sub sample only includes farrow to finish, wean to finish, and finishing operations. Columns (1) and (5) do not controls. Columns (2) and (6) includes *Operation* (four categories with weanfinish as the base) as control variables. Columns (3) and (7) are Columns (2) and (6) plus *Inventory* (four categories with ¿10,000 as the base) as controls. Columns (4) and (8) are Columns (3) and (7) plus *Age*, *College*, *Exp*30, *IA*, *PRRSV*, *PEDV*, and *MgmtPigs* (five categories with AllByRoom is the base). Standard errors in parentheses. APE standard errors are calculated using the delta method. *p<0.1; **p<0.05; ***p<0.01.

developer units and breeding operations, which likely results in greater differences in overall production and biosecurity. With no controls, the average marginal effect of *Contract* is 0.11, 0.33, and 0.18 for *BioRisk*, *BioPlan*, and *PBA*, respectively (Table 1.3 Column 5). The estimate and average marginal effect in Column (5) are not statistically significant for *BioRisk*. Interestingly, relative to the full sample, including additional controls has a similar effect on the direction of change and magnitude of the average marginal effects. The average marginal effect in Column (8) ranges from 0.20 to 0.23 for the subsample and from 0.19 to 0.23 in Column (4) for the full sample.

1.6.1 Selection Bias

Here, we control for selection bias by estimating bivariate probit models that utilize an exclusion restriction. The exclusion restriction that we use is that *FacilityAge* is an important determinant of contract participation but has no direct effect on biosecurity adoption for the types of practices that we consider. As another example, the fourth component of the SPS enhanced biosecurity plan is a line of separation (LOS). Clearly defining a LOS for each building provides a physical barrier to prevent pathogen contact between the outside and pigs being housed on-site. Since a LOS is directly related to hog buildings, the type and how a LOS is defined will likely depend on the age of the building and is an example where our exclusion restriction would not work.

As a crude test to determine if *FacilityAge* is a good predictor of contract participation, we estimate probit models for contract participation and use a likelihood ratio test to determine if *FacilityAge* should be included in the model (Table 1.4). Likelihood ratio test results reject the restricted model in favor of including *FacilityAge* as a predictor of contract participation. Among the variables included, *Exp*30, *PRRSV*, and *FacilityAge* are associated with a lower probability of being a contract producer. Relative to farrow to finish operations, wean to finish, finishing, and other operations are associated with a higher probability of being a contracting producer.

For brevity, the full set of results for bivariate probit models are suppressed, and attention is given to marginal effects for contract and the correlation parameter estimate (Table 1.5).[11] Correlation between unobservables ranges from 0.15 for the bivariate probit model with *BioRis*k and *contract* to -0.50 for the model with PBA and *contract*. For each of the bivariate probit models, we fail to reject the null $H_0 : \rho = 0$, which can be used as a test of exogeneity for contract if we assume the exclusion restriction holds (Wooldridge, 2010). Despite this finding, we observe noticeable differences in the average partial effect relative to probit models that ignore selection bias. The most significant difference is for the effects of contract on PBA. The average partial effects for *contract* are 0.11, 0.37, and 0.43 for $BioRisk$, $BioPlan$, and PBA, respectively, and standard errors are generally larger for the bivariate probit relative to probit models that treat contract as exogenous.

1.6.2 Heterogeneous Effects

An important consideration is determining whether the effects of production contracts are heterogeneous across producers. A potential source of heterogeneity is operation type. Different operations will have different tolerance for diseases risks and contract obligations vary significantly from one operation type to another which could lead to a heterogenous effect for production contracts. For example, a production contract for a finishing operation will have detailed animal health and biosecurity protocols for feeder pig through finishing management while farrow to finish operations would have a more complex biosecurity plan which would include breeding, gestating, farrowing, lactating, weaning through finishing management.

In Table 1.6, we report marginal effects from models that interact *contract* with binary variables for operation type. We find a statistically significant heterogenous effect for finishing operations for $BioPlan$ and PBA adoption. The effect of contracting is larger for $BioPlan$ and smaller for PBA adoption relative to operations that are not finishing operations. When there is not a statistically significant interaction term, marginal effects are similar to those in Column (4) of Table 1.3. The effect of contracting for BioRisk ranges from 0.15 to 0.20 in Table 1.6 and is 0.19 in Column (4) of Table 1.3. Not finding heterogenous

[11] Because of issues with convergence, we do not estimate bivariate probit models for the subsample of the data that only includes wean to finish, farrow to finish, and finishing operations.

Table 1.4: *Probit results for the regression of contracting on controls, N=223*

Variable	(1)	(2)
Intercept	-2.78***	-2.70***
	(0.726)	(0.743)
Age	0.03**	0.03**
	(0.012)	(0.013)
*Exp*30 (0,1)	-0.71**	-0.66**
	(0.303)	(0.308)
College (0,1)	-0.09	-0.12
	(0.232)	(0.235)
IA (0,1)	-0.30	-0.31
	(0.257)	(0.262)
PRRSV (0,1)	-0.37	-0.40*
	(0.227)	(0.231)
PEDV	0.41*	0.46*
	(0.230)	(0.236)
Operation (0,1)		
WeanFinish	1.78***	1.64***
	(0.378)	(0.380)
Finishing	2.68***	2.58***
	(0.465)	(0.467)
Other	2.29***	1.99***
	(0.446)	(0.454)
MgmtPigs (0,1)		
Other	-0.79	-0.908
	(0.570)	(0.614)
ContFlow	-0.51	-0.32
	(0.706)	(0.681)
AllByRoom	0.08	0.07
	(0.336)	(0.338)
AllBySite	0.32	0.30
	(0.248)	(0.253)
Inventory (0,1)		
1-999	-0.35	-0.39
	(0.382)	(0.389)
1000-4999	0.22	0.26
	(0.444)	(0.449)
5000-9999	0.50	0.46
	(0.407)	(0.416)
FacilityAge		-0.10**
		(0.041)
Psuedo R-Squared	0.36	0.38
Log-likelihood	-96.32	-93.00
$H_0 : FacilityAge = 0$		6.65***

Note: Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 1.5: *Maximum likelihood estimates and average partial effects (APE) from probit and bivariate probit models for the effects of production contracts on biosecurity adoption, N=223*

BioRisk	Probit	Bivariate Probit
Estimate	0.51**	0.29
	(0.23)	(0.92)
APE	0.19**	0.11
	(0.08)	(0.35)
ρ		0.15
$H_0 : \rho = 0$		0.09
BioPlan		
Estimate	0.69***	1.13
	(0.24)	(1.04)
APE	0.23***	0.37*
	(0.08)	(0.22)
ρ		-0.23
$H_0 : \rho = 0$		0.88
PBA		
Estimate	0.69***	1.47**
	(0.25)	(0.68)
APE	0.23***	0.43***
	(0.08)	(0.09)
ρ		-0.502
$H_0 : \rho = 0$		2.53

Note: SThis table reports results for the full sample that includes all operation types. In the bivariate probit model the exclusion restriction is that $log(FacilityAge)$ is included in the production contract equation but not the biosecurity adoption equation. Controls include *Age*, *College*, $Exp30$, IA, $PRRSV$, $PEDV$, and $MgmtPigs$ (five categories with AllByRoom is the base), *Inventory* (four categories with ¿10000 as the base), and *Operation* (four categories with weanfinish as the base). Standard errors in parentheses. APE standard errors are calculated using the delta method. *p<0.1; **p<0.05; ***p<0.01.

effect for WeanFinish and Other might be due to a lack of variation in operation type among independent producers (Table 1.2).

Table 1.6: *Heterogenous average partial effects from probit models for the effects of production contracts on biosecurity adoption, N=223*

Variable	Risk Assessment			Biosecurity Procedures			PBA Defined		
Contract	0.20	0.15*	0.20**	0.29**	0.19**	0.25***	0.10	0.30***	0.23***
	(0.13)	(0.09)	(0.09)	(0.13)	(0.08)	(0.08)	(0.12)	(0.08)	(0.09)
$Contract \times WeanFinish$	-0.02			-0.08			0.21		
	(0.17)			(0.15)			(0.15)		
$Contract \times Finishing$		0.28			0.29*			-0.33***	
		(0.20)			(0.16)			(0.06)	
$Contract \times Other$			-0.07			-0.16			-0.02
			(0.22)			(0.19)			(0.18)
Pseudo R-Squared	0.07	0.08	0.07	0.18	0.19	0.18	0.15	0.17	0.15
LR Statistic	21.93	23.37	22.01	55.78	57.46	56.22	44.48	49.10	42.57

Note: This table reports heterogenous APEs for the full sample. Controls are *Age*, *College*, *Exp*30, *IA*, *PRRSV*, *PEDV*, and *MgmtPigs* (five categories with AllByRoom is the base), *Inventory* (four categories with ¿10000 as the base), and *Operation* (four categories with weanfinish as the base). Main effects for operation type are suppressed for convenience. Standard errors calculated using delta method. *p<0.1; **p<0.05; ***p<0.01.

1.7 Conclusion

This chapter determines the effects of contracting on biosecurity adoption. The focus is on three components of biosecurity in the Secure Pork Supply. Namely, conducting biosecurity risk assessments, providing biosecurity procedures to employees, and defining a perimeter buffer area. We find strong evidence that contracting producers are more likely to adopt biosecurity. Throughout the chapter, we argue that compensation based on disease status and quality assurance audits act through production contracts to result in higher biosecurity adoption. As a test of one particular hypothesis with implications for preparation for, and potential consequences of larger scale animal disease outbreaks in the United States, our analysis provides fodder for the discussion of the benefits of production contracts that extend beyond reducing producer input expenditures, accessing credit, and reducing risk that is typically examined in the literature. We find production contracts facilitate the adoption of enhanced biosecurity practices that might help provide business continuity in the event of a foreign animal disease outbreak as well as help protect operations from endemic diseases.

The results of this chapter are not without limitations. Throughout the chapter, we maintain that our target population is producers in the 13 states that represent the bulk of U.S. hog production. Still, our sample is heavily skewed towards Iowa producers. Future research should substitute the use of membership lists of state pork producer associations with alternative associations. Equally important, our identification relies on an exclusion restriction for the age of buildings used in hog production. A more detailed record of production practices, financial background, and production contract details might allow for future research to use a selection on observables identification strategy.

Several have documented structural change at the farm level (Key and McBride, 2007; O'Donoghue et al., 2012; Parcell et al., 2016; Taylor, 2007). Although the process of restructuring is ongoing, and the merits of industry structure are continually being debated, the net result is that the U.S. pork industry has held its ground domestically and has made major inroads in export markets. The United States has one of the most competitive pork industries in the world but still faces challenges. The economic impact of livestock disease has heightened and the importance of ensuring a continuous, safe, and wholesome supply of pork for consumers is at the forefront of many producer and industry-wide decisions. Production contracting should be regarded as one effective step, amongst many, in achieving enhanced biosecurity for the pork industry.

Chapter 2

The Market for Traceability with Applications to U.S. Feeder Cattle

2.1 Introduction

Throughout agriculture, there have been increasing calls for knowing additional information about food production. Food and livestock traceability programs that facilitate the sharing of information are product, industry, and country-specific. For example, the European Union's 2002 General Food Law mandates traceability for all food, food animals, and feed and includes sector-specific requirements (European Commission, Health and Consumer Protection Directorate-General, 2007). For several countries, traceability systems are established following food safety and animal disease events. For example, disease has been the driving force behind the development of several livestock traceability programs worldwide (World Perspectives Inc, 2018). In addition to food safety and animal disease, motives to develop traceability systems include supply chain management and product differentiation (Golan et al., 2004).

Varying motives among participants and the specificity of traceability makes answering policy questions challenging. Today, most policy debates have focused on whether voluntary participation is sufficient to meet the stated goals of a country's traceability goal. Mandatory traceability policies are best suited to address market failures from information asymmetries and the supply of a public good (Hobbs, 2003). Proponents of mandatory traceability have been met with varying levels of resistance at the farm-level (Smyth et al., 2006). In the United States, government subsidies for traceability costs have been used as an alternative policy tool to increase participation in livestock traceability (USDA–APHIS, 2018, 2020a). Developing traceability systems and answering traceability policy questions requires an understanding of economic incentives for participating individuals, firms, and industries.

The literature on the economics of food and livestock traceability has focused on consumer preference (Dickinson and Bailey, 2002; Hobbs et al., 2005), liability costs (Pouliot and Sumner, 2008), food recall costs (Resende-Filho and Buhr, 2007), contracting and the value of traceability (Resende-Filho and Hurley, 2012), contracting and information asymmetries (Hobbs, 2004; Resende-Filho and Buhr, 2008), transaction costs (Banterle and Stranieri, 2008), traceability perceptions and preferences (Schulz and Tonsor, 2010a,b), and aggregate economic impacts (Pendell et al., 2010, 2013). An area omitted from the literature is an investigation of the implicit market for voluntary traceability.

Golan et al. (2004) state that one motive for establishing traceability systems is to verify a product's credence attributes. Motivated by the seminal work of Rosen (1974), we go further by arguing that participating in voluntary traceability can be viewed as a product characteristic, and thus serves as a source of product differentiation. Souza-Monteiro and Caswell (2010) model an exogenously determined premium for traceability but do not directly consider traceability as a product characteristic in a market setting. Likewise, Dickinson and Bailey (2002) implicitly make this argument in their analysis of meat characteristics. The obvious question that follows is whether there is a market where premiums and discounts exist for traceability. Likewise, how do premiums and discounts available for traceability participation determine the aggregate provision of traceability?

This chapter studies the implicit market for traceability for the first known time. To do this, we adapt conceptual and empirical methods in order to link individual decision making to aggregate traceability supply and demand. Producers of an agricultural input supply traceability and downstream firms demand traceability. We use voluntary participation in

U.S. cattle traceability as an empirical application. The empirical application links feeder cattle sellers and feeder cattle buyers in a hypothetical feeder cattle market using stated choice experiments.[1] In the empirical application, we determine traceability premiums and discounts that clear the implicit market and study how participation adjusts to policies.

Determining how to encourage participation in a voluntary traceability system requires an understanding of the incentives (e.g., prices and policies) to adopt traceability and the value participants place on traceability system attributes. Results from this paper provide program designers with a framework that can be used to develop traceability programs. Of course, program designers are presented with a balancing act when deciding on how to develop a traceability system—namely balancing the attributes that make traceability useful and the incentives that might encourage adoption.

This chapter makes three main contributions to the literature. First, we recognize that there is an implicit market for voluntary traceability. The framework that we develop can be applied to other technology adoption problems where the technology leads to a price differential. In this context, agents interact in commodity markets, and prices determine the aggregate provision of traceability. Ignoring, supply, demand, and traceability price effects might lead to poorly designed policies.

Second, we contribute to the existing literature that uses stated choice experiments to assess farmer decision making. Despite the extensive use of stated choice experiments, none have considered both sides of an economic transaction through the simulation of hypothetical markets. Motivated by our first contribution, we show how stated choice experiments can be designed to determine both supply and demand for a commodity in a market setting. Building on Schulz and Tonsor (2010b), the stated choice experiment design can be used to study other traceability programs and attributes. For feeder cattle, by considering both traceability supply and demand, we can directly observe differences in the incentives that sellers need to adopt traceability and the incentives that buyers are willing to offer.

[1] Feeder cattle sellers or sellers are used to denote producers that supply feeder cattle and reflect the producer group that makes the initial traceability adoption decision. Feeder cattle buyers or buyers are used to denote producers that procure feeder cattle and traceability from sellers. Feeder cattle sellers include seedstock, cow-calf, and operations retaining ownership of weaned calves. Feeder cattle buyers include backgrounding/stocker operations and feedlots.

Finally, we focus on policies that aim to improve participation in voluntary traceability programs. We are first to directly consider policies that target increases in participation at the individual level. Pendell et al. (2010) examine the changes in domestic and export demand that would need to occur to offset the aggregate costs of a national animal identification program. Pendell et al. (2013) consider economic impacts from losing access to beef export markets from failing to meet age and source verification requirements. Here, we directly consider how policies that decrease adoption costs would improve adoption. We also examine how participation rates change in response to changes in the entity managing the traceability program, which have important implications for confidentiality and liability of producer information.

2.2 Conceptual Framework

This section, as well as the entirety of the chapter, is motivated by the observation that voluntary traceability is a product characteristic. As such, there is an implicit market for traceability where prices govern the provision of traceability for an agricultural commodity or food product. The section begins by defining the attributes that characterize a traceability program. With a well-defined definition of traceability, we focus on adoption by sellers, procurement by buyers, and equilibrium. The section concludes by considering a cost subsidy, which we also consider in the empirical application.

2.2.1 Defining Traceability

There are several working definitions for food and animal identification and traceability. A popular definition is that breadth (number of attributes and quantity of information recorded), depth (number of supply chain segments included in the system), and precision (the degree of accuracy or assurance of the system) describe a traceability system (Golan et al., 2004). Pouliot and Sumner (2008) define traceability as the probability that a firm or producer is identified as the source of contamination. Resende-Filho and Buhr (2008) consider the relationship between the rate that a traceability system works and the ability to successfully traceback meat products. In their analysis, precision is conditional on the system working and is either 0% or 100% accurate. Souza-Monteiro and Caswell (2010) model a multi-ingredient (breadth), multi-firm (depth) supply chain and define traceability as the precision of information provided by firms. In our context, we will describe the three components of a traceability system following (Golan et al., 2004).

We will consider a competitive agricultural input market, where $s = 1, ..., S$ upstream farmers (sellers) produce the input and $b = 1, ..., B$ downstream firms (buyers) purchase the input. A single attribute, traceability characterize the agricultural input. We are effectively asserting that traceability is separate from other production decisions and product characteristics Souza-Monteiro and Caswell (2010). That is, sellers will choose the amount of traceability to supply independent of other production decisions. Likewise, buyers will choose the type of traceability to procure from sellers independent of other purchasing decisions. We have just defined the depth of the traceability system, a single supply chain link between buyers and sellers of the agricultural input.[2]

In the literature studying the economics of traceability, researchers will often model one component of Golan et al. (2004)'s traceability definition as a continuous choice variable.[3] This treatment of traceability contrasts the empirical literature. Empirically, researchers recognize that individuals face traceability alternatives, and the choice is discrete (Schulz and Tonsor, 2010b; Souza-Monteiro and Caswell, 2010). Each traceability alternative is characterized by differences in depth, breadth, and precision. We provide a direct link between the theoretical and empirical traceability literature by considering discrete traceability adoption. Specifically, each seller will choose among J (indexed by j) discrete traceability alternatives to adopt. Likewise, each buyer will choose among J (indexed by j) traceability alternatives to procure from sellers. For completeness, let $j = 0$ denote the alternative

[2] A specific example for livestock is cow-calf producers selling feeder cattle to feedlots. For grains, depth might be farmers supplying grain to an elevator. A system with more depth might trace grain between farmers, elevators, and mills.

[3] Hobbs (2004) models voluntary firm participation in an industry-wide traceability program as discrete but does not consider traceability alternatives.

of not participating in traceability.[4] For sellers, each traceability alternative is characterized by the information recorded and cataloged in the system, liability, adoption costs, and traceability premiums/discounts received from buyers. For buyers, traceability alternatives are characterized by the information recorded and cataloged in the system, liability, traceability premiums/discounts paid to sellers (costs), and premiums/discounts received from consumers.[5] Subsequent paragraphs provide a discussion of each traceability attribute.

Information units. Each traceability system is used to record, catalog, and trace units of information about the agricultural input (Golan et al., 2004). We denote units of information by t_j. We assume that t_j is finite, captures the breadth of the system, and is observed by all. For example, t_j could be the source of origin information for the agricultural input. A traceability system with more breadth might record the source of origin and production practice information.

Liability. Liability is an important part of traceability adoption. In their analysis of cattle traceability, Schulz and Tonsor (2010a) find that 45.2% of cow-calf producers are very concerned with producer liability. Souza-Monteiro and Caswell (2010) model the mitigating effects of traceability on liability costs. While traceability might be able to mitigate loss, Pouliot and Sumner (2008) acknowledge that traceability effectively allows downstream firms to transfer some of the liability costs to upstream suppliers. In their model, Pouliot and Sumner (2008) consider exogenously determined traceback probabilities and model the probability of a food safety event as a function of agent effort.

In our analysis, we assume that there is an exogenously determined risk that a seller or buyer will be identified and liable for damages. Denote liability ℓ_j and assume that it is a continuous variable that adequately measures both risks of being identified and damages. Sellers know ℓ_j when they participate in the traceability program. Similarly, buyers know ℓ_j when they procure an input with traceability alternative j. We assume ℓ_j is such that it allows buyers to transfer liability to sellers (Pouliot and Sumner, 2008). That is, ℓ_j is a disincentive for sellers to adopt traceability alternative j.

[4] Choosing not to participate in traceability is not an opt-out option in the conventional sense. Some attributes and outcomes arise from non-participation in traceability.

[5] We omit consumers from the analysis.

Prices and costs. Adopting traceability is costly to the seller. Traceability costs for alternative j are denoted by $c_j \in [0, \infty]$. A slight abstraction from practice, for convenience, we will assume that costs are independent of the units of information recorded. In addition to costs, the seller receives a premium/discount for supplying traceability alternative j by $p_j^1 \in [-\infty, \infty]$. Likewise, to procure alternative j buyers pay p_j^1. We assume that p_j^1 is the only traceability cost that buyers face.[6] Competition implies that each seller and buyer take p_j^1 as given. Finally, buyers receive premium/discount $p_j^2 \in [-\infty, \infty]$ from consumers by supplying output with alternative j. Buyers take p_j^2 as given.

2.2.2 Adoption, Procurement, and Equilibrium

We use a random utility framework to characterize traceability adoption and procurement by sellers and buyers, respectively.

Seller adoption. Sellers receive utility $U_{sj} = U(t_j, \ell_j, c_j, p_j^1; \beta_s, \varepsilon_{sj})$ by supplying alternative j. Sellers are heterogeneous. β_s captures preference heterogeneity across sellers and ε_{sj} captures random taste variation across sellers and traceability alternatives. β_s and ε_{sj} have density functions f_β and f_ε, respectively.

The adoption decision rule for seller s is to supply traceability alternative j if $U_{sj} > U_{sk}\ \forall\ j \neq k$. The supply of traceability alternative j is the share of sellers that adopt the alternative. The share of sellers adopting alternative j is expressed as:

$$Q_{sj} = \iint_{\{\beta_s, \varepsilon_{sj} | U_{sj} > U_{sk},\ \forall\ j \neq k\}} f_\varepsilon(\varepsilon) f_\beta(\beta) d\varepsilon d\beta. \tag{2.1}$$

In words, equation 2.1 aggregates over sellers choosing alternative j to provide an expression for the share of adopters. For a set of prices, costs, liabilities, and units of information, equation 2.1 shows that seller heterogeneity drives the supply of a traceability alternative.

[6] In practice, there are several scenarios where this assumption might not be true. An additional traceability cost for buyers might be the reapplication of the identification technology or application of new identification technology. As a specific example, results from the 2011 National Animal Health Monitoring System (NAHMS) study by USDA–APHIS–VS–NAHMS (2013) reported that 48% of feedlots applied new individual-animal identification at animal receiving time.

Thus, $Q_{sj} = Q_{sj}(t, \ell, c, p^1; \beta, \varepsilon)$.

Buyer procurement. Buyers receive utility $U_{bj} = U(t_j, \ell_j, p_j^1, p_j^2; \alpha_b, \varepsilon_{bj})$ by procuring traceability alternative j. Buyers are heterogeneous. α_b captures preference heterogeneity across sellers and ε_{bj} captures random taste variation across sellers and traceability alternatives. α_b and ε_{bj} have distribution functions f_α and f_ε, respectively.

The procurement decision rule for buyer b is to purchase traceability alternative j if $U_{bj} > U_{bk}\ \forall\ j \neq k$. The share of buyers purchasing alternative j is expressed as:

$$Q_{bj} = \iint_{\{\alpha_b, \varepsilon_{bj} | U_{bj} > U_{bk},\ \forall\ j \neq k\}} f_\varepsilon(\varepsilon) f_\alpha(\alpha) d\varepsilon d\alpha. \tag{2.2}$$

Equation 2.2 is interpreted analogously to equation 2.1 and $Q_{bj} = Q_{bj}(t, \ell, p^1, p^2; \alpha, \varepsilon)$.

Equilibrium. Equations 2.1 and 2.2 allow us to link traceability participation by both segments of an input market to individual decision making. Let the set of prices for traceability alternative j be P_j^1. Holding constant all other traceability attributes, we hypothesize that there exists a premium/discount for alternative j, $p_j^{1*} \in P_j^1$, such that:

$$Q_{sj}^* = Q_{bj}^*\ \forall\ j \in J. \tag{2.3}$$

There exists a set of traceability premiums/discounts such that the implicit market clears for all j traceability alternatives. In a similar analysis, given fixed supply, Bayer et al. (2004) provide the assumptions that are needed to prove the sufficient conditions for the existence and uniqueness of equilibrium in a housing market. Specifically, for fixed supply, the equilibrium price vector is unique if utility is linear and decreasing in price, and α and ε are drawn from continuous distributions. In our analysis, it is reasonable to expect that we would need to exploit similar assumptions for seller utility and heterogeneity, to prove existence and uniqueness of equilibrium.

2.2.3 Policy Implications

The previous section has important policy implications. The main focus of traceability policy is whether voluntary participation is sufficient for Q_j to meet the stated goals of the traceability program for the commodity under consideration (Golan et al., 2004). A recent policy alternative for livestock traceability in the United States is to subsidize traceability costs (USDA–APHIS, 2018, 2020a). What is the effect of a traceability cost subsidy on participation by sellers and buyers of the agricultural input?

Suppose there is a traceability policy that will subsidize participation costs for the supplier of the agricultural input. Denote the subsidy for traceability by $\delta_j \in [0, 1]$. Assume preferences for sellers are such that for $c_j \geq (1-\delta_j)c_j$ we find $U(t_j, \ell_j, (1-\delta_j)c_j, p_j^1; \beta_s, \varepsilon_{sj}) \geq U(t_j, \ell_j, c_j, p_j^1; \beta_s, \varepsilon_{sj})$. From equation (2.1), policymakers would like to know the effect of the subsidy on traceability supply, $\frac{\partial Q_{sj}}{\partial \delta_j}$. An advantage of our conceptual framework is that we can examine the effects of δ_j in (Q_j, p_j^1) space. This is only made possible by considering traceability in a market setting.

δ_j shifts Q_{sj} such that equilibrium adjusts from $(Q_j^{'}, p_j^{1'})$ to $(Q_j^{''}, p_j^{1''})$. The relative differences of $(Q_j^{''} - Q_j^{'})$ and $(p_j^{''} - p_j^{'})$ will depend on the relative slopes of the supply and demand curves in equations 2.1 and 2.2. A cost subsidy will shift traceability supply, and prices in a decentralized input market will adjust to clear implicit traceability markets under the policy. In what follows, we provide empirical context for a traceability cost subsidy.

2.3 Empirical Application

Empirically, we consider voluntary participation in U.S. cattle traceability systems. The ability to trace individual animals to the source of origin has many potential benefits that span the beef value chain. These benefits may include animal health monitoring, improved response times to disease events, enhancing consumer demand, and accessing and maintaining foreign markets (Schulz and Tonsor, 2010a). There have been several efforts in the United States to increase participation in animal traceability programs and policies have evolved (USDA–APHIS, 2018). The National Animal Identification System (NAIS) was a program developed in 2004 in part as response to bovine spongiform encephalopathy (USDA–APHIS, 2006). More recently, the U.S. Department of Agriculture (USDA) announced a new framework for approaching animal traceability, the federal animal disease traceability (ADT) program (USDA–APHIS, 2014). Unlike the NAIS program, which initially proposed a mandatory full traceability program, the current focus of the ADT program in the beef industry is breeding cattle over 18 months of age and dairy cattle (USDA–APHIS, 2018). U.S. traceability programs for feeder cattle are currently voluntary and administered privately within the industry.

Many studies have highlighted that the United States has been slow to adopt livestock and meat identification and traceability systems relative to other countries which have mandatory systems in place (Brester et al., 2011; Pendell et al., 2013). Several countries with mandated traceability are important foreign markets for U.S. meat and others are competitors for key export markets. The U.S. beef cattle industry is divided into distinct, but often overlapping sectors, including seedstock production, cow-calf production, stocker/backgrounding, and feedlot. For an animal to be traced to its origin of birth, traceability adoption has to occur at the seedstock and cow-calf levels. The lack of U.S. beef industry participation in voluntary traceability systems has been attributed to the demographics that characterize the cow-calf sector (Brester et al., 2011; Schulz and Tonsor, 2010a,b). The cow-calf sector is comprised of a large number of smaller operations where participation costs might be prohibitive. A key objective in the literature studying U.S. livestock traceability is determining aggregate economic impacts from adopting traceability or the lack thereof (Pendell et al., 2010, 2013). Market interactions among industry participants in U.S. cattle traceability have been ignored in the literature.

2.3.1 Data

In many situations, on-farm decisions are not directly observable, and thus to study these decisions, researchers rely on primary data collection. A mail survey was developed for U.S.

feeder cattle sellers and buyers and administered from October to November 2018. This period was selected as it coincides with a time when producers make significant marketing and procurement decisions. Questionnaire development followed Schulz and Tonsor (2010b) to make direct comparisons with the literature that assess cow-calf producer preferences for cattle traceability attributes.

The objective of the survey was to collect data on producer and operation characteristics, animal health practices, livestock marketing methods, current cattle traceability implementation, perceptions of ongoing traceability efforts in the United States, and risk preferences. The survey was administered and collected in collaboration with BEEF Magazine. For sellers, a random sample was generated based on the requirement that a producer has at least 20 beef cows in inventory. For buyers, a random sample was created based on the condition that a producer has sold at least 50 head of fed cattle in the last 12 months. The surveys were sent to 1,500 feeder cattle sellers and 1,500 buyers. A $1 bill, cover letter, and postage-paid return envelope were included in each invitation packet (Tonsor, 2018). The response rate for the seller survey was 318 (21%) and 195 (13%) for buyers. Summary statistics for select variables are presented in Table 2.1.

2.3.2 Stated Choice Methods

Stated choice methods have become a popular tool to assess a respondent's preferences for product attributes. Most applications have been in consumer and market research. Recently, these methods have been used to study farmer decision making (e.g., McKendree, 2017; Roe et al., 2004; Schulz and Tonsor, 2010b; Tonsor, 2018; Vestal et al., 2013, among others). Stated choice methods allow researchers to create hypothetical decisions and market scenarios.

Specific to livestock markets, studies that use choice experiment methods can determine what incentives—which might include prices or policies that encourage adoption—most impact producer decisions to adopt a technology or supply a livestock characteristic. For example, Roe et al. (2004) use stated choice methods to elicit hog producer preferences for

Table 2.1: *Select summary statistics for selected variables for feeder cattle seller and buyer respondents*

	Seller		Buyer	
Variable	Mean	Std. dev.	Mean	Std. dev.
Age (years)	63.80	12.97	59.70	13.59
Auction (0,1)	0.59	0.49	0.52	0.50
Region (0,1)				
CB	0.19	0.39	0.31	0.46
NC	0.09	0.29	0.17	0.37
NP	0.29	0.45	0.27	0.45
NW	0.19	0.39	0.10	0.30
SE	0.10	0.31	0.08	0.27
SP	0.14	0.34	0.07	0.26
Cows (head)	180.74	190.25	–	–
Head $> 1,000$ (0,1)	–	–	0.14	0.34

Note: Seller is feeder cattle sellers. Buyer is feeder cattle buyers. *Age* is the age of the respondent in years. *Auction* is a dummy variable that equals 1 (0 otherwise) if auction markets are the most common the most common method of marketing and procuring cattle by sellers and buyers, respectively. *Region* is coded following Schulz and Tonsor (2010a,b). CB is corn belt states, NC is northern crescent states, NP is northern plains states, NW is northwest states, SE is southeast states, and SP is southern plains stats. *Cows* is beef cow inventory as of January 1, 2018. *Head* $>$ 1000 is a dummy variable that equals 1 (0 otherwise) if the feedlot operator sold more than 1,000 head in the last 12 months.

production contract attributes. Alternatively, stated choice methods might be used to determine what incentives producers are willing to offer to procure specific characteristics or technologies. For example, McKendree (2017) uses stated choice methods to determine how feedlots manage different forms of risk.

While these studies provide useful context for on-farm decision making, they only focus on one side of an economic transaction and are not able to assess the viability of incentive structures. Roe et al. (2004) focus on the supply of hogs. McKendree (2017) studies feeder cattle procurement. Specific to cattle traceability, research has determined cow-calf producer preferences for traceability attributes (Schulz and Tonsor, 2010b) but ignores the demand for feeder cattle with traceability attributes. In this study, we contribute to the literature by considering both sides of the private market transaction for feeder cattle. By doing so, we can better inform policymakers and further guide targeted policy adjustments. That is, we can directly observe what incentives sellers need and what incentives buyers are willing to offer.

Guided by our conceptual framework, we develop two separate stated choice experiments for sellers and buyers to simulate feeder cattle transactions.[7] The stated choice experiments were designed to capture current traceability systems while also limiting complexity (Norwood et al., 2006). In the stated choice scenarios, sellers were asked to choose among three alternative traceability systems. The first traceability alternative is an electronic system that involves applying radio frequency identification (RFID) tags, and the second alternative is a visual system that involves using traditional plastic ear tags. The third alternative, no traceability, is not an opt-out option in the conventional sense as it also has attributes and reflects an actual alternative available to producers. In the stated choice scenarios, buyers were asked to procure feeder cattle that were currently participating in electronic, visual, or no traceability. In both surveys of sellers and buyers, the no traceability option was included to reflect an exhaustive list of alternatives (Adamowicz et al., 1998). Different identification technologies imply different levels of precision according to Golan et al. (2004)'s definition.

[7] Instructions and descriptions provided to the stated choice experiment respondents are provided in Appendix A (sellers) and B (buyers).

For sellers, the electronic traceability option included varying levels of implementation cost, the managing entity, information shared with buyers, and feeder cattle price premiums and discounts. A premium is paid for electronic traceability, and a discount is received for choosing no traceability. The buyer stated choice experiment included varying levels of fed cattle premiums and discounts, feeder cattle premiums and discounts, managing entity, and information shared back with sellers. The fed cattle premium is the premium for electronic traceability, and the discount is the discount for fed cattle with no traceability. All feeder and fed cattle premiums and discounts are relative to the visual traceability alternative. Visual traceability serves as the base scenario because most operations already use some form of visual ID (e.g., tags, brands, tatoos, etc.) which would result in no additional implementation costs and does not reflect a change from what operations are already doing. For example, results from 2011 NAHMS show that 22.5% and 45% of large feedlots applied individual tags and hide brands to cattle after arrival, respectively (USDA–APHIS–VS–NAHMS, 2013).

Including feeder cattle premiums and discounts in the stated choice experiments allows us to link buyers and sellers in a hypothetical market scenario. Feeder cattle premiums and discounts are assumed to be the only cost to buyers. This reflects how most traceability costs are borne at the seller level, where implementation costs occur (Pendell et al., 2010). Most studies assume that any additional costs at the buyer level are small and include the cost of retagging animals upon arrival (Brester et al., 2011). For sellers, feeder cattle premiums and discounts reflect the adjustment to the sale price for supplying a traceability alternative. Figure 2.1 presents an example of the stated choice experiment.

Both stated choice experiments are designed using main-effects and two-way interaction effects to create choice tasks. PROC OPTEX and PLAN in SAS were used to develop an orthogonal fractional factorial design. The D-efficiency criterion was used to identify the optimal design. The stated choice designs included 17 choice scenarios for producers. To reduce survey respondent burden, choice scenarios were randomly assigned to two blocks of 6 scenarios and one block of 5 scenarios.

Example of seller stated choice question

	Visual Traceability	***Electronic Traceability***	***No Traceability***
Information Shared with Cattle Buyers	Source of Origin	Health Certification and Vaccination Records	None
Implementation Cost ($/head)	$9.00	$1.00	$0.00
Managing Entity	Private-Industry	Government & Private-Industry Partnership	None
Sales Price Premium/Discount ($/head)	$0.00	$15.00	-$7.50
I choose …			

Example of buyer stated choice question

	Visual Traceability	***Electronic Traceability***	***No Traceability***
Information Shared with Cattle Buyers	Source of Origin	Source of Origin	None
Feeder cattle Premium/Discount ($/head)	$0.00	$7.50	-$15.00
Managing Entity	Private-Industry	Government & Private-Industry Partnership	None
Fed cattle Premium/Discount ($/head)	$0.00	$15.00	$0.00
I choose …			

Figure 2.1: *Stated choice question examples.*

2.3.3 Empirical Model

Empirically, we would like to learn about equations 2.1 and 2.2, which requires further assumptions about the utility function. First, we assume that random taste variation is additively separable so that we can write utility $U_{sj} = V(t_j, \ell_j, c_j, p_j^1; \beta_s) + \varepsilon_{sj}$ and $U_{bj} = V(t_j, \ell_j, c_j, p_j^1; \alpha_b) + \varepsilon_{bj}$ for sellers and buyers, respectively.

Next, assume that ε_{sj} and ε_{bj} are distributed type 1 extreme value. Seller and buyer logit probabilities are given by:

$$q_{sj} = \frac{e^{V_{sj}}}{\sum_k e^{V_{sk}}} \tag{2.4}$$

and

$$q_{bj} = \frac{e^{V_{bj}}}{\sum_k e^{V_{bk}}}. \tag{2.5}$$

Combining equations 2.1 and 2.4, simulated traceability supply is given by

$$Q_{sj} = \int \frac{e^{V_{sj}}}{\sum_k e^{V_{sk}}} f_\beta(\beta) d\beta. \tag{2.6}$$

Likewise, combining equations 2.2 and 2.5 gives simulated traceability demand of

$$Q_{bj} = \int \frac{e^{V_{bj}}}{\sum_k e^{V_{bk}}} f_\alpha(\alpha) d\alpha. \tag{2.7}$$

Finally, we need to specify V_{sj} and V_{bj} for feeder cattle sellers and buyers, respectively. From the stated experiments, we consider three traceability alternative $j \in${Electronic, Visual, None}. For sellers, systematic utility is a function of costs, feeder cattle premiums/discounts, liability, and information units. Denote feeder cattle premiums/discounts p_j^F. An important component of liability risks is the entity managing the traceability. Empirically, we use the managing entity as a proxy for liability risks and denote $\ell_j \in${Private-Industry, Gov, Gov and Private-Industry}. We use information shared in the choice experiments to proxy information units so that $t_j \in${Origin, Health Records, Origin and Health Records}.

For feeder cattle sellers, we approximate systematic utility with a mixed logit model of the form:

$$V_{sj} = \beta_1 p_j^F + \beta_2 c_j + \beta_{s3}\ell_j + \beta_{s4}t_j, \ \forall\ j = \text{Electronic}, \tag{2.8}$$

$$V_{sj} = \beta_2 c_j + \beta_{s3}\ell_j + \beta_{s4}t_j, \ \forall\ j = \text{Visual}, \ \text{and} \tag{2.9}$$

$$V_{sj} = \beta_{s0} + \beta_1 p_j^F, \ \forall\ j = \text{None} \tag{2.10}$$

where visual traceability is the reference for feeder cattle premiums and discounts, and $\boldsymbol{\beta_s} = (\beta_{s0}, \beta_{s3}, \beta_{s4})$ are normally distributed random parameters whose structure follows $\boldsymbol{\beta_s} = \bar{\boldsymbol{\beta}} + \boldsymbol{R}\boldsymbol{\upsilon_s}$ (Greene and Hensher, 2005; Train, 2009). In this specification, $\bar{\boldsymbol{\beta}}$ is a fixed mean, $\boldsymbol{R}$ is a lower triangular Cholesky matrix, and $\boldsymbol{\upsilon_s}$ is a standard normal random variable capturing taste variation.

Systematic utility is a function of fed cattle premiums/discounts, feeder cattle premiums/discounts, liability, and information units for buyers. Similarly for buyers, we approximate utility with a mixed logit model:

$$V_{bj} = \alpha_1 p_j^F + \alpha_2 p_j^{LC} + \alpha_{b3}\ell_j + \alpha_{b4}t_j, \ \forall\ j = \text{Electronic}, \tag{2.11}$$

$$V_{bj} = \alpha_{b3}\ell_j + \alpha_{b4}t_j, \ \forall\ j = \text{Visual, and} \tag{2.12}$$

$$V_{bj} = \alpha_{b0} + \alpha_1 p_j^F + \alpha_2 p_j^{LC}, \ \forall\ j = \text{None} \tag{2.13}$$

where p_j^{LC} are the fed cattle premiums and discounts, visual is the reference for premiums and discounts, and $\boldsymbol{\alpha_b} = (\alpha_{b0}, \alpha_{b3}, \alpha_{b4})$ are normally distributed random parameters. The random parameters are specified as $\boldsymbol{\alpha_b} = \bar{\boldsymbol{\alpha}} + \boldsymbol{L}\boldsymbol{\upsilon_b}$ where $\bar{\boldsymbol{\alpha}}$ is a fixed mean, $\boldsymbol{L}$ is a lower triangular Cholesky matrix, and $\boldsymbol{\upsilon_b}$ is a standard normal random variable capturing taste variation.

2.4 Results

Model specification is determined using a series of likelihood ratio tests. Tests reject conditional logit models in favor of mixed logit models. Next, we use likelihood ratio tests to test for correlated random parameters in the mixed logit model and reject the mixed logit without random parameters. The final model specification is mixed logits with correlated random parameters where all non-monetary variables are assumed to be normally distributed (Table 2.2).[8]

A potential problem with the models in Table 2.2 is that there might be systematic differences in preferences for price and cost variables among producers. For example, Brester et al. (2011) find significant economies of size for cow-calf producer participation in age and source verification programs. In their study, participation costs ranged from $14.51/head sold for small operations currently tagging animals to $5.39/head sold for large operations not currently tagging animals (Brester et al., 2011). While our choice experiments only consider tag costs, perceptions about economies of size and scope might lead to a differential in preference estimates.

To determine the effects of operation size on preferences, we estimate separate models based on inventory. These estimations allow us to account for heterogeneity in the distributions characterizing the random parameters and in the fixed parameters. Ignoring this source of heterogeneity would produce bias estimates. For sellers, separate models were estimated based on whether the producer has 50 beef cows in inventory. For buyers, separate models were estimated based on whether the producer sold more than 1,000 head in the last 12 months. In each case, likelihood ratio tests fail to reject pooled models in Table 2.2.

Results in Table 2.2 show that most coefficients are statistically significant and have the expected sign. Of interest are the effects of premiums, discounts, and costs on the probability of participating in each traceability system. Implementation costs have a negative effect on the likelihood of adopting visual and electronic traceability. Feeder cattle premiums and

[8] See Revelt and Train (1998) for a detailed discussion of mixed logit models with correlated random parameters. Hensher et al. (2005) provide a detailed discussion of how to derive the Cholesky matrix from the model's estimated variance-covariance matrix.

Table 2.2: *Feeder cattle seller and buyer correlated random parameter mixed logit results for traceability attributes*

	Seller		Buyer	
Variable	Estimate	Std. error	Estimate	Std. error
Nonrandom parameter:				
$FedP$	–	–	0.006	(0.011)
$FeederP$	0.058***	(0.010)	−0.038***	(0.012)
$Cost$	−0.172***	(0.025)	–	–
Random parameter means:				
$Manage$:				
Private-Industry	1.194***	(0.186)	0.422***	(0.126)
Government and Private-Industry	−0.211	(0.131)	0.420***	(0.125)
$Info$:				
Health Records	−0.245*	(0.140)	0.102	(0.118)
Origin and Health Records	0.274**	(0.122)	0.166	(0.130)
$None$	−3.941***	(0.624)	−3.324***	(0.521)
Random parameter std. devs.:				
$Manage$:				
Private-Industry	1.784***	(0.220)	0.751***	(0.165)
Government and Private-Industry	1.190***	(0.151)	0.335**	(0.155)
$Info$:				
Health Records	1.272***	(0.182)	0.125	(0.146)
Origin and Health Records	0.801***	(0.195)	0.565***	(0.172)
$None$	5.397***	(0.698)	2.892***	(0.476)
N	3846		1866	
Log-likelihood	−989.537		−522.226	
AIC	2023.100		1088.500	
Pseudo R-squared	0.297		0.236	

Note: Seller is feeder cattle sellers. Buyer is feeder cattle buyers. For sellers the feeder premium/discount is the $/head amount that a producer would receive based on the traceability system. For buyers the feeder premium/discount reflects a cost. These price adjustments to the market price range from discounts of up to $15 per head for selecting No Traceability and premiums of up to $15 per head for selecting Electronic Traceability. The fed cattle price premium/discount has a similar interpretation for buyers as the feeder premium/discount does for sellers. Number of observations is the product of 3 choices per task, number of choice tasks, and respondents. Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

discounts have a positive (negative) effect on the probability of adopting electronic (no) traceability for sellers. Feeder cattle price premiums and discounts reflect costs to buyers and have the expected sign. Fed cattle price premiums and discounts do not have a statistically significant effect on the buyer's choice of traceability. This result might be due to how fed cattle are typically sold in the United States. Many fed cattle pricing methods include standard $/hundredweight adjustments based on quality, cutability yield grade, and weight standards,[9] and it is currently unclear how packers and feeder cattle buyers would currently directly differentiate the price based on the presence or absence of a traceability system.

Estimating mixed logit models with correlated random parameters capture another source of heterogeneity. Namely, correlation in preferences for traceability attributes across alternatives. Like Tonsor et al. (2009), we provide correlation statistics and estimated Cholesky matrices in Tables 2.3 for sellers and buyers. The decomposition of the Cholesky matrix isolates two sources of heterogeneity that contribute to standard deviation parameters, attribute-specificity and cross-correlations. Attribute-specificity contributes to standard deviation estimates through the heterogeneity around the mean of each random parameter, and cross-correlations are sources of heterogeneity that are due to correlation with other random parameters (Hensher et al., 2005).

While model estimates and Cholesky matrices provide useful insights for changes in choice probabilities, our focus is on aggregate traceability supply and demand. In particular, we are interested in how participation adjusts to prices and policy. To understand these effects, we use elasticity estimates and simulated supply and demand, which use equations 2.6 and 2.7.

2.4.1 Elasticities

Based on the policy implications in Section 2.2.3, a useful first step towards understanding how subsidies impact traceability supply and demand is an investigation of elasticities. Elasticities from discrete choice models do not have the same interpretation as those obtained

[9]For example, see USDA Market News Service National Weekly Direct Slaughter Cattle–Premiums and Discounts report, https://www.ams.usda.gov/mnreports/lm_ct155.txt.

Table 2.3: *Feeder cattle seller and buyer cholesky and correlation matrices for mixed logit models*

Seller:	Private-industry	Gov and private-industry	Health records	Origin and health records	None
Private-industry	1.784***	0.680	−0.597	0.189	−0.159
Gov and private-industry	0.809***	0.873***	0.128	−0.478	−0.008
Health records	−0.760***	0.927***	0.425*	−0.632	0.026
Origin and health records	0.152	−0.663***	0.201	0.373**	0.065
None	−0.860	0.739∗	−2.737***	3.891***	2.282***
Buyer:					
Private-industry	0.751***	0.893	−0.495	0.298	0.258
Gov and private-industry	0.299*	0.151	−0.051	0.692	−0.185
Health records	−0.062	0.109	0.000	0.675	−0.931
Origin and health records	0.168	0.535***	0.000	0.070	−0.824
None	0.746	−2.67***	−0.076	−0.600	0.546

Note: Main diagonal elements are the main diagonal for the Cholesky matrix, elements below main diagonal are elements of Cholesky matrix, and elements above main diagonal are correlation statistics.

in traditional supply and demand analysis but still convey important information. For discrete choice models, elasticities are interpreted as the percentage change in the probability of choosing a traceability system for a percentage change in a traceability system attribute. We estimate direct and cross-elasticities using the point elasticity method described in Hensher et al. (2005). For the mixed logit model, individual-specific estimates are used to estimate elasticities and aggregated using probability-weighted sample enumeration.

Direct- and cross-elasticities for sellers and buyers are in Table 2.4. Sellers are more price-sensitive to changes in the electronic feeder cattle price premium than to changes in the discount for no traceability (Table 2.4). Specifically, the probability of choosing electronic traceability increases by 0.130% and 0.024% in response to a 1% increase in the feeder cattle price premium for electronic traceability and discount for no traceability, respectively. Both estimates are inelastic. Estimates show a larger substitution from visual traceability to electronic traceability relative to substituting from no traceability (Table 2.4, Row 1). Similarly, elasticity estimates from changes in costs show more substitution between electronic and visual traceability relative to no traceability (Table 2.4, Rows 3 and 5). A 1% increase in costs results in a decrease of 0.250% and 0.292% in the choice probabilities for electronic, respectively.

Feeder cattle price premiums and discounts for traceability represent changes in upfront costs for buyers. In line with previous research, we assume that this is the only cost for feedlot producers participating in a traceability system as implementation costs have already occurred at the seller level (Brester et al., 2011). For a 1% increase in the discount for feeder cattle with no traceability, the choice probability for procuring cattle with no traceability increases by 0.150%, and substitution among visual and electronic traceability is similar to decreases in the choice probabilities of 0.023% and 0.022%, respectively. There is a greater substitution to visual traceability relative to no traceability for increases in the cost of procuring feeder cattle with electronic traceability. When making decisions about traceability, buyers are likely weighing alternatives between procuring cattle with traceability and implementing traceability themselves once cattle are received.

Table 2.4: *Feeder cattle seller and buyer direct and cross-elasticities for correlated random parameters logit models*

	Traceability system		
Variable	Electronic	None	Visual
Seller:			
Electronic Traceability Feeder Premium[a]	0.130***	−0.061***	−0.127***
	(0.003)	(0.001)	(0.003)
No Traceability Feeder Discount[b]	0.024***	−0.100***	0.025***
	(0.001)	(0.003)	(0.001)
Electronic Traceability Cost[a]	−0.250***	0.110***	0.249***
	(0.007)	(0.002)	(0.005)
Visual Traceability Cost[c]	0.199***	0.081***	−0.292***
	(0.004)	(0.002)	(0.007)
Buyer:			
Electronic Traceability Fed Premium[a]	0.025***	−0.011***	−0.017***
	(0.001)	(0.000)	(0.001)
No Traceability Fed Discount[b]	0.003***	−0.022***	0.003***
	(0.000)	(0.001)	(0.000)
Electronic Traceability Feeder Premium[a]	−0.130***	0.057***	0.091***
	(0.005)	(0.002)	(0.003)
No Traceability Feeder Discount[b]	−0.022***	0.150***	−0.023***
	(0.001)	(0.004)	(0.001)

Note: Elasticities are calculated using the point elasticity method and calculated for each individual in the sample and aggregated using probability-weighted sample enumeration. Delta method standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

[a] Direct-elasticities for electronic traceability and cross-elasticities for visual and no traceability.

[b] Direct-elasticities for no traceability and cross-elasticities for electronic and visual traceability.

[c] Direct-elasticities for visual traceability and cross-elasticities for electronic and no traceability.

2.4.2 Price effects and model predictions

Given preferences, we are interested in finding the prices that equate equations 2.6 and 2.7. For fixed prices, costs, and attributes, we predict choice probabilities and aggregate them to calculate participation. Iterating over a set of prices for a specific traceability system produces supply and demand curves. For predictions, we hold all other variables at the data means. Since premiums and discounts are relative to visual traceability, we study electronic and no traceability markets and determine own-price effects. As a benchmark, we predict participation at the data means (Figure 2.2). The largest participation rate for sellers is electronic traceability (44.4%), and the largest participation rate for buyers is visual traceability (47.6%), which generally aligns with results from the 2011 NAHMS study.

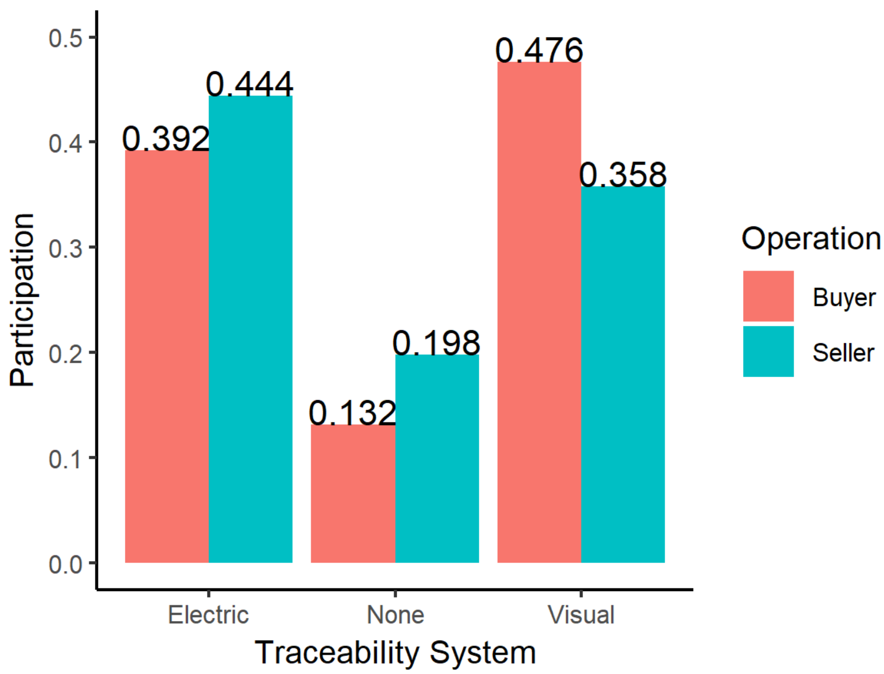

Figure 2.2: *Predicted mean participation rates for feeder cattle sellers and buyers.*

Figure 2.3 shows electronic and no traceability participation changes in response to changes in premiums and discounts, respectively.[10] We find a more elastic effect for elec-

[10]Note that discounts are on the y-axis for the bottom graph, which explains why the seller curve is downward sloping, and the buyer curve is upward sloping. The top graph is more easily interpreted as a standard supply and demand graph.

tronic traceability relative to no traceability. Figure 2.3, paired with elasticities in Table 2.4, provides a complete understanding of own-price effects and substitution patterns. The bottom graph and elasticity results suggest a more elastic own-price effect for buyers relative to sellers. The own-price effect for electronic traceability is the same for buyers and sellers.[11]

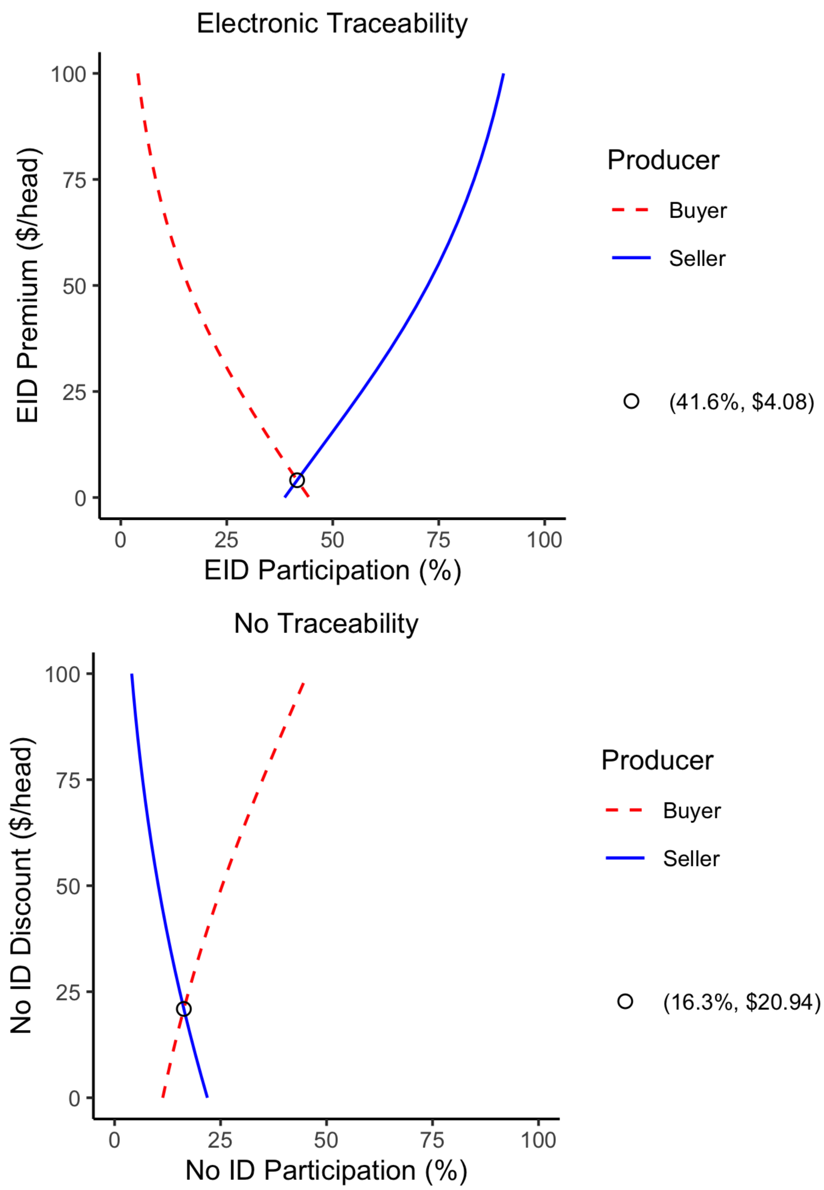

Figure 2.3: *Effects of $/head premiums and discounts on electronic and no traceability participation rates for feeder cattle sellers and buyers.*

Together, these results have important policy implications. At a premium of $4.08/head,

[11]We did not formally test this.

41.6% of buyers and sellers choose electronic traceability. A discount of $20.94/head results in 16.3% of buyers and sellers choosing not to adopt traceability. Policies that aim to incentivize electronic traceability adoption at the farm-level directly will result in shifts in the seller supply curve, and prices will adjust to determine a new level of participation. The inelastic supply curve in the bottom panel of Figure 2.3 suggests that any policy that provides a direct disincentive for non-adoption will be less effective.

2.4.3 Policy effects and model predictions

Here, we consider the traceability subsidy proposed in Section 2.2.3. Specifically, we consider policies that subsidize 50% and 100% of adoption costs for sellers that adopt electronic traceability.

In our policy scenarios, we also consider the trade-offs between a government traceability system and a system that partners with private industry. In developing a national traceability system, confidentiality and security of data have always been a top concern among producers (Schulz and Tonsor, 2010a). The management of a traceability system and data has important implications for how the government can respond to disease events. A recent proposal in response to producer feedback is a partnership between industry and APHIS (USDA–APHIS, 2018). Specifically, the plan outlines a partnership where data is privately managed, and animal health officials can only access data for tracing during disease events. A corollary example exists in Australia where the Australian government contracts with a private entity to maintain the database and thus exempts the data from their freedom of information laws (World Perspectives Inc, 2018). Participation in a system like this in the United States that includes government partnership will depend on producer preferences for the managing entity.

Figure 2.4 shows a strong preference for an electronic traceability program that partners with private industry. Ignoring a cost-share policy, premiums of $9.52/head and $2.06/head result in 43.9% and 30.5% producer participation in government and jointly managed traceability systems, respectively. A visual inspection of Figure 2.4 shows higher participation by both producer groups in a jointly managed program with $0/head premiums relative to a program managed by the government. By allowing industry management, there are large increases in producer participation. However, deciding who manages the traceability system and the associated data has important implications for how traceability data is used during disease events.

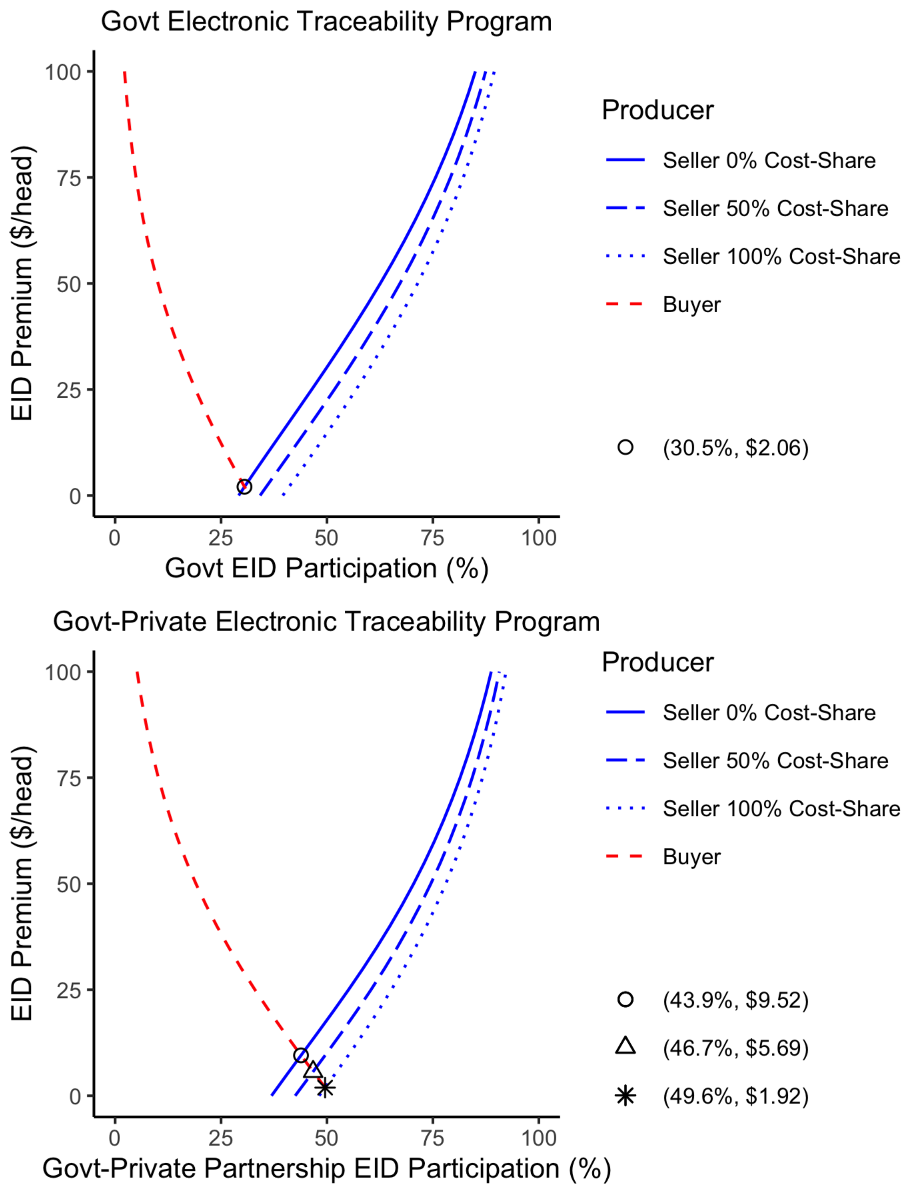

Figure 2.4: *Effects of prices, cost-share policies, and managing entity on producer participation in electronic traceability.*

Feeder cattle premiums of \$5.69/head and \$1.92/head result in 46.7% and 49.6% of producers participating in a jointly managed electronic traceability program with 50% and 100% cost-shares, respectively (Figure 2.4). Cost-share policies also increase seller participation in a program managed by the government, but preferences for the managing entity are such that buyer participation is low, and there is no intersection with sellers. Recognize that allowing prices to vary within a policy scenario is only realistic when traceability is voluntary. A mandatory traceability system would likely result in there not being any premiums for traceability. Thus, program design will become more important for producer participation.

To calculate the government cost of a cost-share policy, we use the 2019 U.S. calf crop (USDA-NASS, 2020), average RFID tag costs from the stated choice experiments, and the changes in traceability participation from Figure 2.4. The 2019 calf-crop was 36.1 million head, and average RFID costs are \$5.00/head. We assume that changes in producer participation are equivalent to changes in the number of cattle participating as a percent of the total calf crop. For cost calculations, we use participation estimates for sellers when the feeder cattle premium is \$0.00/head. Finally, we calculate policy costs when the policy is applied at the margin (targeted) and when the policy is applied to all producers adopting under the policy (all).

Government cost estimates for each scenario are in Table 2.5. As an example calculation, costs from a targeted 50% cost-share policy for a program managed by the government are 36.1 million head $\times$ (34.2% $-$ 29.2%) $\times$ \$2.50/head = \$4.51 million per year. For each policy scenario in Table 2.5, "Targeted" and "All" estimates are likely a very conservative lower and upper bound, respectively, on realized government costs. In each case, costs from a program managed through a private industry partnership are higher because of higher participation. Thus, the government would need to weigh benefits of higher participation against higher costs in future discussions about how a national traceability system should be managed.

Sumner et al. (2005) find that the cost involved with ex-post control or eradication of a disease is higher than ex-ante prevention, where the difference in cost depends on the number of farms and production quantity. If one of the main functions of live animal traceability is to allow animal health officials to quickly identify agricultural premises that are exposed

Table 2.5: *Goverment cost estimates for traceability cost-share policies (millions of dollars)*

	Producer Group	
Policy	Targeted	All
Government program:		
50% cost-share	4.51	40.87
100% cost-share	18.77	71.48
Government-private program:		
50% cost-share	5.05	34.52
100% cost-share	20.22	86.82

Note: Estimates are calculated using a tagging cost of $5.00/head and a 2019 calf-crop of 36.1 million head. Seller participation rates in a government program when the feeder cattle premium is $0.00/head are 29.2%, 34.2%, and 39.6% for 0%, 50% and 100% cost-shares, respectively. Seller participation rates in a government-private program when the feeder cattle premium is $0.00/head are 36.9%, 42.5%, and 48.1% for 0%, 50% and 100% cost-shares, respectively.

to diseases so that diseases can be isolated and eradicated (Schulz and Tonsor, 2010a), then ex-post government costs could be minimized under a cost-share policy between feeder cattle sellers and the government.

2.5 Conclusion

Little work exists to explain traceability adoption at the individual level. In this chapter, we argue that voluntary traceability is a product characteristic, and there exists an implicit market for this characteristic. We show that traceability suppliers and intermediate traceability consumers can be linked using a random utility framework and the economics of food traceability. Importantly, we show that any policy that targets increases in voluntary participation should consider the equilibrium effects. A key feature that has been ignored in the literature for voluntary traceability programs is the potential for traceability to add value to products. Guided by conceptual arguments, we show how stated choice experiments and discrete choice models can be used to empirically study traceability markets and, more broadly, commodity markets. The empirical application that we choose to focus on is voluntary participation in U.S. cattle traceability, and empirical results have important implications for the U.S. beef industry.

The Beef Industry Long Range Plan 2016-2020 set forth by the National Cattlemen's Beef Association (NCBA) includes the strategic initiative to "Secure the broad adoption of individual animal I.D. traceability system(s) across the beef community to equip the industry to effectively manage a disease outbreak while enhancing both domestic and global trust in U.S. beef and ensuring greater access to export markets" (National Cattlemen's Beef Association, 2018). This shows traceability remains a high priority for a large segment of the industry, however, there are many challenges which lead to major barriers to the success of industry-wide traceability implementation.

Both mandatory and voluntary approaches raise questions of viability. NAIS was originally designed as a mandatory program, but due to strong opposition, became a voluntary program at the federal level (Murphy et al., 2009). A survey of U.S. cow-calf producers found 50.3% of producers believed NAIS should not be mandatory, while 21.2% believed it should be mandatory and 28.5% were undecided (Schulz, 2008). Golan et al. (2004) noted that voluntary traceability systems must increase adopting firm's net revenues or they will not be adopted. Traceability adoption is an example of a private behavior that generates positive spillovers affecting the supply of a public good, that is, the ability to better manage, and potentially cushion the shock of, animal disease incursions. This makes it less clear who will benefit and who will pay for it in the supply chain. Cow-calf producers believe most of the traceability benefits are distributed to retailers and processors, whereas most costs are largely born by the cow-calf sector (Schulz, 2008). The significant gap between benefits and costs for cow-calf producers likely influences willingness to invest in traceability implementation.

Our results are extremely important for policy makers. Traceability has long been discussed and debated in the beef cattle industry, and many differing views continue today. The ability of traceability systems to either add value to industry sectors along the supply chain, increase demand, and/or offer other tangible benefits to market participants is often nebulously defined. The need to effectively prevent and control animal disease outbreaks, and the role of traceability from a generally defined standpoint, is a greater point of consensus within the industry. Our economic model demonstrates that there is a theoretical foundation for accomplishing both of these objectives. Our empirical findings show that government policies aimed at increasing traceability adoption would be most effective when reducing costs at the supplier level. Jettisoning current private and public traceability programs because of their lack of participation may set the industry further back of global customers and competitors. U.S. government traceability program designers should consider a joint partnership with private industry to encourage participation and meet the goals traceability programs are designed for.

Chapter 3

Cow-Calf Producer Willingness to Report Disease: A Test of Adverse Selection

3.1 Introduction

Livestock disease has played an important role in shaping U.S. food and agricultural policy. In 1884, the Animal Industry Act established the Bureau of Animal Industry (BAI) to combat contagious livestock disease in the United States. Soon after, meat inspection laws were strengthened by an 1891 meat inspection act (Food and Nutrition Board, 1990), and the Federal Meat Inspection Act became law in 1906. When the BAI was formed, the U.S. food system was plagued by livestock disease, and human health was severely impacted. The role of the BAI was to "conduct scientific investigations and administered statutes and regulations to protect the public from infected or diseased meat products, eradicate animal diseases, and improve livestock quality." (National Archives and Records Administration, 2016, section 17.1). Following the success of the BAI and the Federal Horticulture Board, after several iterations of restructuring, the Animal and Plant Health Inspection Service (APHIS) was formed in 1971 to consolidate efforts to protect the U.S. food system (USDA–

APHIS, 2019).

Today, there has been a resurgence of interest in livestock disease policy. The 2018 Farm Bill provided funding for a three-part program to help support foreign animal disease (FAD) prevention and management efforts by the U.S. Department of Agriculture's (USDA) APHIS (USDA–APHIS, 2020b). A key part of the animal disease provisions in the 2018 Farm Bill is $150 million in funding for USDA to spend on developing and expanding the National Animal Vaccine and Veterinary Countermeasures Bank (Spike, 2018). USDA APHIS recently announced that they were awarding $10.2 million in funds through the National Animal Disease Preparedness and Response Program (NADPRP) and the National Animal Health Laboratory Network (NAHLN) to support disease prevention, emergency response training, and projects to improve laboratory diagnostic capability (USDA–APHIS, 2020c).[1]

Global disease surveillance strategies for emerging infectious diseases depends on early detection of disease outbreaks in animal populations (Halliday et al., 2012). In the United States, efforts by USDA APHIS to prevent and control FAD incursions depend crucially on disease surveillance, traceability, biosecurity, and timely self-reporting of disease suspicions. Disease reporting plays an important role in determining the success of disease surveillance programs (Halliday et al., 2012), and is as important as disease detection (Brugere et al., 2017; Lupo et al., 2014). Indemnity payments are the key policy variable that provide incentives for self-reporting of disease suspicions.

When herd depopulation is necessary to control and eradicate the disease, indemnity payments are made available to compensate producers. Indemnity payments to impacted livestock producers equal the fair market value of the euthanized animals, and in most cases, 100 percent of the indemnity amount is paid (USDA–APHIS–VS, 2015a). A key economic question is: To what extent do indemnity payments affect a producer's decision to self-report the disease.

An important aspect of livestock disease reporting is the potential for the problem of adverse selection. Adverse selection occurs because producers have private information about

[1] The National Animal Disease Preparedness and Response Program (NADPRP) and the National Animal Health Laboratory Network (NAHLN) are the two programs that were established under the 2018 Farm Bill.

the disease status of their livestock herd and policymakers would like to incentivize producers to reveal this private information.[2] Indemnity payments are the monetary incentive for producers to reveal the health status of their herd. Determining how to set the level of indemnity payments is challenging for policymakers (Wolf, 2006). If indemnity payments are set too low, producers with higher quality animals may be reluctant to report (Enticott and Lee, 2015; Hennessy and Wolf, 2018). If payments are too high, we might expect to find over-reporting of disease suspicions.

This chapter determines the effects of livestock disease policies on producer self-reporting rates. To do this, we start by developing a conceptual framework that culls several features from the literature on the economics of disease (e.g., Fraser, 2018; Gramig and Horan, 2011; Gramig et al., 2009; Hennessy, 2007; Reeling and Horan, 2015, among others). The conceptual framework provides a link between producer decision making and the reported supply of diseased animals. Stated choice methods are used to determine the effects of indemnity payments on cow-calf producer self-reporting of foot-and-mouth disease (FMD) suspicions. We use stated preference methods because data on livestock disease outbreaks would only allow us to observe those cases that were reported or detected. Stated choice experiments allow us to observe those that report disease and those that do not. We empirically study FMD as a specific example because it is a thoroughly researched, high risk, highly contagious, FAD that has received considerable attention from industry groups following the passing of the 2018 Farm Bill.

This chapter makes two contributions to the literature. First, we contribute to the growing body of research that conceptually studies the role of economic incentives on disease reporting. Building on Hennessy (2007), Gramig et al. (2009) provide a novel assessment of the effects of indemnity payments on producer disease reporting. In their analysis, Gramig et al. (2009) consider the case where government testing always returns a positive result for a disease. Thus, producers know if their animals are sick with a disease that should be reported and know the government's emergency response strategy. We build on Gramig

[2] Adverse selection is a classic problem in economics that arises when an agent possesses private or hidden information.

et al. (2009), giving more attention to the role of disease testing and prevalence.[3] FADs and diseases with existing eradication programs share several symptoms with less harmful diseases. In our model, producers report disease suspicions, and the government test result determines whether animals are culled or treated for a less harmful disease.

The empirical literature on livestock disease reporting economics and policy is limited. To our knowledge, the only other paper to estimate the effects of indemnity payments on disease reporting is Kuchler and Hamm (2000). Using the 1952-1992 U.S. scrapie eradication program as a natural experiment, Kuchler and Hamm (2000) find that the supply of diseased animals is price elastic, where prices are indemnity payment levels. We contribute to the literature by directly estimating producer preferences for indemnity payments and determine the effects of the size of indemnity payments on the share of producers reporting FMD suspicions. A novel test of adverse selection arises because we empirically consider the interactions between the size of indemnity payments and the disease prevalence rate. Elasticity estimates range from 0.064% to 0.216% for the effects of a 1% increase in the share of production losses covered by indemnity payments on the probability of reporting FMD suspicions. We find that the within-herd prevalence of the disease has a small effect on the disease reporting rate for a given indemnity payment. Thus, those that report FMD suspicions do so early before the disease spreads within their herd.

3.2 Conceptual Framework

In this section, we develop a conceptual framework that links disease reporting rates to producer-level decision making. After making this connection, we study the effects of indemnity policy and government intervention strategies on reported diseased animal supply. The goal is to develop a framework that yields testable hypotheses. Importantly, we choose to ignore the dynamics of disease reporting as we have no way of testing the predictions that a dynamic model would yield.

[3] Sheriff and Osgood (2010) consider the role of auditing on seller disclosure of food safety. Again, Sheriff and Osgood (2010) do not allow sellers to report quality defects that would test safe.

We begin with $i = 1, 2, ..., N$ livestock producers who observe symptoms that their respective livestock herds are infected with an unknown disease. Denote the within-herd disease prevalence rate by $d_i \in [0, 1]$. A source of uncertainty arises because producers do not know the type of disease that is infecting their herds. Indexing disease type by j, we consider two disease types $j \in \{R, NR\}$ where type R diseases are reportable and type NR are non-reportable.[4] In the United States, reportable livestock disease is diseases that are foreign to the U.S. or have an eradication program in place by APHIS (USDA–APHIS, 2017). Producers do not know the disease type because several livestock diseases share similar symptoms. Thus, each producer must decide whether to report symptoms of sick animals to animal health officials. By not knowning disease type, our framework allows for the possibility that choosing not to report is inadvertent. Denote the reporting decision by $r_i \in \{0, 1\}$.

3.2.1 Reporting

First, consider the case where a producer chooses to report, $r = 1$.

Diagnostic testing. After producers report disease suspicions to animal health officials, diagnostic testing is performed at no cost to the producer to determine the disease type. Denote the probability of testing positive for a type R disease by $P_R \in [0, 1]$, which is determined exogenously. Following a positive test result, the government takes action to control the reportable disease. There are no testing errors from diagnostic tests.

Government disease control. Researchers model the effects of a single government strategy (Gramig et al., 2009) or ignore the government's role in controlling disease (Fraser, 2018). In practice, the government has a collection of disease response strategies to control disease. In the United States, USDA APHIS has six response strategies for FADs, which include: stamping-out, stamping-out modified with emergency vaccination to kill, stamping-out with emergency vaccination to slaughter, stamping-out with emergency vaccination to live, emergency vaccination to live without stamping-out, and manage without widespread stamping-out or vaccination (USDA–APHIS–VS, 2015b).

[4] Disease has no human health implications.

We consider two government response plans. Index government response plans by $G \in \{F, V\}$. The first government intervention is full depopulation, denoted by $F \in \{0, 1\}$, where all infected and susceptible animals are depopulated. The second government response is vaccinate, denoted $V \in \{0, 1\}$, where animals are vaccinated without depopulation. The strategies that we consider represent the two extremes. Producers take the government's disease response plan as given and is conditional on the producer testing positive for a type R disease.

Producer losses. Disease and government intervention are costly to producers (Gramig et al., 2009). Production losses are conditional on reporting, testing positive for type R disease, and the government disease control strategy. Production losses from government strategies are denoted $\ell_G(d_i)$, for $G \in \{F, V\}$. Assume $\ell_F(d_i) \geq \ell_V(d_i)$ and $\partial \ell_G(d_i)/\partial d_i > 0$. Losses from each strategy capture loss in asset value, reductions in animal performance, and business disruption. An example of a business disruption are movement controls put in place by the government to control disease spread.

No government action is taken if the producer does not test positive for a type R disease. Instead, the producer privately treats a type NR disease and treatment costs are denoted by $c(d_i)$. Assume $c(d_i)/\partial d_i > 0$. We assume $\ell_F(d_i) \geq c(d_i) \geq \ell_V(d_i)$ because producers bear the cost of disease control.

Prices. Absent herd depopulation, producers market diseased livestock and receive salvage value $s_j(d_i)$. The salvage value depends on the disease type. Assume $\partial s_j(d_i)/\partial d_i < 0$ and $s_{NR}(d_i) > s_R(d_i)$. Buyers will pay a higher price for sick animals relative to animals sold following a type R disease outbreak.

Indemnity Policy. Indemnity payments are made available to type R disease impacted producers who report. We assume that indemnity payments cover a share of production loss, and are only paid when the government depopulates infected herds. Denote the share of losses covered by indemnity payments by $\tau \in [0, 1]$ and the total payment by $\tau \ell_F(d_i)$. While we assume that $\ell_F(d_i) \geq c(d_i) \geq \ell_V(d_i)$, it is clear that τ will play an important role for producers evaluating loss at the margin under different scenarios. That is, τ will determine whether $\ell_F(d_i)(1 - \tau)$ is $>$, $<$, or $=$ to $\ell_V(d_i)$ and $c(d_i)$.

3.2.2 No Reporting

Next, consider the case where a producer chooses not to report, $r = 0$.

Detection. There is risk that producers who fail to report a type R disease are detected through government disease surveillance. Denote the probability of detection by $P_{D|R} \in [0, 1]$. The probability of detection is conditional on animals testing positive for a type R disease.

Government disease control and producer losses. Following detection, the government chooses whether to depopulate the herd (F) or vaccinate (V). Production losses are denoted $\ell_G(d_i)$. Losses are conditional on a positive test for a type R disease and detection. Producers that go undetected, privately treat the disease where costs are $c(d_i)$.

Prices. Producers that go undetected sell sick livestock and receive salvage value $s_{NR}(d_i)$. Undetected producers do not disclose disease status to buyers. We assume animals that go undetected sell for the same amount as animals diagnosed with a type NR disease. Producers that are detected through government surveillance can sell sick animals and receive salvage value $s_R(d_i)$ when a vaccination strategy is taken by the government.

Indemnity Policy. Producers that do not report and are detected through surveillance for a type R disease receive indemnity payments $\tau\ell_F(d_i)$ and pay a fine f. The fine is paid regardless of whether the decision not to report was inadvertent and does not depend on the availability of indemnity payments.

3.2.3 Producer Utility and Diseased Animal Supply

The conceptual framework allows for three producer outcomes that result from reporting:

1. Test positive for type R disease, government depopulates the herd and realize production losses, and receive indemnity payments,

2. test positive for type R disease, government vaccinates the herd and realize production losses, and sell type R infected animals, and

3. test negative for type R disease, privately treat the disease and realize production losses, and sell type NR infected animals.

Three producer outcomes arise from not reporting disease suspicions:

1. Government detection through type R disease surveillance, government depopulates the herd and realize production losses, pay a fine, and receive indemnity payments,

2. government detection through type R disease surveillance, government depopulates the herd and realize production losses, pay a fine, and sell type R infected animals, and

3. no detection through type R disease surveillance, privately treat the disease and realize production losses, and sell animals with unknown disease type.

We use a random utility model approach to characterize producer decisions about reporting disease suspicions. Producers have preferences for reporting strategy attributes and choose the strategy that yields the highest expected utility. Utility from reporting strategy r is $U_{i,r} = U(P_{R,r}, P_{D|R,r}, G_r, \ell_{G,r}, c_r, s_{j,r}, f_r, \tau_r, d_{i,r}; B_i, \varepsilon_{i,r})$. Producers are heterogeneous. B_i is the set of parameters characterizing the utility function with density function $f(B_i)$. $\varepsilon_{i,r}$ is random unobserved variation with density function $f(\varepsilon_{i,r})$.

A producer will choose reporting strategy $r = 1$ if $U_{i,r=1} > U_{i,r=0}$. Denote the set of producers for which $U_{i,r=1} > U_{i,r=0}$ by $A_{r=1} = \{B_i, \varepsilon_{i,r} | U_{i,r=1} > U_{i,r=0}\}$. The share of diseased animals that are reported is expressed as:

$$S_1 = \iint_{A_{r=1}} f(\varepsilon) f(B) d\varepsilon dB. \tag{3.1}$$

Likewise, denote the set of producers for which $U_{i,r=0} \geq U_{i,r=1}$ by $A_{r=0} = \{B_i, \varepsilon_{i,r} | U_{i,r=0} \geq U_{i,r=1}\}$. The share of diseased animals that are not reported is expressed as:

$$S_0 = \iint_{A_{r=0}} f(\varepsilon) f(B) d\varepsilon dB. \tag{3.2}$$

Beyond functional form and distributional assumptions made by the researcher, the number of reported and not reported cases depends on the economic variables entering each producers utility function.

3.2.4 Policy Implications

Equations 3.1 and 3.2 have important policy implications. First, realize that equations 3.1 and 3.2 give the share of diseased animals that are and are not reported to animal health officials. Equations 3.1 and 3.2 do not give shares for animals that test positive for type R disease. That is, miss-reporting and over-reporting are just as problematic as under-reporting (Brugere et al., 2017). The policy variables are $G \in \{F, V\}$, τ, and f. Setting $G \in \{F, V\}$, τ, and f will depend on policymaker tolerance for P_R, the probability of a positive test for type R disease, and $P_{D|R}$, the probability the disease surveillance detects producers with type R diseased animals.For $\bar{P}_R$ and $\bar{P}_{D|R}$, a policymaker would like to set $G \in \{F, V\}$, τ, and f such that $S_1(S_0)$ is maximized(minimized).

Effects of indemnity payments. Kuchler and Hamm (2000) find an elastic supply function for the supply of diseased animals, and Hennessy and Wolf (2018) provide further argument for an upward sloping supply curve. Our framework allows us to provide further context to this hypothesis. Specifically,

$$\frac{\partial S_1}{\partial \tau}\frac{\tau}{S_1} > 1 \tag{3.3}$$

would confirm that indemnity payments induce sufficiently higher reporting rates. However, the elasticity in equation 3.3 says nothing about whether indemnity payments induce early reporting. Finding

$$\frac{\partial^2 S_1}{\partial d_i \partial \tau} > 0 \tag{3.4}$$

and, for example,

$$\left.\frac{\partial^2 S_1}{\partial d_i \partial \tau}\right|_{d_i=25\%} > \left.\frac{\partial^2 S_1}{\partial d_i \partial \tau}\right|_{d_i=50\%} \tag{3.5}$$

would provide evidence that indemnity payments induce higher early reporting thereby reducing adverse selection. Equation 3.4 shows that indemnity payments and disease prevalence rates complement each other in inducing reporting. The example in equation 3.5 shows that indemnity payments induce higher rates of change in reporting at lower prevalence rates.

3.3 Data

The full incidence of livestock disease is categorized by individuals who report, are detected by surveillance, and are not detected by surveillance. A problem with studying the economics of livestock disease reporting is that we only observe livestock disease cases reported or detected by disease surveillance. Assuming that disease surveillance does not catch 100% of unreported cases, observational data does not record producers who do not report disease and go undetected. Using observational data would result in us having to change the research question and relevant policy counterfactual. As an example, observational data would not allow us to answer the question, "if a livestock producer who did not report disease suspicions had instead received a policy treatment, would they have changed their reporting strategy?"

In this chapter, we rely on primary data collection to study the effects of government disease intervention and indemnity payments on producer willingness report disease suspicions. A mail survey was developed for U.S. cow-calf producers to collect information on operation and producer characteristics, biosecurity and animal health practices, FMD knowledge and risk perceptions, and disease reporting practices and perceptions. Sampling procedures, survey packet development, and data collection were done in collaboration with BEEF Magazine.[5] The final survey instrument was granted exemption by the Kansas State University Committee on Research Involving Human Subjects and Institutional Review Board.

BEEF Magazine developed an eligible mail distribution list of 2,000 United States cattle producers based on the requirement that the operation has at least 20 head of any cattle in inventory.[6] In an effort to increase survey response, a $1 bill, cover letter, and postage-paid return envelopes were included in each invitation packet (Dillman et al., 2009; Schulz and Tonsor, 2010a,b; Tonsor, 2018). Printed survey invitation packets were mailed on October 22, 2018, with no follow-up solicitation. Survey responses were accepted until January 15, 2019. The final survey response rate was 22%, and data included 442 partially complete or

[5] Schulz and Tonsor (2010a), Schulz and Tonsor (2010b), and Tonsor (2018) also used magazine subscription lists to survey livestock producers. McKendree (2017) used state association membership and Feedlot Magazine mailing lists to survey feedlot operations.

[6] The survey instrument includes questions that allow us to determine how producers classify their cattle operation.

complete responses.

3.3.1 Stated Choice Experiments

We use stated choice methods to determine producer preferences for reporting strategy attributes and the effects of alternative disease policies. The stated choice experiments present producers with scenarios were they observe suspicions of an FMD outbreak in their cow herd. The decision for each respondent is to decide whether to report FMD suspicions to an accredited veterinarian, a binary choice.

FMD is a highly contagious viral disease that infects cows, pigs, sheep, goats, deer, and other animals with divided hooves (USDA–APHIS–VS, 2013). FMD is on the National List of Reportable Animal Diseases in the United States and is an OIE-World Organisation for Animal Health reportable disease. 9 C.F.R. §161.4 (2012) states the disease reporting requirements and standards for accredited veterinarians in the United States. However, the United States lacks a standardized national system for animal disease reporting (USDA-APHIS, 2020). While there are legal implications of failing to disclose a known case of FMD, our stated choice experiments frame the scenario for cattle producers as observing symptoms and suspicions of an outbreak. Thus, in our scenarios there are no direct legal consequences from not reporting.

Several factors contribute to an individual's decision to report disease suspicions that go beyond economics.[7] However, as the number of variables increases in stated choice methods, so does the task complexity and survey respondent burden (Louviere et al., 2000). A survey of the literature, our conceptual framework, and research objectives are used to determine attribute and attribute levels.

The attributes and attribute levels are a subset of the variables considered in Section 3.2. The FMD suspicion reporting scenarios varied by *prevalence rate* (d_i in Section 3.2), *positive test* (P_R in section 3.2), *government response policy* (G in Section 3.2), *indemnity policy* (τ in Section 3.2), and *livestock buyer discount* (s_j in Section 3.2) (Delabouglise and Boni,

[7]For example, Palmer et al. (2009) finds that trust for Western Australia sheep and cattle farmers reporting disease.

2019; Fraser, 2018; Gramig et al., 2009; Hennessy and Wolf, 2018; Kuchler and Hamm, 2000; Tonsor and Schulz, 2020). An example stated choice scenario is in 3.1. Complete directions and descriptions from the survey instrument are in appendix B.

Please indicate which option you would select. (Please select either "Yes" or "No")

Prevalence rate (%)	10%	
Positive test (%)	50%	
Government response policy	Vaccinate	
Indemnity policy (%)	0%	
Livestock buyer discount ($/cwt)	$5	
I would choose to report suspicions of FMD:	☐ Yes	☐ No

Figure 3.1: *FMD reporting stated choice experiment example.*

In the choice experiments, *prevalence rate* is the percent of the cow herd that is showing signs of infection. *Prevalence rate* has three levels (10%, 50%, 100%). *Positive test* is the probability of animals testing positive for FMD and has three levels (10%, 50%, 100%). *Government response policy* is the government's action to control the disease and has three levels (vaccinate, conditional herd depopulation, and full herd depopulation. *Indemnity policy* is the share of production losses covered by indemnity payments and has three levels (0%, 50%, and 100%). *Livestock buyer discount* is the discount applied to animals coming from FMD impacted regions and has three levels ($0/cwt, $5/cwt, and $10/cwt).

With five attributes, each with three levels, a full factorial design would involve 3^5 choice tasks. For a binary choice situation, we use a main effects and two-interaction effects design drawn from the full factorial design and maximize D-efficiency to identify a smaller number of choice sets (Kuhfeld et al., 1994; Lusk and Norwood, 2005).[8] The resulting design includes 11 choice tasks, randomly blocked into a set of five and a set of six.

3.3.2 Sources of Response Bias

Given the nature of the choice experiments, there are two sources of response bias that warrant discussion. The first is social desirability bias where respondents behave in ways

[8]Louviere et al. (2000) advise that in binary choice situations, randomly drawing choice sets from the full factorial will perform poorly in approximating the statistical properties of the full design.

that are perceived to be viewed favorably by the researcher. In our context, respondents might always choose to report FMD suspicions because they believe that researchers view this as the "right thing to do". Several methods exist to address social desirability bias. However, Norwood and Lusk (2011) show that these methods might not work well in settings where respondents are anonymous.

The second source of bias is linked to realism and a respondent's subjective beliefs about the scenarios in the choice experiment. The role of subjective beliefs in decision making is well documented, and most credit Savage (1954) with developing a theory of subjective expected utility. A natural extension, research argues that subjective beliefs can lead to scenario adjustment or scenario rejection in stated choice experiments (Bradley, 1988; Burghart et al., 2007; Cameron et al., 2011; Kataria et al., 2012). Scenario rejection refers to the case where respondents view the choice scenarios as unrealistic, and scenario adjustment refers to the situation where respondents adjust some aspect of choice scenarios based on their subjective beliefs (Cameron et al., 2011). In our context, respondents might have priors about whether an FMD outbreak will occur or on given FMD policy.

The two sources of response bias might result in preferences that are biased downwards, where the economic variables in the choice experiments have a small effect on a respondent's decision to report FMD suspicions. We estimate discrete choice models for the full sample and a sample that omits respondents that answered with the same choice for each choice task as a crude attempt to correct social desirability bias. While this is a crude attempt to correct for social desirability bias, it could also result in an overcorrection. There might be some respondents whose preferences were such that they always choose to report FMD or never choose to report.

The survey included questions to elicit subjective beliefs about several aspects of FMD reporting. The first question asked, "How many times in the next 100 years do you think an FMD outbreak will occur in a U.S. livestock population (cattle, sheep, goats, swine)?" The second question asked, "If an FMD outbreak occurred on your operation, would you expect indemnity payments to be provided by the government?" These two questions capture producer expectations about FMD and policy. To control for scenario rejection, we estimate discrete choice models for the full model and a sample that omits those that do not expect an FMD outbreak in the next 100 years. We also attempt to incorporate FMD and policy expectations as respondent-specific variables in the model.

3.3.3 Summary

Table 3.1 provides a summary of select variables for respondents in the panel of U.S. cattle producers. The first two columns provide a summary of the full sample of 3,426 observations across 306 individual producers (N=3426). The next two columns omit respondents that do not expect a U.S. FMD outbreak in the next 100 years and include 2,790 observations across 248 producers (N=2790). Data for (N=2790) reflects one attempt to control for realism. The last two columns omit respondents who provided the same answer to each stated choice question and includes 1,318 observations across 120 producers (N=1318). Data (N=1318) reflects our attempt to control for social desirability bias. However, this might be viewed as an overcorrection and restricts cross-sectional variation in the data.

Table 3.1: *Summary of select respondent characteristics*

	N=3426		N=2790		N=1318	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	63.04	13.18	62.83	13.13	60.67	13.76
Cows (head)	225.69	434.35	219.63	370.86	232.78	461.51
Region (0,1):						
CB	0.23	0.42	0.21	0.41	0.28	0.45
NC	0.06	0.24	0.07	0.25	0.06	0.23
NP	0.27	0.45	0.28	0.45	0.32	0.47
NW	0.21	0.40	0.20	0.40	0.20	0.40
SE	0.11	0.31	0.11	0.31	0.07	0.25
SP	0.13	0.33	0.13	0.34	0.07	0.25
Operation (0,1):						
Commercial	0.78	0.42	0.77	0.42	0.75	0.43
Seedstock	0.05	0.21	0.05	0.22	0.07	0.25
Both	0.16	0.37	0.16	0.37	0.16	0.37
Other	0.02	0.12	0.02	0.12	0.02	0.15
FMD Expectation (0,1):						
0 times	0.19	0.39			0.23	0.42
1 time	0.17	0.37	0.21	0.40	0.16	0.37
2 times	0.24	0.43	0.29	0.45	0.22	0.42
3 times	0.12	0.32	0.14	0.35	0.11	0.31
4 times	0.08	0.28	0.10	0.30	0.10	0.30
5 times	0.08	0.27	0.10	0.30	0.10	0.30
6 or more times	0.13	0.33	0.16	0.36	0.07	0.26
Policy Expectation (0,1):	0.47	0.50	0.48	0.50	0.56	0.50

Note: *Age* is the age of the respondent in years. *Cows* is beef cow inventory as of January 1, 2018. *Region* is coded following Schulz and Tonsor (2010a,b). CB is corn belt states, NC is northern crescent states, NP is northern plains states, NW is northwest states, SE is southeast states, and SP is southern plains stats. *Operation* is the operation type that best describes the respondent's cattle operation. *FMD Expectation* is the number of times the respondent expects there to be an FMD outbreak in the United States. *Policy Expectation* is a dummy variable that equals 1 (0 otherwise) if the producer expects their to be indemnity payments following a FMD outbreak in the United States.

3.4 Empirical Framework

The objective is to determine the effects of indemnity payments on producer reporting of FMD suspicions. To do this, we use stated choice experiments and a random utility approach to estimate producer preferences. Specifically, producer i in choice situation t will choose FMD reporting strategy $r = 1$ if $U_{i,r=1,t} > U_{i,r=0,t}$ where U_{irt} is utility from reporting strategy r. Utility is decomposed into observable and unobservable components, $U_{irt} = V_{irt} + \varepsilon_{irt}$ where V_{irt} is the observable component of utility and ε_{irt} is unosbserved random taste variation. Using the notation from Section 3.2, we argue that utility from reporting FMD suspicions can be expressed as:

$$U_{irt} = V(s_{irt}, d_{irt}, P_{R,irt}, F_{irt}, V_{irt}, \tau_{irt}) + \varepsilon_{irt} \tag{3.6}$$

where s_{irt} is the \$/cwt livestock buyer discount, d_{irt} is the within-herd prevalence rate for FMD symptoms, $P_{R,irt}$ is the probability of a positive FMD test result, V_{irt} is an emergency vaccination strategy taken by the government relative to conditional herd depopulation, F_{irt} is an emergency full herd depopulation taken by the government relative to conditional depopulation, τ_{irt} is the share of production losses covered by indemnity payments.

Given the specification in equation 3.6, assuming that ε_{irt} is distributed type 1 extreme value, we approximate producer utility with a mixed logit model of the form:

$$\begin{aligned} U_{irt} = \beta_0 + \beta_1 s_{irt} + \beta_{i2} d_{irt} + \beta_{i3} P_{R,irt} + \beta_{i4} V_{irt} + \beta_{i5} F_{irt} + \beta_{i6} \tau_{irt} \\ + \theta_j E_{ir} + \varepsilon_{irt}, \ \forall\ r = \text{Reporting} \end{aligned} \tag{3.7}$$

$$U_{irt} = \theta_j E_{ir} + \varepsilon_{irt}, \ \forall\ j = \text{No Reporting} \tag{3.8}$$

where $\boldsymbol{\beta_i'} = (\beta_{i2}, \beta_{i3}, \beta_{i4}, \beta_{i5}, \beta_{i6})$ are normally distributed random parameters (Train, 2009). In equations 3.7 and 3.8, the random parameters are specified as $\boldsymbol{\beta_i} = \boldsymbol{\bar{\beta}} + \boldsymbol{\Omega \upsilon_i}$ (Greene and Hensher, 2005) where $\boldsymbol{\bar{\beta}}$ is a vector of fixed means, $\boldsymbol{\Omega} = diag(\sigma_2, \sigma_3, \sigma_4, \sigma_5, \sigma_6)$ is a diagonal matrix of standard deviations, and υ_i is a vector of individual random unobserved taste variation with mean vector zero and identity covariance matrix. Finally, E_{ij} are individual-specific random effects that capture unobserved choice situation invariant heterogeneity (time-invariant heterogeneity in conventional panel data settings), and θ_j are random effect standard deviations (Greene and Hensher, 2005). While we do not directly model the consequences of not reporting using choice attributes in 3.8, the random effects specification allows us to capture individual unobserved effects from not reporting FMD suspicions.

Mixed logit choice probabilities for the model in equations 3.7 and 3.8 are estimated using simulated maximum likelihood. We use 500 Halton draws for simulation estimation (Train, 2009). Using the estimated models for N=3426, N=2790, and N=1318, we estimate equations 3.1 and 3.2 with

$$S_r = N \times \sum_{i=1}^{N} \hat{P}_{ij} \tag{3.9}$$

where $\hat{P}_{ij}$ are predicted mixed logit probabilities (Hensher et al., 2005).

3.5 Results

We use likelihood ratio tests for model specification. First, likelihood ratio tests reject a conditional logit model in favor of a more general mixed logit specification. Next, we test for random effects and reject the null. The final model specification is a mixed logit model with normal distributed random parameters and alternative specific random effects (equations 3.7 and 3.8).

Social desirability bias and realism are potential sources of bias. We estimate the model in equations 3.7 and 3.8 three separate times. The first estimation includes the full sample of respondents (N=3426). The second estimation attempts to account for realism and scenario rejection by omitting respondents that do not expect an FMD outbreak in the next 100 years (N=2790). In the data, 19% of respondents do not expect an FMD outbreak (Table 3.1). The third estimation attempts to account for social desirability bias by omitting respondents who always to choose to report or never report (N=1318). Simulated maximum likelihood estimation results are reported in Table 3.2. Importantly, results show that there are no sign changes in preferences among the three samples.

Table 3.2: *Simulated maximum likelihood estimates for FMD reporting mixed logit models*

	N=3426		N=2790		N=1318	
	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.
Nonrandom Parameter:						
Constant	0.904*	0.464	0.984*	0.568	-1.678***	0.358
s_{irt}	-0.043	0.037	-0.038	0.048	0.020	0.035
Random parameter means:						
d_{irt}	1.988***	0.631	1.840**	0.788	1.206***	0.443
$P_{R,irt}$	1.842***	0.654	2.380***	0.793	1.017**	0.472
$\tau_{R,irt}$	3.566***	0.749	3.890***	1.040	2.255***	0.407
F_{irt}	-1.298***	0.226	-1.259***	0.329	-0.973***	0.200
V_{irt}	1.104***	0.216	1.074***	0.275	1.052***	0.232
Random parameter std. devs.:						
d_{irt}	1.809**	0.807	1.908**	0.928	0.970	0.620
$P_{R,irt}$	2.385***	0.750	3.020***	0.917	2.023***	0.457
τ_{irt}	2.233**	0.941	2.061*	1.076	1.183**	0.485
F_{irt}	0.051	1.469	0.011	1.501	0.013	0.319
V_{irt}	0.464	0.388	0.782	0.601	0.508	0.321
Error components:						
$\theta_{r=1}$	2.455**	1.144	2.966***	0.931	0.040	0.110
$\theta_{r=0}$	2.371**	1.161	2.099	1.434	0.017	0.094
N	3426.00		2790.00		1318.00	
Log-likelihood	-601.27		-462.55		-394.70	
AIC	1230.50		953.10		817.40	
Pseudo R-squared	0.49		0.52		0.14	

Note: (N=3426) refers to the full sample of respondents, (N=2790) omits respondents that do not expect an FMD outbreak in the next 100 years, and (N=1318) omits respondents who always answer “yes” or “no” to stated choice questions. Number of observations is the product of 2 choices per task, number of choice tasks, and number of respondents. Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

A potential problem with the results in Table 3.2 is that there may be other sources of mean and variance heterogeneity based on subjective beliefs. Ignoring significant sources of heterogeneity would bias preference estimates. For each of the models in Table 3.2, we estimate a pooled model and models that stratify the data by *Policy Expectation* and *FMD Expectation*. In each case, we fail to reject the pooled model using likelihood ratio tests. We also estimate models that interact *Policy Expectation* and *FMD Expectation* with specific variables in the mean and variance terms of $\boldsymbol{\beta_i}$ and find similar results.

Using results in Table 3.2, we determine the effects of *indemnity policy* (τ_{irt} in Table 3.2) and *prevalence rate* (d_{irt} in Table 3.2) by estimating elasticities and counterfactual simulations. Point elasticities are estimated for each respondent and averaged using probability-weighted sample enumeration (Hensher et al., 2005). Elasticities for discrete choice models measure the percentage change in the choice probability for a percentage change in an independent variable. Elasticity estimates are in Table 3.3. A benefit of the mixed logit is that it does not impose symmetry on elasticity estimates. A percentage increase in the choice probability for reporting does not impose the same percentage reduction in the choice probability for not reporting.

Table 3.3: *Elasticity estimates*

	N=3426		N=2790		N=1318	
Variable	r=1	r=0	r=1	r=0	r=1	r=0
d_{irt}	0.052***	-0.230***	0.405***	-0.194***	0.155***	-0.195***
	(0.001)	(0.003)	(0.001)	(0.003)	(0.006)	(0.006)
$P_{R,irt}$	0.033***	-0.148***	0.327***	-0.157***	0.105***	-0.132***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.004)	(0.004)
τ_{irt}	0.064***	-0.284***	0.068***	-0.327***	0.216***	-0.272***
	(0.001)	(0.008)	(0.002)	(0.011)	(0.009)	(0.014)
s_{irt}	-0.014***	0.065***	-0.011***	0.053***	0.028***	-0.035***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)

Note: Elasticities are calculated using the point elasticity method and calculated for each individual in the sample and aggregated using probability-weighted sample enumeration. Delta method standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

For a fixed set of attributes, the share of respondents that report FMD suspicions is calculated using equation 3.9 and results in Table 3.2. Iterating over a set of values for an attribute gives FMD reporting curves. As a baseline, Figure 3.2 predicts reporting shares at mean attribute levels. Figure 3.2 shows that 81.7%, 82.7%, and 55.7% of respondents report FMD suspicions for N=3426, N=2790, and N=1318, respectively. The data the generate the figures in this section are in Appendix C and referenced throughout.

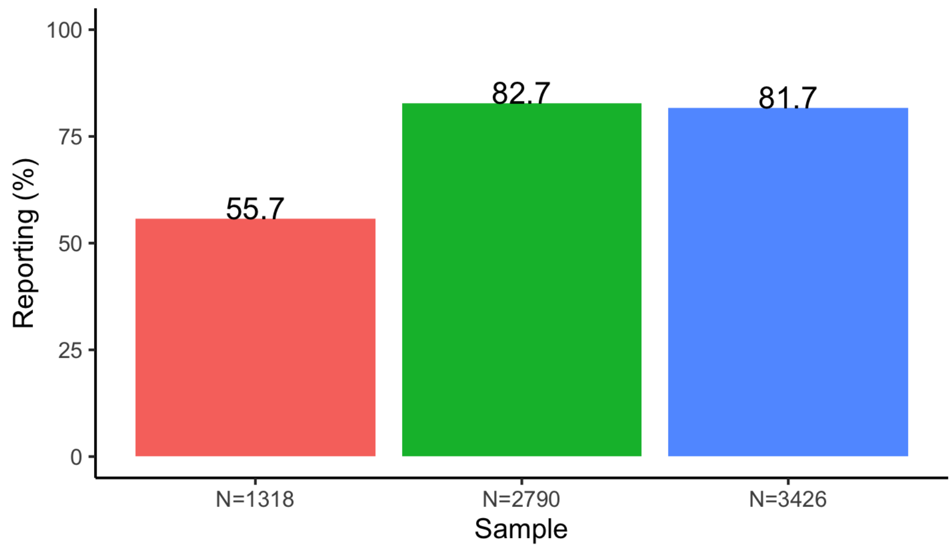

Figure 3.2: *Mean FMD suspicion reporting rates.*

3.5.1 Effects of Indemnity Payments

First, we study the effects of indemnity payments on the rate of FMD reporting. A 1% increase in τ_{irt} increases the probability of reporting FMD suspicions by 0.064%, 0.068%, and 0.216% for N=3426, N=2790, and N=1318, respectively (Table 3.3). Kuchler and Hamm (2000) predicts that the supply of susceptible animals is increasing in indemnity payments and argue that there are two ways to realize higher supply. First, a farmer could increase their efforts to identify sick animals for a fixed number of susceptible animals. Alternatively, a moral hazard problem could arise where farmers increase the number of susceptible animals when such activities yield positive returns (Kuchler and Hamm, 2000). (Kuchler and Hamm, 2000) estimate an elastic supply response where indemnity payments are set relative to market prices. Our estimates suggest a smaller reporting response from increases indemnity payments. Thus, we reject the prediction in equation 3.3 at mean values.

Elasticity estimates in Table 3.3 do capture the effects for the full range of indemnity payments. In Figure 3.3, we predict the rate of FMD reporting for the full set of indemnity payments while holding all other attributes at their mean values. This reveals a relatively more elastic response over the range $\tau_{irt} \in [0, 100]$. For indemnity payments set at 0%, 72.5%, 73.0%, and 40.2% of producers report FMD suspicions for N=3426, N=2790, and N=1318, respectively (Figure 3.3 and Table C.1). When indemnity payments are set at 50%, results from Figure 3.3 reveal that 83.6%, 84.3%, and 59.1% of producers report FMD for N=3426, N=2790, and N=1318, respectively (Figure 3.3 and Table C.1). The large difference for N=1318 in Figure 3.3 magnifies the potential for social desirability and realism bias.

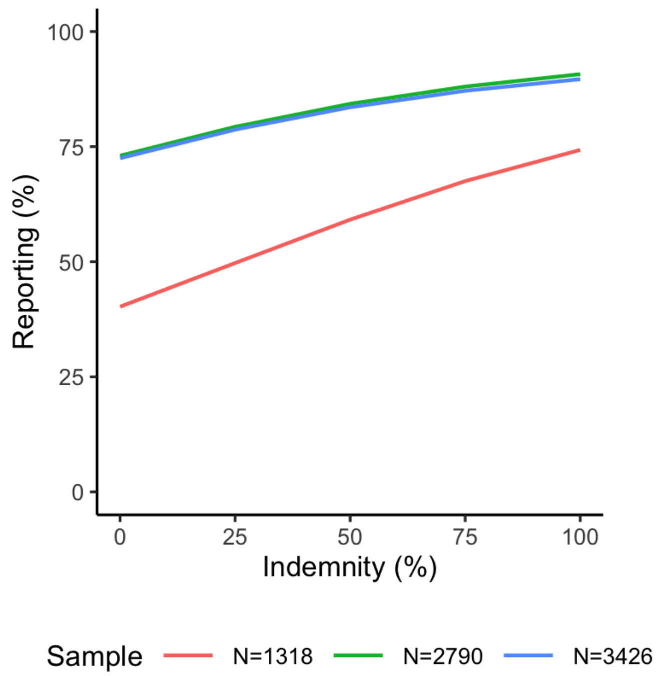

Figure 3.3: *Effects of indemnity payments on FMD suspicion reporting rates.*

3.5.2 Effects of Indemnity Payments and Disease Prevalence

Research has found that there are important interactions between disease prevalence and indemnity payments (Fraser, 2018; Gramig et al., 2009; Kuchler and Hamm, 2000). Elasticity results in Table 3.3 show that disease prevalence has the largest effect on FMD reporting. A 1% increase in disease prevalence increases the disease reporting response probability by 0.052%, 0.405%, and 0.155% for N=3426, N=2790, and N=1318, respectively. However, elasticity estimates in Table 3.3 and Figure 3.3 say nothing about which types of producers reveal FMD suspicions. Policymakers would like to set indemnity payments such that producers reveal disease status before the disease spreads within and across livestock herds.

Figure 3.4 shows the effects of indemnity payments at different disease prevalence rates. Figure 3.4 provides empirical context to equations 3.4 and 3.5. Specifically, Figure 3.4 confirms equation 3.4. Increasing indemnity payments results in an upward shift in the reporting-prevalence curve. Moreover, increasing indemnity payments is more effective at increasing reporting at lower disease prevalence rates. As an empirical counterpart to equation 3.5, at d_{irt} = 25% the results that populate the left panel in Figure 3.4 show that increasing τ_{irt} from 50% to 100% increases reporting from 54.4% to 71.1% (Table C.2). However, the left panel in Figure 3.4 shows that when d_{irt} = 100%, increasing τ_{irt} from 50% to 100% increases reporting from 68.2% to 80.5% (Table C.2). Thus, indemnity payments are more effective at inducing reporting when disease prevalence is low. Figure 3.4 also shows that indemnity payments and disease prevalence have a smaller impact on FMD reporting for N=3426 and N=2790.

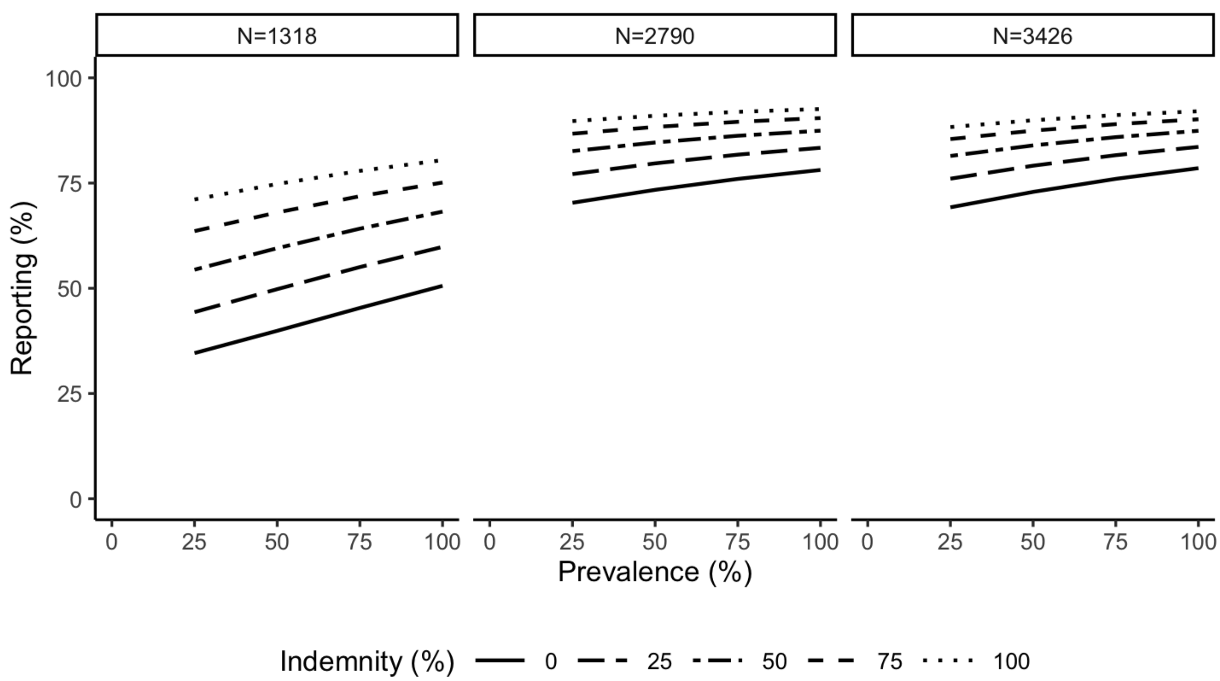

Figure 3.4: *Effects of indemnity payments and disease prevalence on FMD suspicion reporting rates.*

3.6 Limitations

This chapter provides a bold and novel attempt to study the role of indemnity policy on livestock producer disease reporting. As an empirical example, we consider reporting FMD suspicions. There are limitations to our approach that are worth describing.

First, there are limitations to framing the scenarios around FMD. This chapter describes the limitations of social desirability bias and subjective beliefs. Perhaps, a more obvious flaw is that in practice, many may choose not to report FMD because they are not familiar with the disease and symptoms. Conversely, producers may always choose to report because they always consult a veterinarian when animals are sick. For these two alternative scenarios, the economic variables would likely play no role in determining whether a producer reports FMD suspicions, which may result in us overstating the importance of our examined economic conditions. Future research might consider an alternative livestock disease for which that is an existing reporting and eradication program in place.

Second, the choice experiments include a variable for the government disease response. The disease response attribute consists of three levels: full herd depopulation, conditional herd depopulation, and vaccinate. The descriptions for full herd depopulation and conditional herd depopulation follow from (USDA–APHIS, 2015). However, the vaccination strategy includes vaccination of infected animals. While all three plans might be economically feasible and appeal to political pressures, they all may not be deemed viable or likely from an epidemiology perspective. It is difficult to predict which strategy of those described in this chapter, if any of them, would be implemented during an FMD outbreak because the U.S. has not faced an FMD outbreak since 1929. Thus, this attribute is potentially limited in usefulness and practicality. That said, consistent with other stated-preference work this research intentionally spans a set of scenarios that vary in how likely they are to play out given our focus on producer behavior over a range of situations.

Despite these two limitations, this chapter contributes new insights into the role of public policy in livestock disease control. Potentially the effects of indemnity payments are more generalizable to other livestock disease scenarios relative to other attributes in the choice experiment. A promising result is that producers report early before the disease spreads within the herd. However, FMD has such a high transmission rate that it is unlikely that a producer would be able to delay reporting before the disease impacts the entire herd effectively – the broader desire is that early reporting results in quicker public response and hence lower overall spread within the regional or national herd.

3.7 Conclusion

There has been an increase of interest in livestock disease policy following the passing of the 2018 Farm Bill. The 2018 Farm Bill authorizes USDA APHIS to use $150 million in funding to develop an FMD vaccine bank. Despite the importance of livestock disease policy, little work exists to explain the incentives for producers to protect against and report livestock disease. In this chapter, we study the effects of indemnity payments on cow-calf producer willingness to report FMD suspicions. Indemnity payments induce higher reporting at low disease prevalence rates and diminish as the prevalence rate increases. Thus, producers are willing to reveal private information about disease status when disease prevalence is low.

Results also have important policy implications. The stated choice experiments cover a broader mix of policy approaches relative to what is currently being implemented by USDA APHIS. Importantly, our results show that policy plays an essential role in a producer's decision to report FMD suspicions. Equally important, though not directly considered, are the consequences of choosing not to report. Results from this paper highlight the benefits of alternative policy approaches to control FADs. A natural extension would be to determine the costs from policy approaches that we consider to determine the optimal policy response.

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Appendix A

Chapter 2 Appendix

A.1 Seller Choice Experiment Directions

Instructions and description provided to choice experiment seller respondents.

The following 6 scenarios each containing three different options for you to select regarding participation in information sharing, individual animal traceability programs. Two options are voluntary traceability programs you could choose to participate in and the third option (*No Traceability*) is an alternative where you could choose not to participate in either of the two presented traceability programs. For your information in interpreting the alternative traceability program options, please carefully read the following descriptions:

Participation in a *Visual Traceability* program would involve applying 'traditional ear tags' that are read manually upon human inspection. Participation in an *Electronic Traceability* program would involve applying 'button-like' RFID (radio frequency identification) tags that can be read by electronic readers.

Source of origin and/or health certification/vaccination records of your ranch may also be provided to buyers of your cattle by participating in either a *Visual Traceability* (written documentation) or *Electronic Traceability* (electronic documentation) voluntary program.

These options vary in the cost for you to implement on your operation. Choosing *No Traceability* results in no increase in costs while choosing to participate in either the *Visual*

Traceability or *Electronic Traceability* program will increase costs by $1, $5, or $9 (per head).

The entity managing each voluntary traceability program may take one of three forms:

- *Government*: entity such as the USDA (United States Department of Agriculture);
- *Private-Industry*: entity specializes in traceability specifically for the beef cattle industry;
- *Government, Private-Industry Partnership*: joint effort between the public and private sector. Government data use would be limited to only disease monitoring, tracking, and surveillance consistent with public-good aspects of this information.

In addition, these options differ in terms of the premium or discount (per head sold) you would receive. These price adjustments to the market price range from discounts of up to $15 per head for selecting *No Traceability* and premiums of up to $15 per head for selecting *Electronic Traceability*. Negative numbers indicate discounts and positive numbers indicate premiums.

A.2 Buyer Choice Experiment Directions

Instructions and description provided to choice experiment buyer respondents.

The following 6 scenarios each containing three different options for you to select regarding the procurement of feeder cattle that are already participating in information sharing, individual animal traceability programs. Two options are feeder cattle participating in voluntary traceability programs and the third option (*No Traceability*) is an alternative where you could choose to procure cattle that are not participating in either of the two presented traceability programs. For your information in interpreting the alternative traceability program options, please carefully read the following descriptions:

Participation in a *Visual Traceability* program would involve you procuring cattle with 'traditional ear tags' that are read manually upon human inspection. Participation in an *Electronic Traceability* program would involve you procuring cattle with 'button-like' RFID (radio frequency identification) tags that can be read by electronic readers.

Source of origin and/or health certification/vaccination records may also be provided to you by feeder cattle sellers who are already participating in either a *Visual Traceability* (written documentation) or *Electronic Traceability* (electronic documentation) voluntary program.

These options vary in the feeder cattle premium or discount (per head sold) that you would have to offer to procure cattle that are participating in individual animal traceability programs. These price adjustments to the market price range from discounts of up to $15 per head for procuring cattle with *No Traceability* and premiums of up to $15 per head for procuring cattle with *Electronic Traceability*. Negative numbers indicate discounts and positive numbers indicate premiums.

The entity managing each voluntary traceability program may take one of three forms:

- *Government*: entity such as the USDA (United States Department of Agriculture);
- *Private-Industry*: entity specializes in traceability specifically for the beef cattle industry;
- *Government, Private-Industry Partnership*: joint effort between the public and private sector. Government data use would be limited to only disease monitoring, tracking, and surveillance consistent with public-good aspects of this information.

In addition, these options differ in terms of the fed cattle premium or discount (per head sold) you would receive. These price adjustments to the market price range from discounts of up to $15 per head for marketing cattle with *No Traceability* and premiums of up to $15 per head for marketing cattle with *Electronic Traceability*. Negative numbers indicate discounts and positive numbers indicate premiums.

Appendix B

Chapter 3 Appendix

Stated choice experiment instructions and descriptions provided to survey respondents.

Suppose you privately observe that your cow herd is showing signs of being infected with Foot and Mouth Disease (FMD). Having observed signs of FMD being present, you need to decide if you will report suspicions to an accredited veterinarian. On the following pages are hypothetical scenarios which vary with respect to prevalence rate, positive test results, government response policy, indemnity policy, and livestock buyer discount. For your information in interpreting the disease reporting options, please carefully read the following descriptions.

Prevalence rate (%): The percent of your cow herd that is showing signs of being infected with FMD.

- For example, if your cow herd consists of 100 animals and 10% of the herd is showing signs of being infected with FMD, then 10 animals are suspected of having FMD.

Positive test (%): The probability that animals in your cow herd that are suspected of having FMD actually test positive for the disease.

- For example, FMD is often confused with other diseases involving fever and blisters that are less harmful. Diseases that might be confused with FMD include bovine viral diarrhea, footrot, bluetongue, and vesicular stomatitis.

Government response policy: The response strategy taken by the government to eradicate FMD from cow herds that test positive for the disease. Alternative response strategies include:

- **Full herd depopulation**-depopulation of animals clinically infected with FMD and susceptible animals.
- **Conditional herd depopulation**-depopulation of animals clinically infected with FMD and susceptible animals and also vaccination all remaining at-risk animals.
- **Vaccinate**-vaccination of all animals clinically infected with FMD and susceptible animals.

Indemnity policy (%): The share of production losses covered by indemnity payments provided by the government following FMD detection. Indemnity payments are provided when animals must be quarantined and euthanized. They are based on fair market value of the animal, reflect budget conditions and USDA APHIS policies at the time.

- For example, if the indemnity payment covers 100% of losses then you would receive the fair market value, based on USDA APHIS calculations, for each animal that is euthanized to eradicate FMD. During large scale disease outbreaks, the government might choose to provide indemnity payments that cover 50% or 0% (no payments) of production losses.

Livestock buyer discount ($/cwt): FMD is not a public health or food safety concern. Therefore, cattle which pass ante-mortem and post-mortem inspection by USDA Food Safety Inspection Service (FSIS) are safe and wholesome for human consumption. Cattle from impacted regions with no evidence of FMD infection may be available at a discount relative to livestock from not impacted regions.

- For example, buyers might choose to procure animals from an FMD impacted region only at a $5.00/cwt discount compared to animals from FMD-free regions, if animals are disease free or vaccinated for FMD.

Place an "X" in either the "Yes" or "No" box, for the option that you would choose from each of the following 5 scenarios. Even though this a hypothetical exercise, please answer the questions as if you were actually facing these situations on your operation. Although these questions may look very similar, they are each different, so please provide a choice for each scenario.

Appendix C

Chapter 3 Data for Figures 3.3, 3.4, and 3.6

Table C.1: *Data for Figure 3.3*

Sample	Indemnity	Report
N=3426	0	72.49
N=3426	25	78.70
N=3426	50	83.56
N=3426	75	87.13
N=3426	100	89.66
N=2790	0	73.03
N=2790	25	79.31
N=2790	50	84.30
N=2790	75	88.05
N=2790	100	90.75
N=1318	0	40.23
N=1318	25	49.72
N=1318	50	59.15
N=1318	75	67.52
N=1318	100	74.29

Table C.2: Data for Figure 3.4

Sample	Indemnity	Rate	Report
N=3426	0	25	69.24
N=3426	25	25	76.04
N=3426	50	25	81.45
N=3426	75	25	85.46
N=3426	100	25	88.31
N=3426	0	50	72.91
N=3426	25	50	79.13
N=3426	50	50	83.95
N=3426	75	50	87.46
N=3426	100	50	89.93
N=3426	0	75	76.01
N=3426	25	75	81.63
N=3426	50	75	85.92
N=3426	75	75	89.00
N=3426	100	75	91.16
N=3426	0	100	78.54
N=3426	25	100	83.60
N=3426	50	100	87.42
N=3426	75	100	90.16
N=3426	100	100	92.08
N=2790	0	25	70.32
N=2790	25	25	77.13
N=2790	50	25	82.60
N=2790	75	25	86.73
N=2790	100	25	89.73
N=2790	0	50	73.40
N=2790	25	50	79.69
N=2790	50	50	84.65
N=2790	75	50	88.34
N=2790	100	50	90.99
N=2790	0	75	75.99
N=2790	25	75	81.75
N=2790	50	75	86.24
N=2790	75	75	89.56
N=2790	100	75	91.93
N=2790	0	100	78.12
N=2790	25	100	83.38
N=2790	50	100	87.45
N=2790	75	100	90.45
N=2790	100	100	92.60
N=1318	0	25	34.60

N=1318	25	25	44.35
N=1318	50	25	54.42
N=1318	75	25	63.59
N=1318	100	25	71.11
N=1318	0	50	39.90
N=1318	25	50	49.80
N=1318	50	50	59.53
N=1318	75	50	68.02
N=1318	100	50	74.79
N=1318	0	75	45.33
N=1318	25	75	55.05
N=1318	50	75	64.18
N=1318	75	75	71.88
N=1318	100	75	77.90
N=1318	0	100	50.59
N=1318	25	100	59.84
N=1318	50	100	68.22
N=1318	75	100	75.13
N=1318	100	100	80.46

Appendix D

Chapters 2 and 3 Survey Instrument

Q1.1 Survey Number ________ (1)

Q1.2 Survey Version:

- ❍ R1 (1) FMD Survey
- ❍ R2 (2) FMD Survey
- ❍ C1 (3) Feeder Cattle Seller Traceability Survey
- ❍ C2 (4) Feeder Cattle Seller Traceability Survey
- ❍ C3 (5) Feeder Cattle Seller Traceability Survey
- ❍ F1 (6) Feeder Cattle Buyer Traceability Survey
- ❍ F2 (7) Feeder Cattle Buyer Traceability Survey
- ❍ F3 (8) Feeder Cattle Buyer Traceability Survey

Start of Block: R1 Version

Q2.1 Which operation type best describes your cattle operation?

- ❍ Commercial (1)
- ❍ Both commercial and seedstock (2)
- ❍ Seedstock (3)
- ❍ Other (specify) (4) ____

Q2.2 Which marketing method do you most frequently use in marketing your operation's cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q2.3 Do the same buyers purchase cattle from your operation each year?

- ❍ No (1)
- ❍ Yes (2)

Q2.4 Do you usually provide buyers with information about your operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q2.5 How is this information most frequently shared?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q2.6 Has your operation had any of the following disease outbreaks in the last 5 years? If yes, how many months ago was the most recent case?

	Yes (1)	Months ago (1)	No Disease Problems (1)
Bovine Viral Diarrhea (BVD) (1)	❍	__________	❍
Trichomoniasis (Trich) (2)	❍	__________	❍
Bovine tuberculosis (TB) (3)	❍	__________	❍
Vesicular stomatitis (VS) (4)	❍	__________	❍
Infectious bovine rhinotracheitis (IBRV) (5)	❍	__________	❍
Other (specify) (6)	❍	__________	❍

Q2.7 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q2.8 In which state is your cattle operation?

- ❍ Alabama (1)
- ❍ Alaska (2)
- ❍ Arizona (3)
- ❍ Arkansas (4)
- ❍ California (5)
- ❍ Colorado (6)
- ❍ Connecticut (7)
- ❍ Delaware (8)
- ❍ District of Columbia (9)
- ❍ Florida (10)
- ❍ Georgia (11)
- ❍ Hawaii (12)
- ❍ Idaho (13)
- ❍ Illinois (14)
- ❍ Indiana (15)
- ❍ Iowa (16)
- ❍ Kansas (17)
- ❍ Kentucky (18)
- ❍ Louisiana (19)
- ❍ Maine (20)
- ❍ Maryland (21)
- ❍ Massachusetts (22)
- ❍ Michigan (23)
- ❍ Minnesota (24)
- ❍ Mississippi (25)
- ❍ Missouri (26)
- ❍ Montana (27)
- ❍ Nebraska (28)
- ❍ Nevada (29)
- ❍ New Hampshire (30)
- ❍ New Jersey (31)
- ❍ New Mexico (32)
- ❍ New York (33)
- ❍ North Carolina (34)
- ❍ North Dakota (35)
- ❍ Ohio (36)
- ❍ Oklahoma (37)
- ❍ Oregon (38)
- ❍ Pennsylvania (39)
- ❍ Puerto Rico (40)
- ❍ Rhode Island (41)
- ❍ South Carolina (42)
- ❍ South Dakota (43)
- ❍ Tennessee (44)
- ❍ Texas (45)
- ❍ Utah (46)
- ❍ Vermont (47)
- ❍ Virginia (48)
- ❍ Washington (49)
- ❍ West Virginia (50)
- ❍ Wisconsin (51)
- ❍ Wyoming (52)
- ❍ I do not reside in the United States (53)

Q2.9 Biosecurity for beef cattle operations is often defined as the implementation of protocols designed to reduce the likelihood of unwanted pests and disease threats from entering the cattle herd. Which practice best describes the level of biosecurity implemented on your operation?

- ❍ Maintain a closed herd (1)
- ❍ No entry of new cattle but reentry of existing cattle allowed (2)
- ❍ Entry of new cattle with known medical records and initial quarantine (3)
- ❍ Entry of new cattle with known medical records but no initial quarantine (4)
- ❍ Entry of new cattle with no known medical records and no initial quarantine (5)

Q2.10 How would you rate the biosecurity of your operation compared to other operations in your area?

- Very Low -1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- 8 (8)
- 9 (9)
- Very High - 10 (10)

Q2.11 Approximately, what portion of your total annual cow costs are allocated to biosecurity efforts?

________ percent (1)

Q2.12 How many times in the next 100 years do you think an FMD outbreak will occur in a U.S. livestock population (cattle, sheep, goats, swine)?

- 0 times (1)
- 1 time (2)
- 2 times (3)
- 3 times (4)
- 4 times (5)
- 5 times (6)
- 6 or more times (7)

Q2.13 If an FMD outbreak occurred on your operation, how long (number of months) do you think losses would persist?

- Under 1 month (1)
- 1 to 3 months (2)
- 4 to 6 months (3)
- 7 to 9 months (4)
- 10 to 12 months (5)
- 13 to 15 months (6)
- 16 to 18 months (7)
- 19 months or longer (8)

Q2.14 If an FMD outbreak occurred on your operation, what do you think production losses would be in dollars per cow?

- $0 per cow (1)
- $0.01-$100 per cow (2)
- $100.01-$200 per cow (3)
- $200.01-$300 per cow (4)
- $300.01-$400 per cow (5)
- $400.01-$500 per cow (6)
- $500.01-$600 per cow (7)
- $600.01-$700 per cow (8)
- $700.01-$800 per cow (9)
- Over $800 per cow (10)

Q2.15 If an FMD outbreak occurred on your operation, would you expect indemnity payments to be provided by the government?

- ❍ No (1)
- ❍ Yes (2)

Q2.16 If yes, would you expect indemnity payments provided by the government to be made available to cattle producers only if they could document biosecurity efforts?

- ❍ No (1)
- ❍ Yes (2)

Q2.17 Would you expect indemnity payments provided by the government to cover all of the production losses in cattle value?

- ❍ No (1)
- ❍ Yes (2)

Q2.18 If an FMD outbreak occurred on your operation, in your opinion how would buyers of your cattle likely respond? Buyers would continue to purchase cattle known to be FMD free or vaccinated against FMD at a discount of:

- ❍ No discount, buyers would continue to purchase cattle as usual (1)
- ❍ $0.01-$5.00 per hundredweight discount (2)
- ❍ $5.01-$10.00 per hundredweight discount (3)
- ❍ $10.01-$15.00 per hundredweight discount (4)
- ❍ $ 15.01 per hundredweight or higher discount (5)

Q2.19 If an FMD outbreak occurred on your operation, in your opinion how would buyers of your cattle likely respond? Buyers would entirely cease taking cattle for:

- ❍ Not applicable, buyers would continue to purchase cattle as usual (1)
- ❍ Under 1 month (2)
- ❍ 1 to 3 months (3)
- ❍ 4 to 6 months (4)
- ❍ 6 months or longer (5)

Q2.20 If you suspect FMD might be present on your operation, who would you contact? (please check all that apply)

- ❑ U.S. Department of Agriculture (USDA) (1)
- ❑ Neighboring and/or local beef producers (2)
- ❑ Livestock buyers (3)
- ❑ Private veterinarian (4)
- ❑ State Veterinarian's office (5)
- ❑ Other (specify) (6) ____

Q2.21 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q2.22 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Nose-to-nose contact with livestock on adjacent premises is prevented (3)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (4)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (5)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (6)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (7)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (8)	❍	❍	❍	❍	❍	❍

Q2.23 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q2.24 Which animal identification methods to you currently use?

- ❍ Plastic ear tag (1)
- ❍ Metal ("Bright") tag (2)
- ❍ Brand (3)
- ❍ Tattoo (4)
- ❍ Brucellosis tag (5)
- ❍ Electronic ear tag (RFID) (6)
- ❍ None (7)
- ❍ Other (specify) (8) ____________________

Q2.25 What is your age? ________ years (1)

Q2.26 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q2.27 What is the highest level of education that you have completed?

- ❍ High school graduate/GED (1)
- ❍ Some college or 2-year college/technical degree (2)
- ❍ 4-year college degree (3)
- ❍ Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- ❍ Other (specify) (5) ____________________

Q2.28 Approximately, what portion of your household income is from on-farm sources?

________ percent (1)

Q2.29 What was your inventory on January 1, 2018 of cows, replacement heifers (bred or open), and bulls?

________ Cows (1)
________ Replacement heifers (2)
________ Bulls (3)

Q2.30 What was your total annual cow cost for 2018? ________ per head (1)

Q2.31 How many years of experience in cattle production do you have? ________ years (1)

Q2.32 How many more years do you expect to be in cattle production? _______ years (1)

Q2.33 Prevalence rate (%) - 90%
Positive test (%) - 50%
Government response policy- Conditional herd depopulation
Indemnity policy (%) - 0%
Livestock buyer discount ($/cwt) - $10

- ❍ Yes (1)
- ❍ No (2)

Q2.34 Prevalence rate (%) - 90%
Positive test (%) - 50%
Government response policy- Conditional herd depopulation
Indemnity policy (%) - 0%
Livestock buyer discount ($/cwt) - $10

- ❍ Yes (1)
- ❍ No (2)

Q2.35 Prevalence rate (%) - 50%
Positive test (%) - 10%
Government response policy- Full herd depopulation
Indemnity policy (%) - 0%
Livestock buyer discount ($/cwt) - $10

- ❍ Yes (1)
- ❍ No (2)

Q2.36 Prevalence rate (%) - 10%
Positive test (%) - 50%
Government response policy- Vaccinate
Indemnity policy (%) - 0%
Livestock buyer discount ($/cwt) - $5

- ❍ Yes (1)
- ❍ No (2)

Q2.37 Prevalence rate (%) - 10%
Positive test (%) - 50%
Government response policy- Full herd depopulation
Indemnity policy (%) - 100%
Livestock buyer discount ($/cwt) - $0

- ❍ Yes (1)
- ❍ No (2)

Q2.38 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

Start of Block: R2 Version

Q3.1 Which operation type best describes your cattle operation?

- ❍ Commercial (1)
- ❍ Both commercial and seedstock (2)
- ❍ Seedstock (3)
- ❍ Other (specify) (4) ____

Q3.2 Which marketing method do you most frequently use in marketing your operation's cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q3.3 Do the same buyers purchase cattle from your operation each year?

- ❍ No (1)
- ❍ Yes (2)

Q3.4 Do you usually provide buyers with information about your operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q3.5 How is this information most frequently shared?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q3.6 Has your operation had any of the following disease outbreaks in the last 5 years? If yes, how many months ago was the most recent case?

	Yes (1)	Months ago (1)	No Disease Problems (1)
Bovine Viral Diarrhea (BVD) (1)	❍	__________	❍
Trichomoniasis (Trich) (2)	❍	__________	❍
Bovine tuberculosis (TB) (3)	❍	__________	❍
Vesicular stomatitis (VS) (4)	❍	__________	❍
Infectious bovine rhinotracheitis (IBRV) (5)	❍	__________	❍
Other (specify) (6)	❍	__________	❍

Q3.7 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q3.8 In which state is your cattle operation?

- ❍ Alabama (1)
- ❍ Alaska (2)
- ❍ Arizona (3)
- ❍ Arkansas (4)
- ❍ California (5)
- ❍ Colorado (6)
- ❍ Connecticut (7)
- ❍ Delaware (8)
- ❍ District of Columbia (9)
- ❍ Florida (10)
- ❍ Georgia (11)
- ❍ Hawaii (12)
- ❍ Idaho (13)
- ❍ Illinois (14)
- ❍ Indiana (15)
- ❍ Iowa (16)
- ❍ Kansas (17)
- ❍ Kentucky (18)
- ❍ Louisiana (19)
- ❍ Maine (20)
- ❍ Maryland (21)
- ❍ Massachusetts (22)
- ❍ Michigan (23)
- ❍ Minnesota (24)
- ❍ Mississippi (25)
- ❍ Missouri (26)
- ❍ Montana (27)
- ❍ Nebraska (28)
- ❍ Nevada (29)
- ❍ New Hampshire (30)
- ❍ New Jersey (31)
- ❍ New Mexico (32)
- ❍ New York (33)
- ❍ North Carolina (34)
- ❍ North Dakota (35)
- ❍ Ohio (36)
- ❍ Oklahoma (37)
- ❍ Oregon (38)
- ❍ Pennsylvania (39)
- ❍ Puerto Rico (40)
- ❍ Rhode Island (41)
- ❍ South Carolina (42)
- ❍ South Dakota (43)
- ❍ Tennessee (44)
- ❍ Texas (45)
- ❍ Utah (46)
- ❍ Vermont (47)
- ❍ Virginia (48)
- ❍ Washington (49)
- ❍ West Virginia (50)
- ❍ Wisconsin (51)
- ❍ Wyoming (52)
- ❍ I do not reside in the United States (53)

Q3.9 Biosecurity for beef cattle operations is often defined as the implementation of protocols designed to reduce the likelihood of unwanted pests and disease threats from entering the cattle herd. Which practice best describes the level of biosecurity implemented on your operation?

- ❍ Maintain a closed herd (1)
- ❍ No entry of new cattle but reentry of existing cattle allowed (2)
- ❍ Entry of new cattle with known medical records and initial quarantine (3)
- ❍ Entry of new cattle with known medical records but no initial quarantine (4)
- ❍ Entry of new cattle with no known medical records and no initial quarantine (5)

Q3.10 How would you rate the biosecurity of your operation compared to other operations in your area?

- ❍ Very Low -1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8 (8)
- ❍ 9 (9)
- ❍ Very High - 10 (10)

Q3.11 Approximately, what portion of your total annual cow costs are allocated to biosecurity efforts?

________ percent (1)

Q3.12 How many times in the next 100 years do you think an FMD outbreak will occur in a U.S. livestock population (cattle, sheep, goats, swine)?

- 0 times (1)
- 1 time (2)
- 2 times (3)
- 3 times (4)
- 4 times (5)
- 5 times (6)
- 6 or more times (7)

Q3.13 If an FMD outbreak occurred on your operation, how long (number of months) do you think losses would persist?

- Under 1 month (1)
- 1 to 3 months (2)
- 4 to 6 months (3)
- 7 to 9 months (4)
- 10 to 12 months (5)
- 13 to 15 months (6)
- 16 to 18 months (7)
- 19 months or longer (8)

Q3.14 If an FMD outbreak occurred on your operation, what do you think production losses would be in dollars per cow?

- $0 per cow (1)
- $0.01-$100 per cow (2)
- $100.01-$200 per cow (3)
- $200.01-$300 per cow (4)
- $300.01-$400 per cow (5)
- $400.01-$500 per cow (6)
- $500.01-$600 per cow (7)
- $600.01-$700 per cow (8)
- $700.01-$800 per cow (9)
- Over $800 per cow (10)

Q3.15 If an FMD outbreak occurred on your operation, would you expect indemnity payments to be provided by the government?

- No (1)
- Yes (2)

Q3.16 If yes, would you expect indemnity payments provided by the government to be made available to cattle producers only if they could document biosecurity efforts?

- No (1)
- Yes (2)

Q3.17 Would you expect indemnity payments provided by the government to cover all of the production losses in cattle value?

- No (1)
- Yes (2)

Q3.18 If an FMD outbreak occurred on your operation, in your opinion how would buyers of your cattle likely respond? Buyers would continue to purchase cattle known to be FMD free or vaccinated against FMD at a discount of:

- ❍ No discount, buyers would continue to purchase cattle as usual (1)
- ❍ $0.01-$5.00 per hundredweight discount (2)
- ❍ $5.01-$10.00 per hundredweight discount (3)
- ❍ $10.01-$15.00 per hundredweight discount (4)
- ❍ $ 15.01 per hundredweight or higher discount (5)

Q3.19 If an FMD outbreak occurred on your operation, in your opinion how would buyers of your cattle likely respond? Buyers would entirely cease taking cattle for:

- ❍ Not applicable, buyers would continue to purchase cattle as usual (1)
- ❍ Under 1 month (2)
- ❍ 1 to 3 months (3)
- ❍ 4 to 6 months (4)
- ❍ 6 months or longer (5)

Q3.20 If you suspect FMD might be present on your operation, who would you contact? (please check all that apply)

- ❑ U.S. Department of Agriculture (USDA) (1)
- ❑ Neighboring and/or local beef producers (2)
- ❑ Livestock buyers (3)
- ❑ Private veterinarian (4)
- ❑ State Veterinarian's office (5)
- ❑ Other (specify) (6) ____

Q3.21 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q3.22 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Nose-to-nose contact with livestock on adjacent premises is prevented (3)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (4)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (5)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (6)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (7)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (8)	❍	❍	❍	❍	❍	❍

Q3.23 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q3.24 Which animal identification methods to you currently use?

- ❑ Plastic ear tag (1)
- ❑ Metal ("Bright") tag (2)
- ❑ Brand (3)
- ❑ Tattoo (4)
- ❑ Brucellosis tag (5)
- ❑ Electronic ear tag (RFID) (6)
- ❑ None (7)
- ❑ Other (specify) (8) ____

Q3.25 What is your age? _______ years (1)

Q3.26 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q3.27 What is the highest level of education that you have completed?

- ❍ High school graduate/GED (1)
- ❍ Some college or 2-year college/technical degree (2)
- ❍ 4-year college degree (3)
- ❍ Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- ❍ Other (specify) (5) ____

Q3.28 Approximately, what portion of your household income is from on-farm sources?

_______ percent (1)

Q3.29 What was your inventory on January 1, 2018 of cows, replacement heifers (bred or open), and bulls?

_______ Cows (1)
_______ Replacement heifers (2)
_______ Bulls (3)

Q3.30 What was your total annual cow cost for 2018? _______ per head (1)

Q3.31 How many years of experience in cattle production do you have? _______ years (1)

Q3.32 How many more years do you expect to be in cattle production? _______ years (1)

Q3.33 Prevalence rate (%) - 90%
Positive test (%) - 90%
Government response policy- Full herd depopulation
Indemnity policy (%) - 50%
Livestock buyer discount ($/cwt) - $5

- ❍ Yes (1)
- ❍ No (2)

Q3.34 Prevalence rate (%) - 90%
Positive test (%) - 10%
Government response policy- Vaccinate
Indemnity policy (%) - 100%
Livestock buyer discount ($/cwt) - $0

- ❍ Yes (1)
- ❍ No (2)

Q3.35 Prevalence rate (%) - 50%
Positive test (%) - 90%
Government response policy- Conditional herd depopulation
Indemnity policy (%) - 0%
Livestock buyer discount ($/cwt) - $0

- ❍ Yes (1)
- ❍ No (2)

Q3.36 Prevalence rate (%) - 50%
Positive test (%) - 10%
Government response policy- Conditional herd depopulation
Indemnity policy (%) - 100%
Livestock buyer discount ($/cwt) - $5

- ❍ Yes (1)
- ❍ No (2)

Q3.37 Prevalence rate (%) - 10%
Positive test (%) - 90%
Government response policy- Vaccinate
Indemnity policy (%) - 100%
Livestock buyer discount ($/cwt) - $10

- ❍ Yes (1)
- ❍ No (2)

Q3.38 Prevalence rate (%) - 10%
Positive test (%) - 10%
Government response policy- Conditional herd depopulation
Indemnity policy (%) - 50%
Livestock buyer discount ($/cwt) - $0

- ❍ Yes (1)
- ❍ No (2)

Q3.39 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____

____

Start of Block: C1 Version

Q4.1 Which operation type best describes your cattle operation?

- ❍ Commercial (1)
- ❍ Both commercial and seedstock (2)
- ❍ Seedstock (3)
- ❍ Other (specify) (4) ____

Q4.2 Which marketing method do you most frequently use in marketing your operation's cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q4.3 Do the same buyers purchase cattle from your operation each year?

- ❍ No (1)
- ❍ Yes (2)

Q4.4 Do you usually provide buyers with information about your operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q4.5 How is this information most frequently shared?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q4.6 Has your operation had any of the following disease outbreaks in the last 5 years? If yes, how many months ago was the most recent case?

	Yes (1)	Months ago (1)	No Disease Problems (1)
Bovine Viral Diarrhea (BVD) (1)	❍	__________	❍
Trichomoniasis (Trich) (2)	❍	__________	❍
Bovine tuberculosis (TB) (3)	❍	__________	❍
Vesicular stomatitis (VS) (4)	❍	__________	❍
Infectious bovine rhinotracheitis (IBRV) (5)	❍	__________	❍
Other (specify) (6)	❍	__________	❍

Q4.7 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q4.8 In which state is your cattle operation?

- Alabama (1)
- Alaska (2)
- Arizona (3)
- Arkansas (4)
- California (5)
- Colorado (6)
- Connecticut (7)
- Delaware (8)
- District of Columbia (9)
- Florida (10)
- Georgia (11)
- Hawaii (12)
- Idaho (13)
- Illinois (14)
- Indiana (15)
- Iowa (16)
- Kansas (17)
- Kentucky (18)
- Louisiana (19)
- Maine (20)
- Maryland (21)
- Massachusetts (22)
- Michigan (23)
- Minnesota (24)
- Mississippi (25)
- Missouri (26)
- Montana (27)
- Nebraska (28)
- Nevada (29)
- New Hampshire (30)
- New Jersey (31)
- New Mexico (32)
- New York (33)
- North Carolina (34)
- North Dakota (35)
- Ohio (36)
- Oklahoma (37)
- Oregon (38)
- Pennsylvania (39)
- Puerto Rico (40)
- Rhode Island (41)
- South Carolina (42)
- South Dakota (43)
- Tennessee (44)
- Texas (45)
- Utah (46)
- Vermont (47)
- Virginia (48)
- Washington (49)
- West Virginia (50)
- Wisconsin (51)
- Wyoming (52)
- I do not reside in the United States (53)

Q4.9 Biosecurity for beef cattle operations is often defined as the implementation of protocols designed to reduce the likelihood of unwanted pests and disease threats from entering the cattle herd. Which practice best describes the level of biosecurity implemented on your operation?

- Maintain a closed herd (1)
- No entry of new cattle but reentry of existing cattle allowed (2)
- Entry of new cattle with known medical records and initial quarantine (3)
- Entry of new cattle with known medical records but no initial quarantine (4)
- Entry of new cattle with no known medical records and no initial quarantine (5)

Q4.10 How would you rate the biosecurity of your operation compared to other operations in your area?

- Very Low -1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- 8 (8)
- 9 (9)
- Very High - 10 (10)

Q4.11 Approximately, what portion of your total annual cow costs are allocated to biosecurity efforts?

________ percent (1)

Q4.12 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q4.13 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Nose-to-nose contact with livestock on adjacent premises is prevented (3)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (4)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (5)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (6)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (7)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (8)	❍	❍	❍	❍	❍	❍

Q4.14 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q4.15 Which animal identification methods do you currently use?

- ❑ Plastic ear tag (1)
- ❑ Ear notches (2)
- ❑ Brand (3)
- ❑ Tattoo (4)
- ❑ Brucellosis or any other metal tag (5)
- ❑ Electronic ear tag (RFID) (6)
- ❑ None (7)
- ❑ Other (specify) (8) ____

Q4.16 What would it cost you to participate in a Visual Traceability program that involved applying "traditional ear tags" that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q4.17 What would it cost you to participate in an Electronic Traceability program would involve applying "button-like" radio frequency identification tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q4.18 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q4.19 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q4.20 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
“is more cost effective for larger cow-calf operations.” (1)	❍	❍	❍	❍	❍
“results in more liability for cow-calf producers than cattle owners at other stages of production.” (2)	❍	❍	❍	❍	❍
“is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally.” (3)	❍	❍	❍	❍	❍
“as a mandated system is exaggerated in need.” (4)	❍	❍	❍	❍	❍

Q4.21 What is your age? ________ years (1)

Q4.22 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q4.23 What is the highest level of education that you have completed?

- ❍ High school graduate/GED (1)
- ❍ Some college or 2-year college/technical degree (2)
- ❍ 4-year college degree (3)
- ❍ Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- ❍ Other (specify) (5) ____

Q4.24 Approximately, what portion of your household income is from on-farm sources?

________ percent (1)

Q4.25 What was your inventory on January 1, 2018 of cows, replacement heifers (bred or open), and bulls?

________ Cows (1)
________ Replacement heifers (2)
________ Bulls (3)

Q4.26 What was your total annual cow cost for 2018? ________ per head (1)

Q4.27 How many years of experience in cattle production do you have? ________ years (1)

Q4.28 How many more years do you expect to be in cattle production? ________ years (1)

Q4.29 Scenario #1

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q4.30 Scenario #2

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q4.31 Scenario #3

- ❍ Visual Traceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Traceability (3)

Q4.32 Scenario #4

- ❍ Visual Traceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Traceability (3)

Q4.33 Scenario #5

- ❍ Visual Traceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Traceability (3)

Q4.34 Scenario #6

- ❍ Visual Traceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Traceability (3)

Q4.35 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____
____

Start of Block: C2 Version

Q5.1 Which operation type best describes your cattle operation?

- ❍ Commercial (1)
- ❍ Both commercial and seedstock (2)
- ❍ Seedstock (3)
- ❍ Other (specify) (4) ____

Q5.2 Which marketing method do you most frequently use in marketing your operation's cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q5.3 Do the same buyers purchase cattle from your operation each year?

- ❍ No (1)
- ❍ Yes (2)

Q5.4 Do you usually provide buyers with information about your operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q5.5 How is this information most frequently shared?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q5.6 Has your operation had any of the following disease outbreaks in the last 5 years? If yes, how many months ago was the most recent case?

	Yes (1)	Months ago (1)	No Disease Problems (1)
Bovine Viral Diarrhea (BVD) (1)	❍	__________	❍
Trichomoniasis (Trich) (2)	❍	__________	❍
Bovine tuberculosis (TB) (3)	❍	__________	❍
Vesicular stomatitis (VS) (4)	❍	__________	❍
Infectious bovine rhinotracheitis (IBRV) (5)	❍	__________	❍
Other (specify) (6)	❍	__________	❍

Q5.7 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q5.8 In which state is your cattle operation?

- Alabama (1)
- Alaska (2)
- Arizona (3)
- Arkansas (4)
- California (5)
- Colorado (6)
- Connecticut (7)
- Delaware (8)
- District of Columbia (9)
- Florida (10)
- Georgia (11)
- Hawaii (12)
- Idaho (13)
- Illinois (14)
- Indiana (15)
- Iowa (16)
- Kansas (17)
- Kentucky (18)
- Louisiana (19)
- Maine (20)
- Maryland (21)
- Massachusetts (22)
- Michigan (23)
- Minnesota (24)
- Mississippi (25)
- Missouri (26)
- Montana (27)
- Nebraska (28)
- Nevada (29)
- New Hampshire (30)
- New Jersey (31)
- New Mexico (32)
- New York (33)
- North Carolina (34)
- North Dakota (35)
- Ohio (36)
- Oklahoma (37)
- Oregon (38)
- Pennsylvania (39)
- Puerto Rico (40)
- Rhode Island (41)
- South Carolina (42)
- South Dakota (43)
- Tennessee (44)
- Texas (45)
- Utah (46)
- Vermont (47)
- Virginia (48)
- Washington (49)
- West Virginia (50)
- Wisconsin (51)
- Wyoming (52)
- I do not reside in the United States (53)

Q5.9 Biosecurity for beef cattle operations is often defined as the implementation of protocols designed to reduce the likelihood of unwanted pests and disease threats from entering the cattle herd. Which practice best describes the level of biosecurity implemented on your operation?

- Maintain a closed herd (1)
- No entry of new cattle but reentry of existing cattle allowed (2)
- Entry of new cattle with known medical records and initial quarantine (3)
- Entry of new cattle with known medical records but no initial quarantine (4)
- Entry of new cattle with no known medical records and no initial quarantine (5)

Q5.10 How would you rate the biosecurity of your operation compared to other operations in your area?

- Very Low -1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- 8 (8)
- 9 (9)
- Very High - 10 (10)

Q5.11 Approximately, what portion of your total annual cow costs are allocated to biosecurity efforts?

________ percent (1)

Q5.12 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q5.13 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Nose-to-nose contact with livestock on adjacent premises is prevented (3)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (4)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (5)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (6)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (7)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (8)	❍	❍	❍	❍	❍	❍

Q5.14 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q5.15 Which animal identification methods do you currently use?

- ❑ Plastic ear tag (1)
- ❑ Ear notches (2)
- ❑ Brand (3)
- ❑ Tattoo (4)
- ❑ Brucellosis or any other metal tag (5)
- ❑ Electronic ear tag (RFID) (6)
- ❑ None (7)
- ❑ Other (specify) (8) ____

Q5.16 What would it cost you to participate in a Visual Traceability program that involved applying “traditional ear tags” that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q5.17 What would it cost you to participate in an Electronic Traceability program would involve applying “button-like” radio frequency identification tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q5.18 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q5.19 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q5.20 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
“is more cost effective for larger cow-calf operations.” (1)	❍	❍	❍	❍	❍
“results in more liability for cow-calf producers than cattle owners at other stages of production.” (2)	❍	❍	❍	❍	❍
“is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally.” (3)	❍	❍	❍	❍	❍
“as a mandated system is exaggerated in need.” (4)	❍	❍	❍	❍	❍

Q5.21 What is your age? ________ years (1)

Q5.22 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q5.23 What is the highest level of education that you have completed?

- ❍ High school graduate/GED (1)
- ❍ Some college or 2-year college/technical degree (2)
- ❍ 4-year college degree (3)
- ❍ Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- ❍ Other (specify) (5) ____

Q5.24 Approximately, what portion of your household income is from on-farm sources?

________ percent (1)

Q5.25 What was your inventory on January 1, 2018 of cows, replacement heifers (bred or open), and bulls?

________ Cows (1)
________ Replacement heifers (2)
________ Bulls (3)

Q5.26 What was your total annual cow cost for 2018? ________ per head (1)

Q5.27 How many years of experience in cattle production do you have? ________ years (1)

Q5.28 How many more years do you expect to be in cattle production? ________ years (1)

Q5.29 Scenario #1

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.30 Scenario #2

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.31 Scenario #3

- ❍ Visual Traceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.32 Scenario #4

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.33 Scenario #5

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.34 Scenario #6

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q5.35 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____

____

Start of Block: C3 Version

Q6.1 Which operation type best describes your cattle operation?

- ❍ Commercial (1)
- ❍ Both commercial and seedstock (2)
- ❍ Seedstock (3)
- ❍ Other (specify) (4) ____

Q6.2 Which marketing method do you most frequently use in marketing your operation's cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q6.3 Do the same buyers purchase cattle from your operation each year?

- ❍ No (1)
- ❍ Yes (2)

Q6.4 Do you usually provide buyers with information about your operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q6.5 How is this information most frequently shared?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q6.6 Has your operation had any of the following disease outbreaks in the last 5 years? If yes, how many months ago was the most recent case?

	Yes (1)	Months ago (1)	No Disease Problems (1)
Bovine Viral Diarrhea (BVD) (1)	❍	__________	❍
Trichomoniasis (Trich) (2)	❍	__________	❍
Bovine tuberculosis (TB) (3)	❍	__________	❍
Vesicular stomatitis (VS) (4)	❍	__________	❍
Infectious bovine rhinotracheitis (IBRV) (5)	❍	__________	❍
Other (specify) (6)	❍	__________	❍

Q6.7 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q6.8 In which state is your cattle operation?

- Alabama (1)
- Alaska (2)
- Arizona (3)
- Arkansas (4)
- California (5)
- Colorado (6)
- Connecticut (7)
- Delaware (8)
- District of Columbia (9)
- Florida (10)
- Georgia (11)
- Hawaii (12)
- Idaho (13)
- Illinois (14)
- Indiana (15)
- Iowa (16)
- Kansas (17)
- Kentucky (18)
- Louisiana (19)
- Maine (20)
- Maryland (21)
- Massachusetts (22)
- Michigan (23)
- Minnesota (24)
- Mississippi (25)
- Missouri (26)
- Montana (27)
- Nebraska (28)
- Nevada (29)
- New Hampshire (30)
- New Jersey (31)
- New Mexico (32)
- New York (33)
- North Carolina (34)
- North Dakota (35)
- Ohio (36)
- Oklahoma (37)
- Oregon (38)
- Pennsylvania (39)
- Puerto Rico (40)
- Rhode Island (41)
- South Carolina (42)
- South Dakota (43)
- Tennessee (44)
- Texas (45)
- Utah (46)
- Vermont (47)
- Virginia (48)
- Washington (49)
- West Virginia (50)
- Wisconsin (51)
- Wyoming (52)
- I do not reside in the United States (53)

Q6.9 Biosecurity for beef cattle operations is often defined as the implementation of protocols designed to reduce the likelihood of unwanted pests and disease threats from entering the cattle herd. Which practice best describes the level of biosecurity implemented on your operation?

- Maintain a closed herd (1)
- No entry of new cattle but reentry of existing cattle allowed (2)
- Entry of new cattle with known medical records and initial quarantine (3)
- Entry of new cattle with known medical records but no initial quarantine (4)
- Entry of new cattle with no known medical records and no initial quarantine (5)

Q6.10 How would you rate the biosecurity of your operation compared to other operations in your area?

- Very Low -1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- 8 (8)
- 9 (9)
- Very High - 10 (10)

Q6.11 Approximately, what portion of your total annual cow costs are allocated to biosecurity efforts?

________ percent (1)

Q6.12 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q6.13 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Nose-to-nose contact with livestock on adjacent premises is prevented (3)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (4)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (5)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (6)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (7)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (8)	❍	❍	❍	❍	❍	❍

Q6.14 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q6.15 Which animal identification methods do you currently use?

- ❑ Plastic ear tag (1)
- ❑ Ear notches (2)
- ❑ Brand (3)
- ❑ Tattoo (4)
- ❑ Brucellosis or any other metal tag (5)
- ❑ Electronic ear tag (RFID) (6)
- ❑ None (7)
- ❑ Other (specify) (8) ____

Q6.16 What would it cost you to participate in a Visual Traceability program that involved applying "traditional ear tags" that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q6.17 What would it cost you to participate in an Electronic Traceability program would involve applying "button-like" radio frequency identification tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q6.18 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q6.19 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q6.20 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
"is more cost effective for larger cow-calf operations." (1)	❍	❍	❍	❍	❍
"results in more liability for cow-calf producers than cattle owners at other stages of production." (2)	❍	❍	❍	❍	❍
"is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally." (3)	❍	❍	❍	❍	❍
"as a mandated system is exaggerated in need." (4)	❍	❍	❍	❍	❍

Q6.21 What is your age? ________ years (1)

Q6.22 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q6.23 What is the highest level of education that you have completed?

- High school graduate/GED (1)
- Some college or 2-year college/technical degree (2)
- 4-year college degree (3)
- Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- Other (specify) (5) ____

Q6.24 Approximately, what portion of your household income is from on-farm sources?

_______ percent (1)

Q6.25 What was your inventory on January 1, 2018 of cows, replacement heifers (bred or open), and bulls?

_______ Cows (1)
_______ Replacement heifers (2)
_______ Bulls (3)

Q6.26 What was your total annual cow cost for 2018? _______ per head (1)

Q6.27 How many years of experience in cattle production do you have? _______ years (1)

Q6.28 How many more years do you expect to be in cattle production? _______ years (1)

Q6.29 Scenario #1

- Visual Taceability (1)
- Electronic Traceability (2)
- No Tracability (3)

Q6.30 Scenario #2

- Visual Taceability (1)
- Electronic Traceability (2)
- No Tracability (3)

Q6.31 Scenario #3

- Visual Taceability (1)
- Electronic Traceability (2)
- No Tracability (3)

Q6.32 Scenario #4

- Visual Taceability (1)
- Electronic Traceability (2)
- No Tracability (3)

Q6.33 Scenario #5

- Visual Taceability (1)
- Electronic Traceability (2)
- No Tracability (3)

Q6.34 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____
____

Start of Block: F1 Version

Q7.1 Which operation type best describes your cattle operation?

- ❍ Feedlot (1)
- ❍ Feedlot and stocker/backgrounder (2)
- ❍ Stocker/backgrounder (3)
- ❍ Other (specify) (4) ____

Q7.2 Which method do you most frequently use to procure feeder cattle?

- ❍ Sale barn/auction (1)
- ❍ Direct-Video/Internet auction (2)
- ❍ Direct-private treaty (3)
- ❍ Consignment (4)
- ❍ Forward contract (5)
- ❍ Carcass basis (6)
- ❍ Other (specify) (7) ____

Q7.3 When procuring feeder cattle, do sourcing producers usually provide you with information about their operation's health programs?

- ❍ No (1)
- ❍ Yes (2)

Q7.4 how is this information most frequently shared with you?

- ❍ Written documentation (1)
- ❍ Electronic documentation (2)
- ❍ Tell buyer orally (3)
- ❍ Other (specify) (4) ____

Q7.5 For cattle placed on feed over the past 12 months, what percent were given these vaccines:

BVD (bovine viral diarrhea) : _______ (1)
BRSV (bovine respiratory syncytial virus) : _______ (2)
Pasteurella : _______ (3)
Leptospira spp. (lepto) : _______ (4)
PI3 (parainfluenza 3) : _______ (5)
Injectable IBR (infectious bovine rhinotracheitis) : _______ (6)
Intranasal IBR : _______ (7)

Q7.6 For cattle placed on feed over the past 12 months, what percentage were mass treated with an antibiotic to prevent or reduce an outbreak of shipping fever?

Cattle less than 700 lbs when placed : _______ (1)
Cattle between 700-899 lbs when placed : _______ (2)
Cattle greater than 900 lbs when placed : _______ (3)

Q7.7 How would you rate the biosecurity of your operation compared to other operations in your area?

- ❍ Very Low -1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8 (8)
- ❍ 9 (9)
- ❍ Very High - 10 (10)

Q7.8 Approximately, what percent of your total financial expenditure for cattle production is annually spent on biosecurity?

________ percent (1)

Q7.9 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q7.10 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q7.11 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (3)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (4)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (5)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (6)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (7)	❍	❍	❍	❍	❍	❍

Q7.12 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q7.13 For cattle placed on feed over the past 12 months, what percent of cattle arrived with the following methods of animal identification:

Plastic ear tag : ________ (1)
Ear notches : ________ (2)
Brand : ________ (3)
Tattoo : ________ (4)
Brucellosis or any other metal tag : ________ (5)
Electronic ear tag (RFID) : ________ (6)
None : ________ (7)
Other (specify) : ________ (8)
Total : ________

Q7.14 What would you be willing to pay to receive cattle that are already participating in a Visual Traceability program that includes "traditional ear tags" that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q7.15 What would you be willing to pay to receive cattle that are already participating in an Electronic Traceability program that includes "button-like" radio frequency identification (RFID) tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q7.16 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q7.17 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q7.18 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
"is more cost effective for larger feedlot operations." (1)	❍	❍	❍	❍	❍
"results in more liability for feedlot producers than cattle owners at other stages of production." (2)	❍	❍	❍	❍	❍
"is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally." (3)	❍	❍	❍	❍	❍
"as a mandated system is exaggerated in need." (4)	❍	❍	❍	❍	❍

Q7.19 In which state is your cattle operation?

- ❍ Alabama (1)
- ❍ Alaska (2)
- ❍ Arizona (3)
- ❍ Arkansas (4)
- ❍ California (5)
- ❍ Colorado (6)
- ❍ Connecticut (7)
- ❍ Delaware (8)
- ❍ District of Columbia (9)
- ❍ Florida (10)
- ❍ Georgia (11)
- ❍ Hawaii (12)
- ❍ Idaho (13)
- ❍ Illinois (14)
- ❍ Indiana (15)
- ❍ Iowa (16)
- ❍ Kansas (17)
- ❍ Kentucky (18)
- ❍ Louisiana (19)
- ❍ Maine (20)
- ❍ Maryland (21)
- ❍ Massachusetts (22)
- ❍ Michigan (23)
- ❍ Minnesota (24)
- ❍ Mississippi (25)
- ❍ Missouri (26)
- ❍ Montana (27)
- ❍ Nebraska (28)
- ❍ Nevada (29)
- ❍ New Hampshire (30)
- ❍ New Jersey (31)
- ❍ New Mexico (32)
- ❍ New York (33)
- ❍ North Carolina (34)
- ❍ North Dakota (35)
- ❍ Ohio (36)
- ❍ Oklahoma (37)
- ❍ Oregon (38)
- ❍ Pennsylvania (39)
- ❍ Puerto Rico (40)
- ❍ Rhode Island (41)
- ❍ South Carolina (42)
- ❍ South Dakota (43)
- ❍ Tennessee (44)
- ❍ Texas (45)
- ❍ Utah (46)
- ❍ Vermont (47)
- ❍ Virginia (48)
- ❍ Washington (49)
- ❍ West Virginia (50)
- ❍ Wisconsin (51)
- ❍ Wyoming (52)
- ❍ I do not reside in the United States (53)

Q7.20 What is your age? ________ years (1)

Q7.21 What is your gender?

- Male (1)
- Female (2)

Q7.22 What is the highest level of education that you have completed?

- High school graduate/GED (1)
- Some college or 2-year college/technical degree (2)
- 4-year college degree (3)
- Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- Other (specify) (5) ____________________

Q7.23 What was your average cost of gain for fed cattle sold over the past 12 months on your operation?

- Less than $60/cwt (1)
- $60 to $64.99/cwt (2)
- $65 to $69.99/cwt (3)
- $70 to $74.99/cwt (4)
- $75 to $79.99/cwt (5)
- $80 to $84.99/cwt (6)
- $85 to $89.99/cwt (7)
- Over $90/cwt (8)

Q7.24 What is the one-time capacity of your feedlot?

- Less than 1,000 head (1)
- 1,000 to 1,999 head (2)
- 2,000 to 3,999 head (3)
- 4,000 to 7,999 head (4)
- 8,000 to 15,999 head (5)
- 16,000 to 23,999 head (6)
- 24,000 to 31,999 head (7)
- 32,000 to 49,999 head (8)
- More than 50,000 head (9)

Q7.25 How many fed cattle were sold on your operation in the last 12 months?

- Less than 1,000 head (1)
- 1,000 to 1,999 head (2)
- 2,000 to 3,999 head (3)
- 4,000 to 7,999 head (4)
- 8,000 to 15,999 head (5)
- 16,000 to 23,999 head (6)
- 24,000 to 31,999 head (7)
- 32,000 to 49,999 head (8)
- More than 50,000 head (9)

Q7.26 How many years of experience in cattle production do you have? _______ years (1)

Q7.27 How many more years do you expect to be in cattle production? _______ years (1)

Q7.28 Scenario #1

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.29 Scenario #2

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.30 Scenario #3

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.31 Scenario #4

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.32 Scenario #5

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.33 Scenario #6

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q7.34 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____

____

Start of Block: F2 Version

Q8.1 Which operation type best describes your cattle operation?

- Feedlot (1)
- Feedlot and stocker/backgrounder (2)
- Stocker/backgrounder (3)
- Other (specify) (4) ____

Q8.2 Which method do you most frequently use to procure feeder cattle?

- Sale barn/auction (1)
- Direct-Video/Internet auction (2)
- Direct-private treaty (3)
- Consignment (4)
- Forward contract (5)
- Carcass basis (6)
- Other (specify) (7) ____

Q8.3 When procuring feeder cattle, do sourcing producers usually provide you with information about their operation's health programs?

- No (1)
- Yes (2)

Q8.4 how is this information most frequently shared with you?

- Written documentation (1)
- Electronic documentation (2)
- Tell buyer orally (3)
- Other (specify) (4) ____

Q8.5 For cattle placed on feed over the past 12 months, what percent were given these vaccines:

BVD (bovine viral diarrhea) : _______ (1)
BRSV (bovine respiratory syncytial virus) : _______ (2)
Pasteurella : _______ (3)
Leptospira spp. (lepto) : _______ (4)
PI3 (parainfluenza 3) : _______ (5)
Injectable IBR (infectious bovine rhinotracheitis) : _______ (6)
Intranasal IBR : _______ (7)
Total : ________

Q8.6 For cattle placed on feed over the past 12 months, what percentage were mass treated with an antibiotic to prevent or reduce an outbreak of shipping fever?

Cattle less than 700 lbs when placed : _______ (1)
Cattle between 700-899 lbs when placed : _______ (2)
Cattle greater than 900 lbs when placed : _______ (3)
Total : ________

Q8.7 How would you rate the biosecurity of your operation compared to other operations in your area?

- ❍ Very Low -1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8 (8)
- ❍ 9 (9)
- ❍ Very High - 10 (10)

Q8.8 Approximately, what percent of your total financial expenditure for cattle production is annually spent on biosecurity?

________ percent (1)

Q8.9 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q8.10 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q8.11 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (3)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (4)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (5)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (6)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (7)	❍	❍	❍	❍	❍	❍

Q8.12 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q8.13 For cattle placed on feed over the past 12 months, what percent of cattle arrived with the following methods of animal identification:

Plastic ear tag : ________ (1)
Ear notches : ________ (2)
Brand : ________ (3)
Tattoo : ________ (4)
Brucellosis or any other metal tag : ________ (5)
Electronic ear tag (RFID) : ________ (6)
None : ________ (7)
Other (specify) : ________ (8)
Total : ________

Q8.14 What would you be willing to pay to receive cattle that are already participating in a Visual Traceability program that includes "traditional ear tags" that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q8.15 What would you be willing to pay to receive cattle that are already participating in an Electronic Traceability program that includes "button-like" radio frequency identification (RFID) tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q8.16 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q8.17 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q8.18 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
"is more cost effective for larger feedlot operations." (1)	❍	❍	❍	❍	❍
"results in more liability for feedlot producers than cattle owners at other stages of production." (2)	❍	❍	❍	❍	❍
"is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally." (3)	❍	❍	❍	❍	❍
"as a mandated system is exaggerated in need." (4)	❍	❍	❍	❍	❍

Q8.19 In which state is your cattle operation?

- ❍ Alabama (1)
- ❍ Alaska (2)
- ❍ Arizona (3)
- ❍ Arkansas (4)
- ❍ California (5)
- ❍ Colorado (6)
- ❍ Connecticut (7)
- ❍ Delaware (8)
- ❍ District of Columbia (9)
- ❍ Florida (10)
- ❍ Georgia (11)
- ❍ Hawaii (12)
- ❍ Idaho (13)
- ❍ Illinois (14)
- ❍ Indiana (15)
- ❍ Iowa (16)
- ❍ Kansas (17)
- ❍ Kentucky (18)
- ❍ Louisiana (19)
- ❍ Maine (20)
- ❍ Maryland (21)
- ❍ Massachusetts (22)
- ❍ Michigan (23)
- ❍ Minnesota (24)
- ❍ Mississippi (25)
- ❍ Missouri (26)
- ❍ Montana (27)
- ❍ Nebraska (28)
- ❍ Nevada (29)
- ❍ New Hampshire (30)
- ❍ New Jersey (31)
- ❍ New Mexico (32)
- ❍ New York (33)
- ❍ North Carolina (34)
- ❍ North Dakota (35)
- ❍ Ohio (36)
- ❍ Oklahoma (37)
- ❍ Oregon (38)
- ❍ Pennsylvania (39)
- ❍ Puerto Rico (40)
- ❍ Rhode Island (41)
- ❍ South Carolina (42)
- ❍ South Dakota (43)
- ❍ Tennessee (44)
- ❍ Texas (45)
- ❍ Utah (46)
- ❍ Vermont (47)
- ❍ Virginia (48)
- ❍ Washington (49)
- ❍ West Virginia (50)
- ❍ Wisconsin (51)
- ❍ Wyoming (52)
- ❍ I do not reside in the United States (53)

Q8.20 What is your age? ________ years (1)

Q8.21 What is your gender?

- Male (1)
- Female (2)

Q8.22 What is the highest level of education that you have completed?

- High school graduate/GED (1)
- Some college or 2-year college/technical degree (2)
- 4-year college degree (3)
- Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- Other (specify) (5) ____

Q8.23 What was your average cost of gain for fed cattle sold over the past 12 months on your operation?

- Less than $60/cwt (1)
- $60 to $64.99/cwt (2)
- $65 to $69.99/cwt (3)
- $70 to $74.99/cwt (4)
- $75 to $79.99/cwt (5)
- $80 to $84.99/cwt (6)
- $85 to $89.99/cwt (7)
- Over $90/cwt (8)

Q8.24 What is the one-time capacity of your feedlot?

- Less than 1,000 head (1)
- 1,000 to 1,999 head (2)
- 2,000 to 3,999 head (3)
- 4,000 to 7,999 head (4)
- 8,000 to 15,999 head (5)
- 16,000 to 23,999 head (6)
- 24,000 to 31,999 head (7)
- 32,000 to 49,999 head (8)
- More than 50,000 head (9)

Q8.25 How many fed cattle were sold on your operation in the last 12 months?

- Less than 1,000 head (1)
- 1,000 to 1,999 head (2)
- 2,000 to 3,999 head (3)
- 4,000 to 7,999 head (4)
- 8,000 to 15,999 head (5)
- 16,000 to 23,999 head (6)
- 24,000 to 31,999 head (7)
- 32,000 to 49,999 head (8)
- More than 50,000 head (9)

Q8.26 How many years of experience in cattle production do you have? _______ years (1)

Q8.27 How many more years do you expect to be in cattle production? _______ years (1)

Q8.28 Scenario #1

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.29 Scenario #2

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.30 Scenario #3

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.31 Scenario #4

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.32 Scenario #5

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.33 Scenario #6

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q8.34 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____

____

Start of Block: F3 Version

Q9.1 Which operation type best describes your cattle operation?

- Feedlot (1)
- Feedlot and stocker/backgrounder (2)
- Stocker/backgrounder (3)
- Other (specify) (4) ____

Q9.2 Which method do you most frequently use to procure feeder cattle?

- Sale barn/auction (1)
- Direct-Video/Internet auction (2)
- Direct-private treaty (3)
- Consignment (4)
- Forward contract (5)
- Carcass basis (6)
- Other (specify) (7) ____

Q9.3 When procuring feeder cattle, do sourcing producers usually provide you with information about their operation's health programs?

- No (1)
- Yes (2)

Q9.4 how is this information most frequently shared with you?

- Written documentation (1)
- Electronic documentation (2)
- Tell buyer orally (3)
- Other (specify) (4) ____

Q9.5 For cattle placed on feed over the past 12 months, what percent were given these vaccines:

BVD (bovine viral diarrhea) : _______ (1)
BRSV (bovine respiratory syncytial virus) : _______ (2)
Pasteurella : _______ (3)
Leptospira spp. (lepto) : _______ (4)
PI3 (parainfluenza 3) : _______ (5)
Injectable IBR (infectious bovine rhinotracheitis) : _______ (6)
Intranasal IBR : _______ (7)

Q9.6 For cattle placed on feed over the past 12 months, what percentage were mass treated with an antibiotic to prevent or reduce an outbreak of shipping fever?

Cattle less than 700 lbs when placed : _______ (1)
Cattle between 700-899 lbs when placed : _______ (2)
Cattle greater than 900 lbs when placed : _______ (3)

Q9.7 How would you rate the biosecurity of your operation compared to other operations in your area?

- ❍ Very Low -1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8 (8)
- ❍ 9 (9)
- ❍ Very High - 10 (10)

Q9.8 Approximately, what percent of your total financial expenditure for cattle production is annually spent on biosecurity?

________ percent (1)

Q9.9 During the last 12 months, did your operation consult a veterinarian for:

	Yes (1)	No (2)
Disease diagnosis or treatment? (1)	❍	❍
Disease prevention? (2)	❍	❍
Livestock deaths? (3)	❍	❍
Information on biosecurity practices? (4)	❍	❍
Information on foreign animal diseases? (5)	❍	❍

Q9.10 For the biosecurity practices listed below, please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
There is a designated biosecurity manager for the operation (1)	❍	❍	❍	❍	❍	❍
An operation-specific, written, enhanced biosecurity plan has been developed (2)	❍	❍	❍	❍	❍	❍
Animals come only from sources with documented enhanced biosecurity practices (3)	❍	❍	❍	❍	❍	❍
A plan exists to manage animals in a biosecure manner on-site in the event animal movement is stopped for several weeks (4)	❍	❍	❍	❍	❍	❍
Feedstuffs are delivered, stored, mixed, and fed in a manner that minimizes contamination, and feed spills are cleaned up promptly (5)	❍	❍	❍	❍	❍	❍

Q9.11 A Line of Separation (LOS) is an outer control boundary around, or within, the premises to limit movement of virus into areas where animals can be exposed. Please check the left column for those used on your operation. Also please indicate by circling a number, how feasible you believe implementation of each practice would be if an FMD outbreak occurred in the U.S.

	Used (1)	Highly Infeasible (1)	Infeasible (2)	Neutral (3)	Feasible (4)	Highly Feasible (5)
A line of separation is clearly defined and marked on the operation (1)	❍	❍	❍	❍	❍	❍
Entry to the operation is restricted to a limited number of access points (2)	❍	❍	❍	❍	❍	❍
Access is limited to individuals who are essential to the operation (3)	❍	❍	❍	❍	❍	❍
Vehicles, trailers, and equipment that cross the LOS are properly cleaned & disinfected (4)	❍	❍	❍	❍	❍	❍
Animals leaving the operation only move in one direction across the LOS at an Access Point (5)	❍	❍	❍	❍	❍	❍
The area designated for loading/unloading animals is not a people entry point (6)	❍	❍	❍	❍	❍	❍
Areas contaminated by personnel or animals after loading/unloading are properly cleaned and disinfected (7)	❍	❍	❍	❍	❍	❍

Q9.12 Please indicate your level of agreement with the following statements. (please circle the most appropriate answer for each row)

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I am willing to take animal health risks in order to make more money (1)	❍	❍	❍	❍	❍
With respect to the conduct of my business, I prefer certainty to uncertainty (2)	❍	❍	❍	❍	❍
I am willing to take financial risks in order to realize higher average returns (3)	❍	❍	❍	❍	❍
My cattle operation is protected from financial risks (4)	❍	❍	❍	❍	❍
My cattle operation is protected from animal disease risks (5)	❍	❍	❍	❍	❍
With respect to animal health, I prefer certainty to uncertainty (6)	❍	❍	❍	❍	❍

Q9.13 For cattle placed on feed over the past 12 months, what percent of cattle arrived with the following methods of animal identification:

Plastic ear tag : ________ (1)
Ear notches : ________ (2)
Brand : ________ (3)
Tattoo : ________ (4)
Brucellosis or any other metal tag : ________ (5)
Electronic ear tag (RFID) : ________ (6)
None : ________ (7)
Other (specify) : ________ (8)
Total : ________

Q9.14 What would you be willing to pay to receive cattle that are already participating in a Visual Traceability program that includes "traditional ear tags" that are read manually upon human inspection?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q9.15 What would you be willing to pay to receive cattle that are already participating in an Electronic Traceability program that includes "button-like" radio frequency identification (RFID) tags readable by electronic readers?

- ❍ Less than $1/head (1)
- ❍ $1 to $4/head (2)
- ❍ $5 to $8/head (3)
- ❍ $9 to $12/head (4)
- ❍ $13 to $16/head (5)
- ❍ More than $16/head (6)

Q9.16 In designing a national, individual animal traceability system how important are the following issues in the U.S. beef industry?

	Entirely Unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Very Important (5)
Monitoring/managing disease (1)	❍	❍	❍	❍	❍
Increasing consumer confidence (2)	❍	❍	❍	❍	❍
Enhancing marketability (3)	❍	❍	❍	❍	❍
Maintaining current foreign markets (4)	❍	❍	❍	❍	❍
Accessing foreign markets (5)	❍	❍	❍	❍	❍
Improving on-farm management (6)	❍	❍	❍	❍	❍
Managing the supply chain (7)	❍	❍	❍	❍	❍
Enhancing food safety (8)	❍	❍	❍	❍	❍

Q9.17 In designing a national, individual animal traceability system how concerned are you regarding the following issues in the U.S. beef industry?

	Entirely Unconcerned (1)	Unconcerned (2)	Neutral (3)	Concerned (4)	Very Concerned (5)
Cost to participating producer (1)	❍	❍	❍	❍	❍
Confidentiality of information (2)	❍	❍	❍	❍	❍
Reliability of technology (3)	❍	❍	❍	❍	❍
Liability to participating producer (4)	❍	❍	❍	❍	❍
Non-participating firms benefiting (5)	❍	❍	❍	❍	❍
Failure of system to meet stated goals (6)	❍	❍	❍	❍	❍

Q9.18 Please circle your level of agreement with each of the following statements. (please circle the most appropriate answer for each row) Implementing individual animal traceability systems:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
"is more cost effective for larger feedlot operations." (1)	❍	❍	❍	❍	❍
"results in more liability for feedlot producers than cattle owners at other stages of production." (2)	❍	❍	❍	❍	❍
"is unnecessary if COOL (country-of-Origin Labeling) was implemented nationally." (3)	❍	❍	❍	❍	❍
"as a mandated system is exaggerated in need." (4)	❍	❍	❍	❍	❍

Q9.19 In which state is your cattle operation?

❍ Alabama (1)
❍ Alaska (2)
❍ Arizona (3)
❍ Arkansas (4)
❍ California (5)
❍ Colorado (6)
❍ Connecticut (7)
❍ Delaware (8)
❍ District of Columbia (9)
❍ Florida (10)
❍ Georgia (11)
❍ Hawaii (12)
❍ Idaho (13)
❍ Illinois (14)
❍ Indiana (15)
❍ Iowa (16)
❍ Kansas (17)
❍ Kentucky (18)
❍ Louisiana (19)
❍ Maine (20)
❍ Maryland (21)
❍ Massachusetts (22)
❍ Michigan (23)
❍ Minnesota (24)
❍ Mississippi (25)
❍ Missouri (26)
❍ Montana (27)
❍ Nebraska (28)
❍ Nevada (29)
❍ New Hampshire (30)
❍ New Jersey (31)
❍ New Mexico (32)
❍ New York (33)
❍ North Carolina (34)
❍ North Dakota (35)
❍ Ohio (36)
❍ Oklahoma (37)
❍ Oregon (38)
❍ Pennsylvania (39)
❍ Puerto Rico (40)
❍ Rhode Island (41)
❍ South Carolina (42)
❍ South Dakota (43)
❍ Tennessee (44)
❍ Texas (45)
❍ Utah (46)
❍ Vermont (47)
❍ Virginia (48)
❍ Washington (49)
❍ West Virginia (50)
❍ Wisconsin (51)
❍ Wyoming (52)
❍ I do not reside in the United States (53)

Q9.20 What is your age? ________ years (1)

Q9.21 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q9.22 What is the highest level of education that you have completed?

- ❍ High school graduate/GED (1)
- ❍ Some college or 2-year college/technical degree (2)
- ❍ 4-year college degree (3)
- ❍ Graduate degree (MS, MBA, PhD, DVM, etc.) (4)
- ❍ Other (specify) (5) ____

Q9.23 What was your average cost of gain for fed cattle sold over the past 12 months on your operation?

- ❍ Less than $60/cwt (1)
- ❍ $60 to $64.99/cwt (2)
- ❍ $65 to $69.99/cwt (3)
- ❍ $70 to $74.99/cwt (4)
- ❍ $75 to $79.99/cwt (5)
- ❍ $80 to $84.99/cwt (6)
- ❍ $85 to $89.99/cwt (7)
- ❍ Over $90/cwt (8)

Q9.24 What is the one-time capacity of your feedlot?

- ❍ Less than 1,000 head (1)
- ❍ 1,000 to 1,999 head (2)
- ❍ 2,000 to 3,999 head (3)
- ❍ 4,000 to 7,999 head (4)
- ❍ 8,000 to 15,999 head (5)
- ❍ 16,000 to 23,999 head (6)
- ❍ 24,000 to 31,999 head (7)
- ❍ 32,000 to 49,999 head (8)
- ❍ More than 50,000 head (9)

Q9.25 How many fed cattle were sold on your operation in the last 12 months?

- ❍ Less than 1,000 head (1)
- ❍ 1,000 to 1,999 head (2)
- ❍ 2,000 to 3,999 head (3)
- ❍ 4,000 to 7,999 head (4)
- ❍ 8,000 to 15,999 head (5)
- ❍ 16,000 to 23,999 head (6)
- ❍ 24,000 to 31,999 head (7)
- ❍ 32,000 to 49,999 head (8)
- ❍ More than 50,000 head (9)

Q9.26 How many years of experience in cattle production do you have? ________ years (1)

Q9.27 How many more years do you expect to be in cattle production? ________ years (1)

Q9.28 Scenario #1

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q9.29 Scenario #2

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q9.30 Scenario #3

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q9.31 Scenario #4

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q9.32 Scenario #5

- ❍ Visual Taceability (1)
- ❍ Electronic Traceability (2)
- ❍ No Tracability (3)

Q9.33 Your input will strengthen our research and help us obtain more accurate conclusions. If you wish to add any comments that might be useful in our research, please feel free to do so here.

____

____