Chapter 3
Economics of Food Chain Coordination and Food Safety Standards: Insights from Agency Theory

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Abbreviations

BRC	British Retail Consortium
FAO	Food and Agriculture Organization/UN
FSSC	Food Safety System Certification
GAP	Good Agricultural Practices
GFSI	Global Food Safety Initiative
HACCP	Hazard Analysis Critical Control Point
IFS	International Features Standard
SQF	Safe Quality Food
UN	United Nations

Over the past three decades, food markets became increasingly integrated, and contracts between upstream suppliers and downstream manufacturers, retailers, and food service business are increasingly the norm. Economic theory suggests that integrated companies will have fewer foodborne illness outbreaks, since the integrated companies have more control over their supply chain from farm to table. Yet, despite this change in global market structure, there have been many food safety outbreaks in the last decade. The prevention and mitigation of these outbreaks were significantly undermined by the existence of information failures, even within a single company. This chapter introduces agency theory, an economic framework that helps understand the role of information on the vertical contractual relations in the food supply chain. The change in economic incentives under different contract situations is explored. We further discuss how this framework can be used to examine alternative public policies and private strategies to improve supply chain coordination and reduce food safety risks, against some standard established either by the private sector or by government agencies.

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3.1 Introduction

Following the Jack in a Box food safety outbreak in 1993, a reform of American food safety legislation led to the introduction of mandatory Hazard Analysis and Critical Control Points (HACCP) in meat slaughter and processing plants. Similarly, food safety incidents in the European Union led to an upgrade of European food safety regulation. However, despite these improvements, the United States faced a series of high-profile foodborne disease outbreaks across the fresh produce and food processing industries between 2005 and 2008. These incidents seriously compromised the reputation and trust in the American food safety system. During each of these crises, it became apparent how poor the level of information in the system was, as it took days to uncover the source of the problem. Moreover, as was the case of the tomato outbreak in 2006 (that was actually caused by a jalapeno), the system failed to identify the real culprits in a timely manner.

Notwithstanding the epidemiologic, forensic, and legal elements required to contain and minimize the impact of food safety incidents, it is critical to understand the impact of information on the prevention of foodborne disease outbreaks. If authorities and food businesses could quickly identify the origin and extent of food safety outbreaks, their consequences could be substantially minimized. In the age of the Internet and advanced information systems, where we can easily and almost instantly access news of what is happening around the world and access different types of information at our fingertips, this may come as a surprise and a paradox. However, if one takes a closer look at the complexity of modern food chains, one realizes there are both strong economic and legal incentives to conceal information. The legal element is particularly evident in the case of food safety due to liability laws, particularly the negligence and liability laws in the United States.[1] If an agent in the supply chain can be solely and entirely liable for a food poisoning incident, she might be tempted to conceal any information that may lead to a prosecution or an accusation.

Information is thus a key element in a safe food chain. However, it is imperative to distinguish and understand different types of information. First consider the information about the presence (or the absence) of attributes in a product. If we could observe with certainty at the point of sale or consumption whether a food is contaminated, we would avoid consumption of the product, and businesses would only offer safe food. This is not however the case; in most instances food safety levels cannot be inferred from simple observation of a product. Second consider the information about the production or processing method originating the product. The presence of certain attributes of a product is determined by the production process or method. In other words, some processes are more effective in assuring a given level of quality (and safety) than others. Finally, we have to consider the person or business producing the product. Clearly, not all producers have the same competence and commitment to produce and deliver a product. The same production method or process can have very different attributes depending on the agent that is

[1] See Chap. 18 in this book for a detailed treatment of the legal aspects of food safety.

using it. These different aspects of information have different economic values and implications. Therefore, they cannot be dealt with in the same way.

In an ideal world information would be freely and readily available to all private and public agents in the food system such that they could make effective and sound decisions. In reality information is *costly*. Businesses and consumers need to incur expenses to determine the presence or absence of attributes in food, to record and store information and, finally, to transmit and share it. Then, as we will see below, private information plays a key role in bargaining and contracting which also needs to be taken into account. Consequently, unless agents are properly compensated, they have a strong incentive to withhold information. Likewise, if the probability of being liable for a foodborne illness is low, there are limited incentives to adopt preventive costly measures (see Chap. 18). For example, if a highly qualified and competent operator in a slaughter house is not compensated (or given enough time) to comply with food safety protocols (for instance, HACCP) and register any events occurring in a given day, food safety may be compromised and the information he may have acquired will be lost forever. Similarly, if a farmer cannot get a higher price for his product after a significant investment in biosecurity on his feedlot operation, he may not have an incentive to maintain a higher level of prevention. Finally, consider a ready-meal manufacturer testing a product for a pathogen and then reporting the results. This information is highly valuable to the buyer, but the costs of testing are often incurred by the seller who further risks losing revenue should the tests be positive. Clearly, buyers and consumers have the right to expect a high level of food safety and to be informed on any potential risks of contamination; however they should also recognize that assuring such high safety levels and getting access to information are not free.

Economists have long realized the importance of information in market transactions. One of the conditions for the existence of competitive markets is that there is free and accurate information available to all the agents in the marketplace. This is because having full information about the product or service transacted is essential for a complete valuation of what is transacted and for a rational decision. However, the reality is that in most markets, there is imperfect information on the attributes of a given product, on the most effective process to produce a good or a service, or on the ability of an agent to do a job. Moreover, this imperfect information is also prevalent within organizations transacting in a marketplace. Thus, in real markets information is often unobservable and unverifiable which challenges the ability of agents to make accurate valuations of the product or service they aim to purchase. Recognizing this reality and the fact that in a lot of situations we delegate on others the execution of tasks from which we benefit economists has developed agency theory.[2]

This theory, also known as theory of incentives, helps us understand and take into account imperfect information when we want to understand how organizations out-

[2] This chapter introduces agency theory for noneconomists. The next section presents this theory in a nontechnical fashion. Readers that have an economics or management background or want to have a more technical introduction to this theory are encouraged to read intermediary level business economics textbooks. An excellent text covering this theory is Laffont and Martimort (2002).

source the production to another firm or agent. In essence, this theory explains how a buyer and a seller may negotiate a contract when they don't have complete information on the other's ability and diligence to deliver the product with the agreed specification. More specifically, agency theory helps us think about the incentives a buyer needs to put in place to motivate a seller to assure he delivers the product with the agreed levels of quality and price level. Note that this theory does not only apply to market transactions, rather we can also use it to think about how a governmental authority might motivate an industry or consumers to adopt preventive measures to reduce food safety outbreaks.

This chapter introduces agency theory and how it can help us understand the challenges of coordinating food safety in food systems. In the next section, we (1) discuss the reasons why the principal agent framework is appropriate to examine food safety in supply chains, (2) describe the basics of an agency model and its key features, and (3) introduce the limitations of the framework. Then Section 3 provides a couple of applications of this framework, discussing the difference between a business-to-business and a government-to-business case and the challenges of contracting with multiple agents. Section 3.4 describes some of the international challenges of food safety control discussing some of the main private standards, and Sect. 3.5 concludes.

3.2 Agency Theory and the Economics of Information

Food systems are instrumental for the provision of food security, defined as: "when all people, at all times, have physical and economic access to sufficient ***safe*** and nutritious food that meets their dietary needs and food preferences for an active and healthy life" FAO (1996). Food safety is a key aspect of food chains; however as suggested above, buyers and consumers cannot infer the true quality or safety level of a product by direct observation. This is because safety is a credence attribute of food. Derby and Kirby (1973) define credence goods or attributes as those for which the seller knows more about the quality of the product or service it is selling than the buyer. In credence attributes, there is asymmetric information about the true level of food safety, because one of the contracting agents knows more about the characteristics of the product being transacted than its trading counterpart.

Writing on the economics of food safety, Antle (2001) claims there are actually two important food safety information issues in food supply chains. First there is *symmetric imperfect* information, as both suppliers and buyers may ignore the actual level of say *Salmonella* contamination of a given batch of burgers. Second there is asymmetric information as each agent has private information on their ability and efforts to mitigate food safety hazards which they withhold from their counterparts. Hirschauer (2004) links these two information issues as he identifies and describes two main hazards associated with food safety outbreaks: (1) technological hazards, linked to uncertainty about the process of contamination of food, and (2) moral hazards, which are related to opportunism of suppliers and buyers who use their private information and/or shirk on efforts to prevent food contamination.

Technological hazards may be thought of as the source of symmetric imperfect information, while moral hazards are linked to asymmetric information.

Technological innovation and increased awareness of suppliers of their process may reduce the degree of technological hazards. Even if there is uncertainty about how food safety outbreaks emerge, there is also considerable knowledge on how incidents can be prevented or mitigated. In fact, there are now a host of manufacturing practices (sanitation of workers and tools), control processes (such as the Hazard Analysis and Critical Control Points) and technologies (e.g., irradiation) that can effectively increase the level of food safety.

However, some of these techniques require significant investments, which increase the cost of operation and reduce business profitability. In other words, businesses need to have clear incentives to justify investments in food safety. This is where it is important to understand the impact of moral hazard, which requires a deeper understanding of the economics of information and the theory of incentives. The goal of this theory is to explain how we may organize the transaction between a buyer (the principal) who pays a price for a product whose characteristics depend on the effort of a seller or supplier (the agent).The challenge is to define the set of incentives that need to be written in a contract to ensure that an agent accepts to deliver a product with the expected level of quantity (and quality or food safety level) required by the principal. The buyer or principal has thus two main challenges: (1) to assure participation of the agent in the contract and (2) to motivate the buyer to exert the level of effort that ensures the volume of production and/or the level of quality required is delivered. Thus, implicit to the definition of the price proposed by the principal when making an offer is the ability to contract of the level of effort that the supplier (agent) needs to exert to deliver the product with the attributes required by the buyer (principal). Following we present a standard model to further explain the mechanics of an agency theory model.

3.2.1 Principal Agent Model and Contracting

The food supply chain can be seen as a sequence of supplier[3]-buyer pairings, where a buyer wants to obtain a product from an upstream supplier to sell to a downstream buyer or to the final consumer. Both the supplier and buyer maximize their profits, which translates into the buyer trying to obtain the product at the least possible price and the supplier trying to get the highest net benefit[4] from the sale of its output. In modern food chains, these transactions are increasingly governed by contracts between businesses operating at different points in the chain. Essentially, these con-

[3] In this section the words “supplier” and “seller” will be used interchangeably to designate the agent that produces and sells an output to a party downstream.

[4] In other words, to maximize the difference between the price paid by the buyer per unit and the costs of production. These costs include the additional efforts required to produce higher quality, the costs of implementing and managing a quality system, as well as costs of recording and sharing information.

tracts specify a level of output to be delivered by the supplier to the buyer and a price to be paid for such delivery to the former. For example, retailers' often contract with farmers or cooperatives to supply fresh produce to their shops. While initially these contracts mainly specified quantities and prices, increasingly they also specify the production and processing methods as well as the quality attributes of the output to be delivered, namely, its level of food safety.

Recall the three types of information introduced above. In a world of perfect information, the buyer would know with certainty the level of quality of a product, the reliability of a production and processing method, as well as the ability of the supplier to deliver the agreed levels of output and food safety. Let's focus on the later aspect of information and how it affects transactions.[5] Should there be perfect information on the ability and the level of effort exerted by the supplier, when producing the product to be delivered, the level of food safety would be completely observed or inferred. Consequently, a buyer would be able to design a complete and efficient contract to deliver a good with the required specifications at the least possible cost. However, as suggested above, the reality is that buyers do not have perfect and complete information on the true quality of the product they purchase upstream. They can determine the quality but only at a cost. In other words, when designing a supply contract, the buyer faces uncertainty on whether the supplier is actually capable of delivering the product with the required specification. Furthermore, the buyer cannot observe the actions of the seller; therefore, he also faced uncertainty on the seller's commitment to exert the level of effort required to deliver a product with higher level of quality.[6] There is imperfect information because the supplier has private information that is critical to the buyer, but that it is not in his best interest to disclose.

Agency theory helps us understand and model these transactions under imperfect information. This theory determines the incentives that a buyer needs to put in place in order to (1) attract the suppliers that have the ability to deliver the output with the quality attributes required and (2) motivate the seller to exert the level of effort that minimizes the cost of the output and the risks associated with quality failures.[7] More formally, when designing a contract under imperfect information, buyers need to take into account two key risks (Barros and Martinez-Giralt 2012):

- *Adverse selection* is defined as the risk associated with the failure of contracting a supplier that is truly able to deliver the required product or service with the level of quality required. The risk faced by the principal is to select an agent that is unfit for the job or service contracted.
- *Moral Hazard* is the risk associated with shirking in the contracted levels of effort required to produce the volume and quality of output. Given that the buyer

[5] The remaining elements unfold from this.

[6] The problem in here is that for an agent or seller effort is costly, so the least amount of effort exerted the larger the return. Since more quality (or food safety levels) requires more effort, unless the buyer creates the right incentive, the seller will not necessarily exert the level of effort required to deliver a safer food.

[7] See application in Chap. 10 on *E. coli* O157 and Jack in the Box's required testing.

cannot fully observe the effort of the supplier, she has to provide an incentive or a punishment to discourage the seller from shirking on the agreed upon effort. In other words, the problem is to assure the agent exerts the level of effort required to deliver the level of quality expected by the buyer and written in the contract.

These well-known issues have two consequences: (1) prevent buyers from making complete rational decisions and (2) affect the ability of markets to perform efficiently. In the absence of complete information on the attributes of a product, it is impossible to assess their true value. Consequently, the buyer may be paying more than the actual value of the product. This is because the seller is getting an information rent, due to inability of the buyer to observe both the capacity and commitment of the seller. From the presentation so far, it should be clear there is interdependency between buyer and seller, as both want to get something the other has. However, each agent also has a private interest, aiming to maximize her utility or profits. This results in a conflict of interest, because the value and joint utility they get from the transaction depend upon unobservable attributes (of the agents but also of the product they trade). Should the buyer be able to observe with certainty the seller's competency and effort, then she would be able to design a contract that would maximize the utility from the transaction for both parties. The agent would not be able to hide the true value of the good as it would become apparent. The reality however, particularly on food safety, is quite different, as it is virtually impossible to both ascertain the true ability of an agent to perform and to observe his actions.

So, what can be done? Basically, the idea of agency theory is to factor these asymmetries in information when designing a contract. This translates into forcing the supplier to reveal his true ability and to give him a clear disincentive to shirk on the level of effort required to deliver a higher level of quantity or quality. A key and implicit assumption of agency theory is that the contracts can be resolved in a court of law. In other words, should the buyer or the seller fail to comply with the terms of the contract, they can bring the case to a legal authority that will be able to resolve the dispute.

In economics, an agency theory problem is typically analyzed in mathematical terms as a constrained maximization problem.[8] Weiss (1995) pioneered the adoption of this framework to the economics of food safety, and since then there have been a variety of applications. Table 3.1 describes in words the main features of an agency model.

Table 3.1 draws on Starbird (2005) and Elbasha and Riggs (2003), and while it offers a simplified version of the problem, it enables us to draw some important lessons. The first thing to take into account is that in an open economy, there is always an alternative market where the seller can sell the product. This is important, because if a buyer cannot afford to pay at least $\boldsymbol{U}$, the seller will not participate in the contract. Moreover, there is a distribution of ability (or competency) in the seller's market. It is reasonable to assume the buyer knows the nature of this distribution,

[8] Agency theory is an application of noncooperative games. Thusl an alternative way of modeling this problem is using game theory and finding the optimal strategies for each party.

Table 3.1 Framing the relation between buyers and sellers

Partners	Problem/objective function	Choice variables	Comments
Buyer	Wants to design a contract to buy a quantity X of a product valued at p from the seller. She offers a price w to the seller ($p > w$). However, the product is unsafe with probability π. Assume the buyer will bear the total costs L[a] of a food safety incident. The buyer knows that not all sellers are alike, as some are safer than others. Moreover, the probability of a food safety incident can be reduced with more effort from the seller	The buyer chooses the price w to write in a contract to get the X units of product. However, given that the quantity and safety level of the product are linked to the effort exerted by the seller, the level of effort also needs to be considered in a contract	The level of food safety adds considerable complexity to the buyer-seller transaction. The buyer not only has to consider the price to pay to maximize his profits but also how to avoid a possible loss caused by an outbreak
Seller	The seller has an alternative market on which to sell the product that gives him a total profit of U. He has private information on his ability and amount of effort to deliver the product with the required level of food safety. He will accept the contract if his net benefit is at least as high as the net gain from the alternative market	The seller choses the level of effort such that: 1. he get at least the value U 2. higher effort levels will lead to more compensation	The first condition is known as the participation constraint. The second is named incentive compatibility constraint. What this setup clearly shows is that imperfect information imposes additional costs to the buyer, as the supplier will only exert higher effort if he is compensated

[a]The literature associates this loss to the costs of recalling and disposing products, legal fees, regulatory fines, and loss of reputation (see Starbird 2005; Elbasha and Riggs 2003)

but she cannot observe the actual competency of a given seller. Thus, she needs to design the contract such that only the high-quality sellers participate. Clearly, this makes these transactions more costly than buying in a spot market. A further complication (and additional cost) arises from the incentive compatibility constraint, which compensates the supplier for exerting a high level of effort.

Now consider the probability of a food safety outbreak π is a function of the level of food safety θ. The level of food safety can be defined and measured in a number of different ways. For example, it may reflect the level of pathogen contamination of a product, handling practices, exposure to possible contaminants, and contamination by chemical or physical agents. For convenience, assume that it relates to the degree to contamination by pathogens. Thus to a low level of contamination corresponds a high level of food safety, and conversely high levels of contamination have low safety levels. Further assume that the level of food safety is a function of the

supplier's level of effort e and a stochastic term ε. Consequently, the supplier does not have absolute control of the process, and regardless of his efforts, there is always a probability that an incident will occur.

In agency models, the distribution of types of agents in the market is simplified, and it is assumed there are only two types of suppliers: high effort (e^H) and low effort (e^L). A high- effort seller is more efficient and therefore will produce a safe product at a lower cost.[9] That is, this agent is more effective and efficient in delivering food safety. However, unless the buyer compensates the high-effort supplier, the supplier will exert the lower effort. This is in essence the incentive compatibility constraint. Formally we have $\theta(e^H,\varepsilon) > \theta(e^L,\varepsilon)$ and $p[\theta(e^H,\varepsilon)] < p[\theta(e^L,\varepsilon)]$, that is, a high-effort supplier will deliver, on average, a safer product and therefore have a lower probability of originating an outbreak. The stochastic element is a key issue as it adds uncertainty to the problem of the buyer and leads to further opportunities for the high-effort seller to disguise as low effort.

Another feature of the model deserving attention is the loss and how it is distributed. When there is strict liability, the loss needs to be entirely borne by the food chain. In fact, strict liability implies that if a product had a defect and caused an injury, then the agent producing such product will be held accountable even if the event was accidental (see Chap. 18 for a more detailed legal account of the issue). What is clear though is that the way outbreak losses are distributed matters. In our simplified formulation, we suggest that the cost of a food safety hazard is entirely borne by the buyer, but the loss might just as well be entirely passed on to the seller or be shared between the buyer and the seller. What is clear is that if the loss is partially or totally assumed by an external party (say the government or the consumer), there won't be enough incentives to invest in preventive actions. Also, if the legal system fails to punish the culprits of food safety hazards (as suggested in (Starbird 2005; Mahdu et al. 2015) then neither buyers nor suppliers will feel compelled to make the necessary investments to exert higher levels of effort to increase the food safety levels of their foods.

There are many ways to solve agency problems. The most common approach is to first determine the price to be paid to the seller and then to assure the desired level of effort is indeed exerted. Importantly, the existence of asymmetric information leads to an opportunity for the party with information to get a rent[10] which makes the transaction inefficient when compared to a case of full information.

In short, agency theory provides us with a framework to think about transactions when there is asymmetric information on the ability and diligence of a seller to deliver a good demanded by a buyer. The aim of this framework is to provide guid-

[9] Here there is an implicit assumption that quantity and food safety are both increasing in levels of effort. In reality, this may not be the case, and efficiency in producing higher volume may be decoupled from food safety.

[10] In economic terms, a rent is a value that needs to be paid in excess of market price to obtain a service or a product. In order to assure the supplier exerts a high-effort level in food safety precaution, the buyer needs to pay more than she would in the spot market. In this case, the rent is due to information asymmetries.

ance on how to design a contract that is acceptable to the seller and makes him deliver the level of effort required by the buyer in terms of food safety levels. So it helps us think about the appropriate incentive structure to assure supply chains deliver the expected level of food safety.

3.2.2 Limitations of Agency Theory

Agency theory provides very clear and important lessons to our understanding of transactions under imperfect information. However it does have some limitations. First because there is a wider heterogeneity in suppliers than the simplified dichotomy we typically use. Moreover, in practice the contracts will have other conditions beyond just defining a price and a quantity or quality to be delivered. So the framework should be used as a guide to help us think about conditions of the contract and what should be its specifications. Second, the model we presented is static, meaning it considers transactions in only one time period. There are models in the literature that consider the possibility of contracting in multiple periods; however even in those models, it is assumed that the terms of the contract remain constant across periods.[11] Moreover, most of these dynamic models don't allow for agents to change their type or the principal to learn about the ability and diligence of the supplier, which in practice would mean that an inefficient agent cannot improve or the principal to use information in past periods to improve the contract. In practice, however, governments and buyers can offer incentives for suppliers to improve their ability to perform. This limits the possibility of gathering information on the level of performance of the supplier, which would allow the contract to be revised and made more efficient. A third problem regards monitoring and enforcing the contract which relies on the assumption that it is possible to observe and verify compliance. If a court of law cannot verify or validate the evidence on the cause of a food safety outbreak, it will not be possible to find a culprit guilty as charged, which means that the contract may not truly bind the parties.

3.3 Applications of the Theory of Incentives

One of the main features of agency theory is its flexibility. Just as the problem can be defined in terms of a buyer and seller, it can also be specified in terms of a government facing an industry. In that case the principal is the government or a regulator and the agent is the industry. What is the main difference between a government and a private entity as principals? Section 3.3.1 below gives a tentative answer to this question.

[11] Readers' interested in these types of models are referred to Laffont and Martimort (2002), Chap. 8.

Also, in modern supply chains, retailers and food service businesses often contract with several different suppliers. For example, it is unlikely that the supply of tomatoes to a supermarket chain will be sourced from a single supplier throughout the year. Also, when we say the government faces an industry, we implicitly assume there are several different businesses involved. So how can this framework help think about providing incentives to a group of suppliers or to a set of organizations in a given industry? This will be discussed in the section 3.3.2.

3.3.1 Government vs. Industry as Principals

The main difference in having the government as the principal is that governments consider the welfare of both the industry and consumers. In other words, the government needs to assure that society maximizes its welfare, which in economic terms is the sum of industry profits and consumer utility. Clearly, there is a potential conflict between consumers' utility and industry profitability. To see this, consider the additional costs (and corresponding decrease in profitability) the industry incurs to deliver safer food. Then compare these with gains in the utility of consumers and society from additional food safety. For example, consumers will be happier if they avoid pain associated with food outbreaks, but also this means they will have a lower number of sick days (which increases productivity) and also lower medical and hospitalization costs. If the loss of profits to the food industry due to higher costs of food safety prevention is higher than the gains in consumer's utility and societal welfare, then, from a pure economic perspective, society as a whole would be worse-off. So when considering interventions to improve food safety levels, governments need to carefully assess how to weigh the costs and benefits to industry and consumers of different policy interventions to mitigate food safety.

At the heart of the matter, once again, is information on the actual cost (to industry and consumers) of prevention. If consumers knew that the industry is not investing heavily in food safety, then they will infer that food is not as safe and either take their own precautionary measures, avoid those products they perceive as unsafe, or pay less for them. This creates an incentive for the industry to invest on food safety. Elbasha and Riggs (2003) suggest that insofar as the degree of safety is unobservable and non-verifiable, the industry has little incentive to invest in prevention. So, the rule of the government may need to be more subtle. Rather than imposing a level of food safety, the government might make public information about the industry food safety levels. This can be done by investing in monitoring and inspection policies and then reporting results to consumers. Consequently, when it comes to food safety, the government might be better off focusing on finding and disclosing information rather than on direct intervention.[12] For example, the government might con-

[12] Note, however, that the government might be considering a subsidy to promote food safety or specifying the optimal level of a fee or penalty to minimize food safety outbreaks.

sider designing an inspection policy aiming at revealing the true level of food safety of an industry.

Starbird (2005) uses a principal-agent framework to determine the optimal inspection policy that makes a seller exert a higher effort to deliver safe food. The inspection policy is characterized by the sampling method, the acceptance rate, and the penalty from failing to pass inspection. While in his model Starbird does not directly analyze the relation between a regulator and the industry, it does shed light onto how the government may influence the parties in a food chain to invest in food safety measures. It is implicit there that if the government mandates a stricter sampling policy, then the probability of detection of unsafe samples increases which leads the suppliers to increase their effort levels and decrease the odds of a food safety hazard. By the same token, if the government increases the penalties or the amount of public contributions to food safety outbreak costs, then it also incentives the adoption of more precautionary measures.

The government and the legal system can create incentives for the industry to adopt safer food production and processing practices through the negligence and liability laws. As Stearns (2017) suggests in Chap. 18 of this book, avoiding litigation is another instrument liberal societies have to incentivize a safer food marketplace. Liability laws affect the way risks are allocated throughout the supply chain. Notwithstanding potential inequities emerging from opportunism of businesses with more resources to shift their risk upstream, making someone in the supply chain accountable for managing the food safety risks is an alternative to direct intervention by governments. In the United Kingdom, the Food Safety Act of 1990 is an example of how a government can incentivize the industry to invest in food safety by holding businesses selling directly to consumers accountable for the safety of the food they sell (Food Standards Agency 2009).

In short, as one of the problems the government faces is uncertainty over the cost structure and the industry and firms' ability to exert higher effort, agency theory is a very suitable framework to understand how to incentivize the industry to deliver safer food. This theory helps us understand the role of government and the impact of different policy options aiming at increasing food safety levels. Governments do not necessary need to intervene directly with regulation to attain a given level of food safety, rather they may be more effective if they create an incentive structure that forces industry to take due diligence and protect against possible outbreak costs.

3.3.2 Contracting with Multiple Agents

The problem with contracting with different businesses is that information asymmetries not only persist but multiply. Economists have developed agency models to deal with the case where a principal proposes a contract to a set of suppliers. There are a number of possible approaches; the first is to treat the group as an individual, which means that a similar structure to the one above is considered. A second

approach is to offer individual contracts to each supplier in the group. In this second case, the model may consider whether agents are homogenous or heterogeneous. Consider the case of a producers' organization supplying fresh produce to a retailer, producers will have different abilities and willingness to exert effort. Thus, the food safety level will not be constant for every supplier. In fact, unless the identity of each producer is preserved, a low-effort producer may free-ride on the high-effort members of the organization. By the same token, when the government is considering interventions to boost food safety with an industry, it needs to take into account differences across businesses and how less efficient firms may jeopardize the industry efforts to respond to incentives.

One of the ways buyers and governments can mitigate free-riding when dealing with multiple agents is by making compensation to suppliers a function of the level of food safety in the market. The rationale is that if the buyers or consumers know that the risk of getting sick from foodborne pathogens is higher, they will not be willing to pay as much for food. Linking the payment of each individual to the overall performance of the group creates a strong disincentive to free-ride. Hamilton and Zilberman (2006) analyzed this issue in the context of collective reputation associated with environmental labels. While they don't use an agency framework, their insights are quite important and applicable. In their model, they propose that the price paid per unit of output has a fixed component and a variable premium which depends on the purity (the proportion of output that is of high quality). In the context of food safety, this degree of purity can be thought as the proportion of product that passes inspection. Of course, if a given industry or producer organization has a poorer food safety record, then buyers won't pay as much for their products. This creates an incentive for members of the industry or organization to invest in food safety and monitor the effort levels of their members.

To summarize, often a buyer needs to contract with a group of suppliers. These often are heterogeneous in both ability and effort levels, which complicates the design of the contract, as along with adverse selection and moral hazard, the buyer has a potential free-riding problem. This possibility needs to be taken into account, and one way to address it is to decouple the payment and include a component associated with a measure of the suppliers' group performance.

3.4 International Private Standards

As food chains become increasingly global, buyers face additional information gaps when contracting with overseas suppliers. For example, the European Union countries import a significant amount of fresh produce and vegetables from Latin American and African countries. A significant amount of US food imports is governed by contracts with grocery and food retail service.

Dealing with international suppliers increases the complexity of assuring a safe food supply for buyers will not only have more uncertainty about selecting and motivating suppliers to deliver required food safety standards but also have to take

into account the ability of local private or public agents to monitor and enforce contracts. There are often striking differences in the minimum food safety requirements across countries. Thus, the regulatory food safety standard levels in exporting countries may not provide the assurances required by buyers, particularly when exporters are in developing countries and buyers are food retailers or food service businesses from the European Union, Japan, or United States which have higher food safety requirements. One of the ways food manufacturers and retailers have addressed this issue is by setting private standards that include food safety provisions and impose them as a condition to offer a contract. These standards are typically designed by individual buyers (for instance, retailers) or, more commonly, by industry associations. An example is the family of manufacturing standards designed by the British Retail Consortium (BRC), an association of British grocers (representing both large multiples and small independent grocers). These standards define requirements that suppliers need to comply with if they accept a supply contract. Among these conditions are a clear demonstration of the commitment of the managerial team of the supplier to implement a food safety program, a food safety management plan, and a registry on how procedures have been implemented. Moreover these private standards require an audit or a certification process through which the supplier agrees to be monitored by an independent third party agent that will visit the potential supplier and verify whether requirements are being followed.

While these private food safety standards are being used on contracts with both domestic and international suppliers, they are particularly useful when dealing with the latter. Recognizing there was a multiplication of food safety standards designed by different grocers and food manufacturers or their associations and there was an increasing cost of compliance imposed on suppliers, in 2000 a group of 650 international food retail, manufacturing, and food service companies came together to form the Global Food Safety Initiative (GFSI). The goal of this initiative is to assure consumers across the globe access safe food (Sansawat and Muliyil 2012). Following an agreement between seven global food retail companies, any supplier to a manufacturer, retailer, or food service company complying with one of the benchmarked schemes approved by GFSI will no longer be required to comply with other

Table 3.2 Food production and manufacturing schemes recognized by GFSI

Manufacturing schemes	Primary production schemes	Primary and manufacturing schemes
1. British Retail Consortium (BRC) Global Standard 2. Food Safety System Certification (FSSC 22000) 3. International Features Standard 4. Safe Quality Food Code (SQF) 5. Best Aquaculture Practices Standards 6. Global Red Meat Standard	1. CanadaGAP 2. GlobalG.A.P. 3. Safe Quality Food code: (a) Module 2: System elements (b) Module 5: Food safety fundamentals (c) Module 7: Food safety fundamentals	1. PrimusGFS

Adapted from Sansawat and Muliyil (2012)

schemes. The expectation is that this will open options to suppliers of different supply chains and reward those that have invested in improvements of their quality and food safety levels. Thus, the GFSI is becoming an umbrella organization that integrates competing private schemes and contributes to a standardized program to improve food safety levels of supply chains associated with major international retailers, food service, and food manufacturing companies.

The schemes that are recognized and benchmarked under GFSI are the British Retail Consortium Global Standards, the Food Safety System Certification (FSSC 2000), the International Features Standard (IFS), and the Safe Quality Food (SQF) Code. Along with these broader internationally accepted schemes that comprise both primary production and food manufacturing quality and safety assurances, there are also other sectorial, primary, and company-specific schemes that have been recognized under GFSI. These are summarized in Table 3.2 below.

It is beyond the scope of this chapter to provide a detailed comparison between each of the schemes recognized and benchmarked by GFSI. Interested readers are referred to Sansawat and Muliyil (2012), to the GFSI website, or to each of these schemes webpages that have detailed information on the requirements of each of these quality and safety standards. It is also outside the expertise of the author to compare the ability of each of these schemes to deliver an adequate level of food safety. It is nevertheless worth highlighting what the schemes have in common and how they relate to the economic framework discussed above. All aspiring suppliers to companies subscribing with the GFSI benchmarked standard are required to adopt the following procedures (with slight differences across schemes):

1. *Agree a contract*: In other words accept a proposal by the buyer to supply a given agricultural or food product.
2. *Optional preaudit*: Most schemes offer the supplier an opportunity to be visited by an auditor to assess their quality system and how it conforms with the standard requirements.
3. *Certification audit*: In this step, an independent auditor or certifier visits the supplier and performs an extensive and detailed examination of the production or processes as well as the quality scheme. The goal of this certification is to determine whether the supplier is in full compliance with the quality standard or scheme requirements and whether there are nonconformities. If these exist, the supplier will be informed of what needs to be rectified and given a timeline to perform such changes.
4. *Audit*: this is to confirm that (if any) the nonconformities were rectified and any recommended changes were implemented.
5. *Certification document*: Once the independent certification body has verified that the supplier is fully complying with the requirements of the standard and that all required adjustments were implemented, the supplier is issued a certificate of compliance and can start supplying the buyer.
6. *Recertification*: The certification is issued on an annual basis, so each year this process is repeated.

Clearly the process required by the food quality and safety assurance benchmarked and recognized by GFSI relates to the economic framework described in this

chapter. As we just saw, an agro-food producer aiming to supply a major retailer, manufacturer, or food service business will need to accept a contract proposal to the potential supplier. As a buyer imposes compliance with one of the standards benchmarked by GSFI as a condition to get a contract, she is (at least implicitly) taking into account uncertainty associated with adverse selection. This is the reason why most schemes offer a preaudit, which is really a clever way to prescreen a supplier and gather information about his type. Then the certification and audits are actually a mechanism to mitigate moral hazard. The annual recertification is also a mechanism designed to create an incentive for the supplier to keep or improve his effort levels. So, by designing and imposing compliance with a standard as a condition to offer a contract, buyers address the adverse selection problem, forcing the supplier to reveal their true capacity. Moreover, imposing an audit on supplier allows the collection of information that will enable the buyer to learn the risks of each supplier. Also, through certification (that is verification of the extent to which the supplier is complying with the standard), the buyer has a mechanism to detect shirking on the expected level of effort.

While these international food quality and safety standards have obvious merits, they also carry a number of caveats. First it is not clear how growers and consumers are represented and have a say on the development of these standards. So the standards may not be taking fully into account practical knowledge producers may have of their operation and may be creating unrealistic expectations as well as disenfranchising a critical element of food systems.

Second, and possibly more importantly, is the role played by the certifiers which is worth further examination. From the description of the schemes, it seems that the certifiers act as gatekeepers to the buyer, excluding or limiting access to contracts all suppliers that do not conform with the standard requirements. But the preaudit, possibly carried out by the same entity that issues the certification documents, has elements of a consulting or advisory service that provides information to the supplier on what needs to be done to pass the audit. This may lead to a conflict of interest. So do certifiers act as inspectors or as consultants? How do they relate to the supplier and the buyers? If all the certifier is doing is examining conformance with the standard, the supplier may be tempted to adopt the type of misbehavior indicated by Stearns in Chap. 18 of this book, where he says that a supplier may be complying with a standard and still not doing enough to prevent food safety incidents. Furthermore, less scrupulous certifiers may be tempted by bribery from suppliers or to extort additional payments to provide the certification document. This is particularly relevant for contracts with suppliers from countries with limited institutional or governance infrastructures or with sophisticated criminal organizations as it became apparent in the food horse scandal in the United Kingdom (Levitt 2016) or been recently reported on the New Zealand (Roy 2016) and Mexican Avocado industries (The Economist Explains 2016).

When there is a potential conflict of interest and collusion between the certifier and supplier or between the certifier and the buyer, the benefits of food quality schemes and their impact on the level food safety risks being undermined. Tirole (1986) studied this possibility and shows that a monitoring organization (such as a third party certifier) may misreport the actual level of effort and food safety of a sup-

plier by colluding with one of the contracting parties at the expense of the other. This is not a trivial issue, and the opportunism of a third party certifier needs to be taken into account, when they provide signals to the buyer on compliance with the terms of the contract. Note that the third party certifier can be thought of as a supplier of a service to the buyer, the supplier, or both and that it has both hidden information on his ability to monitor a quality standard and on the effort required to do it effectively. Interestingly, Stearns in Chap. 18 of this book provides an example of a lawsuit following an outbreak in the peanut industry, where a buyer relied on a certification document obtained from a private third party certifier hired by the seller to inspect the food safety conditions of the operation.

Third, by designing and enforcing compliance under a given set of rules, international buyers are selecting only those suppliers who can adopt and meet the specified quality standard. However this is not costless, as limiting the pool of potential suppliers increases the costs of contracting. Also, regarding the societal level of food safety, while potentially higher-risk suppliers are excluded from high-value supply chains, they will not necessarily leave the market, rather they may move to lower-value supply networks. In this case the probability of an outbreak will not necessarily diminish. Moreover, these alternative channels may be supplying lower income segments of the population, raising concerns on equity as people with less protection may be facing a higher risk of getting foodborne illnesses. Finally, the increasing interest of media on any food outbreak and its ability to amplify a message without much concern about the actual dimension, limitation, or even source of the problem can lead to spillover effects across all the industry.

A fourth issue related to the use of international private standards contracts with international developing country suppliers regards the jurisdiction on which disputes can be settled. There are really two issues: one is whether noncompliance with a private standard can be considered by a legal court and the second is which legal court would be selected. This is a challenging issue because the authority to penalize a supplier that failed to deliver safe food is not clear-cut. As we saw above, one of the key assumptions of agency theory is that contracts can be resolved in a court of law; on its absence, it may be impossible to enforce a contract.

In short, private food standards have emerged in the last couple of decades in response to regulations that hold retailers, food service, and other businesses selling food directly to consumers accountable for any incidents that may occur. Increasingly, these standards are comparable and have a global scope, often being more demanding than national legislations. As retailer and food service firms impose these standards to their suppliers, they are really addressing the information asymmetries raised and explained by agency theory. In fact, by imposing a standard as a condition for supply, a buyer is forcing their suppliers to reveal their types. The standard becomes a screening device. Furthermore, by having a third party verifying whether the standard is being followed, the buyer is addressing the compliance issue.

Nevertheless, international standards have limitations and may not effectively prevent food safety outbreaks. First, it is important to recognize that the standards are designed to mitigate the risks of liability and reputation of the firms or industry associations that own them and not necessarily to incentive an optimal level of food safety. Second, only the consumers and customers of the businesses that are impos-

ing the standards on their suppliers are safer. While the number of retail and food service business adhering to these international standards is growing and commands a larger market share, there is still a significant amount of food that is sold outside these supply networks. Third, the monitoring of these standards is not continuous, but rather discrete and at most once every quarter, which may not create a strong enough incentive for high levels of compliance.

3.5 Final Remarks

As the food system becomes increasingly complex, careful management of food safety risks is ever more important. A key element to prevention and containment of food safety outbreaks is information. This chapter introduces the economics of information and agency theory. This theory provides key insights on how information about an agents' ability and diligence in performing a given task needs to be considered when contracting food safety levels between suppliers and buyers in a food chain. Unless the agent has an incentive to reveal his type and exert the level of effort required to deliver an acceptable level of food safety, there is a chance he may not deliver what is expected. It is important to understand that this theory is not addressing the problem of getting information on a given product or process, but rather on how to take into account private information when contracting with an agent (person or business) to produce a product with the desired specification.

Understanding this problem and its implications for modern food system is vital as otherwise private and public systems designed to improve food safety levels won't be as effective. In fact, failing to recognize the value of private information may lead producers and processors of food to under invest in prevention and ignore the true level of contamination of the products they sell. The flexibility of this framework helps us understand the characteristics of explicit contracts between buyers and sellers or between regulators and industry but also the implicit contract between a consumer and a food supplier. For instance, using this framework, one may realize that the consumer may also be opportunistic and shirk on her/his own precaution efforts. In fact, consumers may assume all the food available for consumption is safe to eat and trust that a system is in place to assure that is the case. Unsafe food does not have a market, and therefore consumers will not necessarily realize the trade-off between the risks of buying a contaminated food and the costs incurred by the industry to assure a low risk. Governments rightly expect and require that all segments of the population, regardless of their socioeconomic status, have access to safe food. However, just as the consumer, regulators will need to recognize business motivations and challenges and that without the right set of incentives, it may be impossible to get further improvements in the delivery in food safety.

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