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Optimal Policy Response to Food Fraud

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We analyze the optimal government response to food adulteration and mislabeling while accounting for heterogeneity in consumer preferences and producer efficiency, endogeneity in producer quality choices, and asymmetries in food fraud detection. When more-efficient producers commit fraud, the optimal policy response is a strict monitoring and enforcement system. For less-efficient producers, both increased certification costs and monitoring and enforcement can deter food fraud. When the government desires to increase average product quality, the optimal policy is strict monitoring and enforcement. Increasing monitoring and enforcement in the presence of corruption provides increased incentives for collusion between dishonest producers and corrupt policy enforcers.

Key words: certification, consumer heterogeneity, food adulteration, mislabeling, monitoring, producer heterogeneity

Introduction

Food fraud refers to the deliberate substitution, addition, tampering, or misrepresentation of food for economic gains (Spink and Moyer, 2011). In this context, food fraud can be divided into two broad categories: food adulteration and mislabeling. While food adulteration can be defined as the intentional substitution or addition of substances in a food product to reduce its costs of production, mislabeling refers to acts of misrepresentation of the type or quality of food products. Food fraud is motivated by economic gains and is enabled by the fact that information about the nature of credence goods is typically asymmetric. While certification and labeling can resolve the information problem faced by consumers, imperfect enforcement of labeling and/or certification requirements create opportunities for producers to mislabel or adulterate food products.

Although food fraud is as old as commerce itself, its intensity and frequency have been on the rise in recent years due to the globalization and growing complexity of the multitiered agrifood marketing system. In the United States, for instance, the total number of confirmed food adulteration incidents in 2011 and 2012 was 60% higher than those between 1980 and 2010 (U.S. Pharmacopeial Convention, 2013). Between December 2018 and April 2019, Interpol and Europol launched a massive food fraud investigation, called the OPSON VIII operation, in 78 countries in Africa, Asia, Europe, and North America, which resulted in the total seizure of around 16,000 tons and 33 million liters of adulterated food and beverage, respectively (INTERPOL News, 2019). While the actual cost of food fraud is unknown (since at least some fraudulent behavior goes undetected; see Johnson, 2014), PricewaterhouseCoopers Singapore (2015) estimates that food fraud may cost the global food industry $30 billion to $40 billion per year.

In recent years, food fraud incidents like the Chinese melamine milk scandal, the European horsemeat scandal, and Italian olive oil fraud incidents have captured the attention of the media,

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consumers, and governments around the world and have raised serious concerns about the integrity of the agrifood marketing system (Lotta and Bogue, 2015; Meerza and Gustafson, 2020).[1] Both the U.S. Congressional Research Service (Johnson, 2014) and the U.S. Government Accountability Office (2011) have published reports addressing food fraud concerns and highlighting federal and congressional actions to combat food fraud. Similarly, the European Union considers food fraud to be one of the top five challenges for the European economy (Anklam, 2014) and has started introducing significant requirements for food traceability and strict enforcement measures, with significant penalties for fraudulent behavior (Putinja, 2017).[2]

Combating food fraud has also become a key priority of the Chinese government after the milk scandal, which damaged the reputation of China's food exports and was a big blow to the booming Chinese dairy industry (Huang, 2014). In 2011, the Supreme People's Court of China decreed that convicted suspects in lethal cases of food fraud will be given the death penalty, while convicted suspects in nonlethal cases of food fraud, such as mislabeling, will face extended imprisonment and fines (Danovich, 2015).

With different countries adopting different measures to combat food fraud, the question that naturally arises is which policy response to food fraud is optimal. Determining the optimal policy response to food adulteration and mislabeling is a key objective of this paper. Surprisingly, despite the increased importance of this issue, the relevant literature offers little (theoretical or empirical) guidance on the effectiveness of different policy responses to food fraud. Exceptions include Hamilton and Zilberman (2006), Baksi and Bose (2007), and Bonroy and Constantatos (2015), which focus on policies addressing mislabeling. To our knowledge, no study has investigated the optimal regulatory response to food adulteration, which can have significantly greater costs than mislabeling.

In particular, Hamilton and Zilberman (2006) study the performance of an eco-certification policy in the presence of mislabeling. They find that policy performance depends on market structure and show that the average quality of a "green" product can be increased by imposing a positive per unit certification cost. Baksi and Bose (2007) study the performance of different certification and labeling requirements and show that, while, in most cases, self-labeling is the socially optimal option, third-party labeling becomes socially desirable when the per unit monitoring cost is high and/or when the total number of firms to be monitored is low. Finally, reviewing the theoretical literature on the economics of labeling, Bonroy and Constantatos (2015) discuss undesirable side effects of labeling, such as mislabeling, and suggest that any given purity level of labeling in the high-quality market can be achieved either by imposing a positive per unit certification cost or through monitoring and enforcement.

Only Meerza, Giannakas, and Yiannaka (2019) explicitly consider food fraud in the form of food adulteration, analyzing the system-wide market and welfare effects of food fraud in the form of food adulteration and mislabeling. They show that, contrary to what is traditionally believed, both high- and low-quality producers have incentives to engage in fraudulent behavior. Key factors that determine the impacts of food fraud and the group of producers that is more likely to adulterate or mislabel their produce are the enforcement policy parameters (which are exogenous in their model), public attitudes toward fraudulent behavior, and the relative magnitude of the demand and supply effects of food fraud. Our study extends Meerza, Giannakas, and Yiannaka and the aforementioned studies focusing on mislabeling by endogenizing the regulatory response to food adulteration and mislabeling. In addition to determining the optimal policy response to food adulteration and

[1] The 2008 Chinese milk scandal involved selling watered-down milk as high-quality milk, while adding melamine to boost the milk's protein content (Mooney, 2008). Melamine is harmful to human health, however, and as a result, the contamination affected around 290,000 babies worldwide, 6 of whom died and 52,000 of whom were hospitalized (The Grocery Manufacturers Association, The GMA Science and Education Foundation, and A. T. Kearney, 2010). In 2013, authorities throughout Europe found beef products containing undeclared or improperly declared horsemeat, an incident known as the European horsemeat scandal (BBC News, 2013). Most of the Italian olive oil fraud incidents involve the adulteration or mislabeling of extra virgin olive oil (Frankel et al., 2011; Kirchgaessner, 2015).

[2] Traditionally, food fraud results in lesser penalties than those imposed for other types of crime (Danovich, 2015).

mislabeling, our study (i) identifies the policy impact on the purity of labeling and the average product quality in the market and (ii) examines the effectiveness of fraud-deterring policies in the presence of political and bureaucratic corruption.

In analyzing the optimal policy response to food fraud, our study follows Meerza, Giannakas, and Yiannaka (2019) and explicitly accounts for the empirically relevant heterogeneity in consumer preferences and producer efficiency, endogeneity in producer quality choices, and asymmetries in the probability of food fraud detection. In addition to enhancing the empirical relevance of our study, the explicit consideration of agent heterogeneity and endogenous producer quality choices enable the identification of a critical link between the efficiency of dishonest producers and the fraud-deterring policy impact on the purity of labeling and the average product quality in the market.

Optimal Government Response to Food Fraud

This section focuses on determining the optimal policy response to food fraud. In particular, the government seeks to determine the optimal type and degree of policy response, accounting for the impact of its decisions on all interest groups involved (i.e., consumers, producers, and taxpayers). Similar to Bonroy and Constantatos (2015), we assume that the government has two policy instruments to deter food fraud: an increase in certification costs and monitoring and enforcement. The increase in the certification costs of the high-quality product, denoted by cf, can be achieved through any regulation that increases these costs. The level of monitoring and enforcement, on the other hand, is determined by the audit probability, ϕ_1, and the penalties, ρ. With the penalties on detected food adulteration and mislabeling being, typically, set elsewhere in the legal system, this enforcement parameter is generally exogenous to policy makers (Giannakas and Fulton, 2000, 2002). The analysis focuses initially on food adulteration, with the similarities and differences between the optimal policy response to food adulteration and mislabeling discussed at the end of this section.

Government Problem

The optimal policy response of the government to food fraud can be determined through the optimization of a Bergsonian, non-equally weighted social welfare function that includes the welfare of all interest groups affected by food fraud (i.e., consumers, producers, and taxpayers). In particular, the government problem can be written as

$$\max_{cf,\phi_1} SW = k.CS + l_1.PS_h + l_2.PS_h^{ch} + l_3.PS_l + m.TS$$

$$(1) \qquad => \max_{cf,\phi_1} SW = k.CS + l_1.PS_h + l_2.PS_h^{ch} + l_3.PS_l + m.[\omega\rho n - b\rho - \phi_1\psi - PH]$$

$$\begin{aligned} => \max_{cf,\phi_1} SW = {} & k.CS(\lambda, P_h^c(cf), P_l^c, \mu(cf,\phi_1,\rho)) + l_1.PS_h(cf,\phi_0,\phi_1,\rho) \\ & + l_2.PS_h^{ch}(cf,\phi_0,\phi_1,\rho) + l_3.PS_l(cf,\phi_0,\phi_1,\rho) \\ & + m.[\omega(\phi_1)\rho n - b\rho - \phi_1(k,l,m,\psi)\psi(s,n) - PH(A_h^{ch}(cf,\phi_0,\phi_1,\rho),\varepsilon)], \end{aligned}$$

where CS, PS_h, PS_h^{ch}, PS_l, and TS is the welfare of consumers, high-quality producers, dishonest producers, low-quality producers and taxpayers, respectively. The weight placed by the government on the welfare of consumers, high-quality product producers, dishonest producers, low-quality product producers and taxpayers is k, l_1, l_2, l_3, and m, respectively, with the relationship between them capturing the political preferences of the government. The taxpayer welfare in the social welfare function is given by $TS = [\omega\rho n - b\rho - \phi_1\psi - PH]$, where the parameters ω, ρ, n, and ψ are the percentage of audited farms getting caught while committing fraud, the penalty for detected food fraud, the total number of producers, and the total cost of auditing all producers, respectively.

In this context, the term $\omega\rho n$ captures the revenue generated from the punishment of producer fraudulent behavior, while the costs of punishment, monitoring, and public health are given by the terms $b\rho$, $\phi_1\psi$, and PH, respectively.[3]

The consumer and producer welfare measures in the social welfare function are determined by Meerza, Giannakas, and Yiannaka (2019) who, as noted earlier, use a model of heterogeneous consumers and producers to analyze the market and welfare impacts of food fraud in the form of food adulteration and mislabeling. Meerza, Giannakas, and Yiannaka assume that there are two types of products in the market—high- and low-quality products—and that dishonest producers market the adulterated product as the high-quality product. They show that while food fraud reduces the welfare of all consumers (of both high- and low-quality product), it has asymmetric impacts on different producers. Based on these findings, the social welfare function in equation (1) includes the welfare of consumers (CS, which includes the welfare of both high- and low-quality product consumers) and the welfare of the three different producer groups (i.e., welfare of high-quality producers, PS_h, welfare of dishonest producers, PS_h^{ch}, and welfare of low-quality producers, PS_l). Below, we outline the consumer and producer decision models that yield the welfare estimates used in our analysis. For a detailed description of these models and derivations see Meerza, Giannakas, and Yiannaka.

Consumer Decisions and Welfare

In the presence of food adulteration, consumers have a choice to consume the product marketed as high quality (which could be a high-quality or an adulterated product), a low-quality product, or a substitute. Consumers differ in their preferences for the different products; their utility is given by

$$(2)\quad \begin{aligned} &U_h = U - P_h^c + \mu\lambda_h\alpha - (1-\mu)\varepsilon\psi \quad \text{if a unit of the product marketed as high quality is consumed,}\\ &U_l = U - P_l^c + \lambda_l\alpha \text{ if a unit of the low-quality product is consumed,}\\ &U_a = U \text{ if a unit of the substitute product is consumed,} \end{aligned}$$

where U_i is the utility associated with the unit consumption of food i ($i = h, l, a$) and P_h^c and P_l^c are the prices of the high- and low-quality products, respectively. The parameter U is the per unit base level of utility associated with the consumption of the different products. To enable the coexistence of the different products in the market, we assume that U exceeds P_h^c and P_l^c and that $P_h^c > P_l^c$. The parameters λ_h and λ_l are nonnegative utility enhancement factors associated with the consumption of high- and low-quality products, respectively; while $\alpha \in [0,1]$ captures the differences in consumer preferences for the different products. The parameter μ is the probability that the food product is high quality, which makes $(1-\mu)$ the probability that the food product is adulterated (i.e., the probability of food adulteration). The parameter ε is the probability of getting sick when consuming the adulterated product, and ψ is the total cost of receiving medical treatment, making $(1-\mu)\varepsilon\psi$ the expected cost of getting sick when consuming the adulterated product.

The uncertainty about the nature of the product marketed as high quality and the probability of getting sick due to food adulteration reduce the utility associated with the consumption of the product marketed as high quality. The reduced utility reduces the demand for product marketed as high quality and increases the demand for its low-quality counterpart. The resulting increase in the equilibrium price of the low-quality product reduces the utility associated with the consumption of this product, causing the welfare of both high- and low-quality product consumers to fall under food adulteration.

[3] The size of parameter b depends on the type of punishment, with $b > 1$ for imprisonment, torture, parole, and probation and $b \equiv 0$ for fines (Becker, 1968).

The consumer welfare in the presence of food adulteration (which captures the welfare of both high- and low-quality product consumers) is given by

$$(3) \quad CS = \frac{(\mu\lambda_h - \lambda_l)\{(\lambda_h - \lambda_l) - (P_h^c - P_l^c)\}^2 - (\lambda_h - \lambda_l)\{(\mu\lambda_h - \lambda_l) - (P_h^c - P_l^c) - (1-\mu)\varepsilon\psi\}^2}{2(\lambda_h - \lambda_l)(\mu\lambda_h - \lambda_l)}.$$

Producer Decisions and Welfare

In the presence of food adulteration, producers have a choice to produce high-quality product, adulterated product, low-quality product, or an alternative good; their net returns function is given by

$$(4) \quad \begin{aligned} NR_h &= P_h^f - w_h - \delta A \text{ if a unit of the high-quality product is produced,} \\ NR_h^{ch} &= P_h^f - \beta(w_h + \delta A) - \phi(A)\rho \text{ if a unit of the adulterated product is produced,} \\ NR_l &= P_l^f - w_l - \gamma A \text{ if a unit of the low-quality product is produced,} \\ NR_a &= 0 \text{ if a unit of an alternative product is produced,} \end{aligned}$$

where P_h^f and P_l^f are the producer price for the high- and low-quality product, respectively, and w_h and w_l are the production costs of the high- and low-quality product, respectively, which are outside producers' control. The parameters δ and γ are cost-enhancement factors associated with the production of the high- and low-quality products, respectively, and $A \in [0,1]$ captures differences in the efficiency of producers, with greater values of A corresponding to reduced producer efficiency. The reduction in the cost of production due to the adulteration activity is given by $(1-\beta)(w_h + \delta A)$, where $(w_h + \delta A)$ are the costs of producing the high-quality product for the producer with differentiating attribute A and the parameter $\beta \in [0,1]$ captures the cost savings associated with food adulteration.

The expected costs of fraudulent behavior are given by $(\phi_0 + \phi_1 A)\rho$, where ϕ_0 and ϕ_1 represent the probability that producers will be detected by third parties (e.g., media, former employees, and firms/business partners) and the audit probability, respectively, and ρ is the penalty for detected food fraud. This formulation of the detection probability function captures the idea that the more-efficient producers are (e.g., due to education, experience, management skills), the greater their ability to avoid detection of their fraudulent behavior.[4] While the detection probability decreases with the level of producer efficiency, all producers face a strictly positive detection probability since the intercept of this detection function, ϕ_0, is exogenous to producers.

Depending on the nature of the relationship between the net expected benefit of fraudulent behavior and producer efficiency, Meerza, Giannakas, and Yiannaka (2019) identify four scenarios:

1. the net expected benefit of fraudulent behavior increases with the efficiency of producers $[w_h > (\beta w_h + \phi_0\rho)$ and $\delta A < (\beta\delta + \phi_1\rho)A]$, which results in producers of high-quality product finding it optimal to be involved in fraudulent activity;

2. the net expected benefit of fraudulent behavior decreases with the efficiency of producers $[w_h < (\beta w_h + \phi_0\rho)$ and $\delta A > (\beta\delta + \phi_1\rho)A]$, which results in producers of both high- and low-quality product to become involved in food fraud;

[4] Meerza, Giannakas, and Yiannaka (2019) discuss some real-world examples that support this assumption. One of them involves a leading juice company, which, in an attempt to reduce the probability of being detected adding liquid beet sugar to its orange juice, constructed a sophisticated network of pipelines hidden in the ceiling of the factory to transfer the liquid beet sugar to the production area. Although food inspectors audited this company regularly, it was only when a disgruntled former employee provided detailed information that this fraudulent behavior was detected (Kurtzweil, 1999). The parameter ϕ_0 in our detection probability function captures such third-party monitoring. Reports by the U.S. Food and Drug Administration have also included several cases of producers developing unique ways to concoct mixtures that, when tested, resembled the chemical profile of natural products (Kurtzweil, 1999).

3. the net expected benefit of fraudulent behavior exceeds that of the high-quality product for all producers $[w_h \geq (\beta w_h + \phi_0 \rho)$ and $\delta A \geq (\beta\delta + \phi_1 \rho)A]$, which results in the exit of the high-quality product from the market; and

4. the net expected benefit of fraudulent behavior is less than that of the high- or/and the low-quality product for all producers $[w_h \leq (\beta w_h + \phi_0 \rho)$ and $\delta A \leq (\beta\delta + \phi_1 \rho)A]$, which results in the absence of adulterated product from the market.

To account for the empirically relevant coexistence of all products in the market, Meerza, Giannakas, and Yiannaka and our study focus on Scenarios 1 and 2.

Scenario 1

As mentioned previously, in the presence of food adulteration, consumers decrease their valuation of the product marketed as high quality which, in turn, reduces the demand for this product and increases the demand for its low-quality counterpart. Since, under Scenario 1, only (some) high-quality product producers find it optimal to adulterate their product and sell it as high quality, the supply curve of the product marketed as high quality is kinked as it includes supply of both the high-quality and the (less costly) adulterated product. Comparing the equilibrium quantity, consumer price, and price received by producers of the product marketed as high quality in the presence and absence of food adulteration, Meerza, Giannakas, and Yiannaka (2019) show that both equilibrium quantity and prices fall in the presence of food adulteration. In contrast, the increase in the demand for the low-quality product results in increased equilibrium quantity, consumer price, and price received by producers of the low-quality product. Under this scenario, the welfare of the different producer groups is given by

$$
(5)\qquad
\begin{aligned}
PS_h &= \frac{\begin{array}{c}[(P_h^f - P_l^f)\{(\beta\delta + \phi_1\rho) - \delta\} - (w_h - \beta w_h)\phi_1\rho + (\delta - \beta\delta)\phi_0\rho] \\ \times [\{(\beta\delta + \phi_1\rho) - \delta\}\{2(\delta - \beta\delta)(P_h^f - w_h) - \delta(P_h^f - P_l^f)\} \\ -\delta\{2(\delta - \beta\delta) - \phi_1\rho\}(w_h - \beta w_h) - \delta\phi_0\rho(\delta - \beta\delta)]\end{array}}{2(\delta - \beta\delta)^2\{(\beta\delta + \phi_1\rho) - \delta\}^2} \\
PS_h^{ch} &= \frac{\begin{array}{c}(w_h - \beta w_h - \phi_0\rho) \\ \times [\{(\beta\delta + \phi_1\rho) - \delta\}(2P_h^f - \phi_0\rho) - (\beta\delta + \phi_1\rho)(w_l + w_h) + 2\delta w_l]\end{array}}{2\{(\beta\delta + \phi_1\rho) - \delta\}^2} \\
PS_l &= \frac{\{\delta(P_l^f - \beta w_h) - \beta\delta(P_h^f - w_h)\}^2}{2\beta\delta(\delta - \beta\delta)^2}.
\end{aligned}
$$

Scenario 2

Similar to Scenario 1, the demand curve for the product marketed as high quality (low quality) falls (increases) under Scenario 2. However, since both high- and low-quality producers find it optimal to produce the adulterated product and sell it as high quality under Scenario 2, the supplies of the products marketed as high-quality and the low-quality products increase and decrease, respectively. Thus, while similar to Scenario 1, the equilibrium consumer and producer prices of the product marketed as high quality (low quality) decrease (increase) under Scenario 2, the effect of food adulteration on the equilibrium quantity is ambiguous and depends on the relative magnitude of the demand and supply effects of food adulteration. The welfare of the different producer groups under this scenario is given by

$$PS_h = \frac{(\beta w_h + \phi_0\rho - w_h)[2\{(\delta - \beta\delta) - \phi_1\rho\}(P_h^f - w_h) - \delta(\beta w_h + \phi_0\rho - w_h)]}{2\{(\delta - \beta\delta) - \phi_1\rho\}^2}$$

$$(6) \qquad PS_h^{ch} = \frac{\begin{array}{c}[(\delta - \beta\delta)(P_h^f - P_l^f - \phi_0\rho) - \phi_1\rho\{(P_h^f - w_h) - (P_l^f - \beta w_h)\}] \\ \times [2\phi_1\rho\{(\delta - \beta\delta) - \phi_1\rho\}(P_h^f - w_l - \phi_0\rho) \\ -(\beta\delta + \phi_1\rho)\{(\delta - \beta\delta - \phi_1\rho)(P_h^f - P_l^f) \\ -(\delta - \beta\delta)\phi_0\rho + 2\phi_0\phi_1\rho^2 - (w_h - \beta w_h)\phi_1\rho\}]\end{array}}{2(\phi_1\rho\{(\delta - \beta\delta) - \phi_1\rho\})^2}$$

$$PS_l = \frac{\{\phi_1\rho(P_l^f - \beta w_h) - \beta\delta(P_h^f - P_l^f - \phi_0\rho)\}^2}{2\beta\delta(\phi_1\rho)^2}.$$

Since the equilibrium price of the high-quality (low-quality) product decreases (increases) in the presence of food adulteration, the net returns associated with the production of the high-quality (low-quality) product fall (increase). Honest producers who continue to produce the high-quality product in the presence of food adulteration lose, while producers who adulterate their product and those who continue to produce the low-quality product gain. These results hold under both Scenarios 1 and 2. What changes between these scenarios is the group of producers involved in (and benefiting from) food fraud.

Optimal Government Response and Policy Impacts

Given the above, the first-order conditions for the government problem specified in equation (1) can be expressed as

$$(7) \qquad \begin{aligned} \frac{\partial W}{\partial cf} &= \overbrace{k\frac{\partial CS}{\partial P_h^c}\frac{\partial P_h^c}{\partial cf}}^{-} + \overbrace{k\frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial cf}}^{+} + \overbrace{l_1\frac{\partial PS_h}{\partial cf}}^{+} + \overbrace{l_2\frac{\partial PS_h^{ch}}{\partial cf}}^{-} + \overbrace{l_3\frac{\partial PS_l}{\partial cf}}^{-} - \overbrace{m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial cf}}^{-} = 0 \\ &=> k\frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial cf} + l_1\frac{\partial PS_h}{\partial cf} + m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial cf} = k\frac{\partial CS}{\partial P_h^c}\frac{\partial P_h^c}{\partial cf} + l_2\frac{\partial PS_h^{ch}}{\partial cf} + l_3\frac{\partial PS_l}{\partial cf}, \end{aligned}$$

$$(8) \qquad \begin{aligned} \frac{\partial W}{\partial \phi_1} &= \overbrace{k\frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial \phi_1}}^{+} + \overbrace{l_1\frac{\partial PS_h}{\partial \phi_1}}^{+} + \overbrace{l_2\frac{\partial PS_h^{ch}}{\partial \phi_1}}^{-} + \overbrace{l_2\frac{\partial PS_l}{\partial \phi_1}}^{-} - \overbrace{m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial \phi_1}}^{-} + \overbrace{m\frac{\partial \omega}{\partial \phi_1}}^{+}\rho n - \overbrace{m\psi}^{+} = 0 \\ &=> k\frac{\partial CS}{\partial \phi_1} + l_1\frac{\partial PS_h}{\partial \phi_1} + m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial \phi_1} + m\frac{\partial \omega}{\partial \phi_1}\rho n = l_2\frac{\partial PS_h^{ch}}{\partial \phi_1} + l_3\frac{\partial PS_l}{\partial \phi_1} + m\psi. \end{aligned}$$

Consistent with *a priori* expectations, equations (7) and (8) indicate that the optimal policy response to food fraud (i.e., the optimal level of certification costs and auditing) is determined by equating the marginal benefits with the marginal costs of certification costs and monitoring and enforcement. The marginal benefits of reduced food adulteration include increased welfare of consumers and honest producers and the penalties collected on detected fraudulent behavior in the case of an increased ϕ_1. In contrast, the marginal costs of food fraud deterrence include decreased welfare of dishonest and low-quality product producers and either the enforcement or the

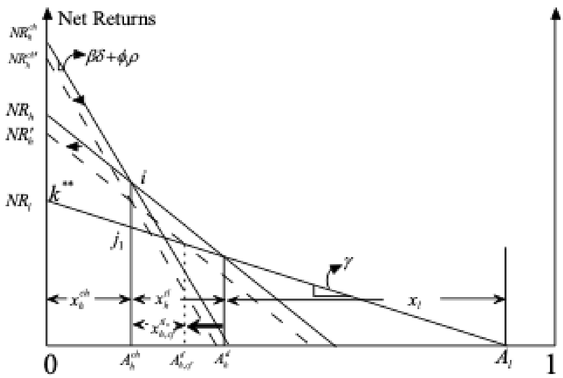

Figure 1. Effects of an Increase in the Certification Costs on Food Adulteration (Scenario 1)

certification costs. The expressions for the equilibrium cf and ϕ_1 are provided in the analysis that follows.

RESULT 1. *When more-efficient producers engage in fraudulent behavior (Scenario 1), an increase in the certification costs (i) cannot reduce food adulteration, (ii) decreases the average product quality, and (iii) decreases the supply of product marketed as high quality.*

Figure 1 shows the economic impacts of certification under food adulteration when the net expected benefits from food fraud increase with producer efficiency and more-efficient producers engage in fraudulent behavior (i.e., under Scenario 1). The figure graphs the net returns associated with the different options available to producers presented in equation (4). Producers differ in their costs of producing the different products (captured by the differentiating attribute A) and the differentiating attributes of the marginal producers (i.e., producers who are indifferent between different options) determine the shares of the producers choosing the various options (and the supplies of the different products; see Meerza, Giannakas, and Yiannaka, 2019). In this context, prior to the increase in certification costs, producers with differentiating attribute $A\varepsilon[0,A_h^{ch}]$ engage in fraudulent behavior, while producers with differentiating attribute $A\varepsilon(A_h^{ch},A_h^d]$ produce the high-quality product and producers with differentiating attribute $A\varepsilon(A_h^d,A_l]$ find it optimal to produce the low-quality product under Scenario 1.

An increase in certification costs will increase both the production cost and price of the high-quality product with the cost increase exceeding that in price.[5] Therefore, an increase in certification costs under Scenario 1 results in an inward shift of the net returns curves associated with the production of the high-quality and adulterated products (i.e., NR_h shifts to NR'_h and NR_h^{ch} shifts to $NR_h^{ch'}$). The intersection of the net returns curve associated with the production of low-quality product, NR_l, and the net returns curve associated with the production of high-quality product, NR'_h, determines the new supply of the product marketed as high quality, $A_{h,cf}^d$. Note that while the supply of the product marketed as high quality decreases after increasing the certification cost (as producers of the high-quality product with $A\varepsilon(A_{h,cf}^d,A_h^d]$ switch to the low-quality product), the supply of the adulterated product remains the same as the increased cf change the returns to food adulteration and those associated with the production of the high-quality product by the same amount. Therefore, when more-efficient producers are engaged in fraudulent behavior, an increase in the certification costs does not reduce fraudulent activities.[6] What it does reduce, instead, is the supply of the high-quality product and the average product quality in the market.

[5] Costly certification will increase the price of the high-quality product by an amount less than the increase in its cost whenever the demand and supply of this product are not completely inelastic and elastic, respectively.

[6] Note that the condition that would deter food fraud under Scenario 1 (i.e., $cf \geq P_h - P_l$) is inconsistent with the (more-efficient) high-quality product producers being involved in food adulteration, as this condition results in the producers of high-quality product being driven out of the market.

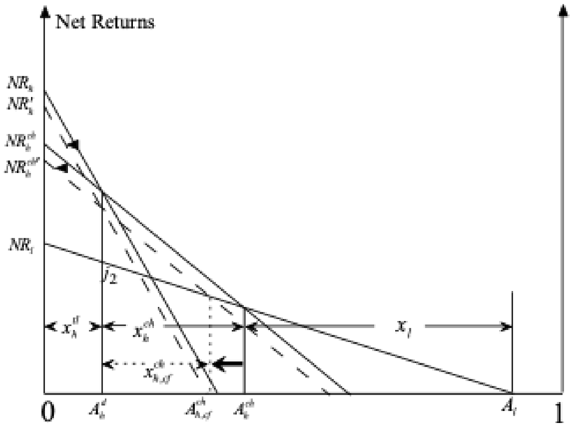

Figure 2. Effects of an Increase in the Certification Costs on Food Adulteration (Scenario 2) When the Supply Effect Dominates the Demand Effect of Food Adulteration

RESULT 2. *When less-efficient producers engage in fraudulent behavior (Scenario 2), an increase in the certification costs (i) reduces food adulteration, (ii) increases the average product quality, and (iii) decreases the supply of product marketed as high quality.*

As noted earlier, when the net expected benefit of fraudulent behavior decreases with the efficiency of producers (Scenario 2), the total supply of product marketed as high quality increases (supply effect of food adulteration) and the demand for high-quality product decreases (demand effect of food adulteration). Figure 2 shows the effects of an increase in certification costs under Scenario 2 when the supply effect dominates the demand effect of food adulteration. In this context, as in Scenario 1, an increase in the certification costs by cf results in an inward shift of the net returns curves associated with the production of high-quality and adulterated products and reduced supply of the product marketed as high quality. Unlike in Scenario 1, however, the supply of adulterated product decreases by $A_h^{ch} - A_{h,cf}^{ch}$ after the increase in cf, while the supply of high-quality product remains the same, improving the average product quality in the market. When the increase in the certification costs is such that the net returns curves associated with the production of low-quality and adulterated products intersect at the point j_2 in Figure 2, no producer will find it optimal to adulterate their product. The increase in the certification costs that completely deters food adulteration is given by

$$(9) \qquad cf^* = \frac{\{\delta - (\beta\delta + \phi_1\rho)\}\{(P_h - w_h) - (P_l - w_l)\} - (\delta - \gamma)\{(\beta w_h + \phi_0\rho) - w_h\}}{\{\delta - (\beta\delta + \phi_1\rho)\}}.$$

It is important to note that, while an increase in the certification costs under Scenario 2 reduces food adulteration and improves the average product quality in the market, an increase in the certification costs over cf^* results in diminishing average product quality in the market, as, in such a case, producers of the high-quality product find it optimal to switch to the lower-quality counterpart. Before concluding this part, it is also important to note that the qualitative nature of the results is the same when the demand effect dominates the supply effect of food adulteration under Scenario 2. What changes is the increase in the certification costs that completely deters food adulteration, which, when the demand effect dominates the supply effect, is given by

$$(10) \qquad cf^{**} = \frac{\{(\beta\delta + \phi_1\rho) - \delta\}\{(P_h - w_h) - (P_l - w_l)\} - (\delta - \gamma)(w_h - \beta w_h - \phi_0\rho)}{\{(\beta\delta + \phi_1\rho) - \delta\}}.$$

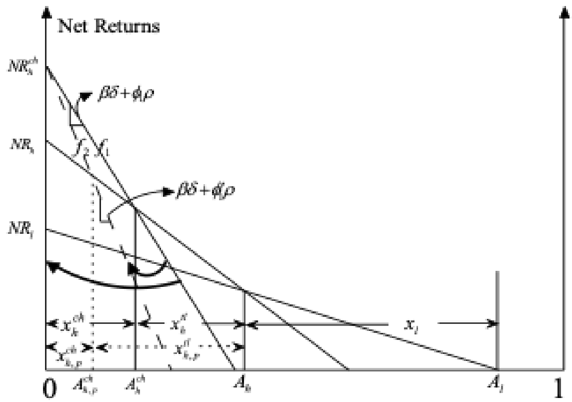

Figure 3. Effects of Monitoring and Enforcement When More-Efficient Producers Commit Fraud (Scenario 1)

RESULT 3. *When the government wants to deter food fraud (which is the optimal policy for a government placing high weight on the welfare of consumers and/or welfare of honest high-quality producers), the optimal policy design depends on the efficiency of dishonest producers and the relative costs of the fraud-combating mechanisms.*

Figure 3 shows the effects of monitoring and enforcement when more-efficient producers are engaged in fraudulent behavior (Scenario 1). The slope of the net returns curve associated with the production of adulterated product (i.e., the NR_h^{ch} curve) is $\beta\delta + \phi_1\rho$. When the government increases the audit probability, ϕ_1, the slope of NR_h^{ch} increases which, in turn, reduces the net expected benefit of fraudulent behavior. Therefore, when more-efficient producers are engaged in fraudulent behavior, increased monitoring decreases the number of dishonest producers and improves the average product quality in the market.

It is important to note that food fraud can be completely deterred under Scenario 1 when the slope of the net returns curve associated with the production of adulterated product becomes infinite (which occurs when $\phi_1\rho = \infty$). With the audit probability, ϕ_1, taking values between 0 and 1, the only way to completely deter food fraud under Scenario 1 is by enforcing severe punishment of food fraud. Specifically, the optimal policy choice is to establish a small probability of harsh punishment for fraudulent behavior in the agrifood marketing system (i.e., set $(\phi_1\rho)_d^* = \infty$ in such way that $\lim_{\rho\to\infty}(\phi_1 = 0)$).

Severe punishment is not necessary to completely deter food fraud under Scenario 2, however. Figure 4 shows the effects of monitoring and enforcement under Scenario 2 when the supply effect dominates the demand effect of food adulteration. As mentioned earlier, under this scenario, it is less-efficient producers that are involved in food fraud. In Figure 4, the curve NR_h^{ch} represents the (expected) net returns associated with the production of adulterated product. As in Scenario 1, an increase in the audit probability ϕ_1 increases the slope of NR_h^{ch} (making it steeper), resulting in a reduction in the net expected benefit of fraudulent behavior. In this case, the government can completely deter food fraud by increasing the audit probability ϕ_1 in such a way that the NR_h^{ch} curve intersects point k^*, resulting in no incentives for fraudulent behavior for all producers (as the NR_h^{ch} curve lies underneath those associated with the alternative options for all A). The value of ϕ_1 that deters food fraud is

$$(11) \qquad \phi_1^* = \frac{(\delta-\gamma)(P_h - \beta w_h - \phi_0\rho) - \beta\delta\{(P_h - w_h) - (P_l - w_l)\} - \{\delta(P_l - w_l) - \gamma(P_h - w_h)\}}{\{(P_h - w_h) - (P_l - w_l)\}\rho}.$$

Therefore, similar to the increase in certification costs, monitoring and enforcement can completely deter food fraud when less-efficient producers are engaged in fraudulent behavior.

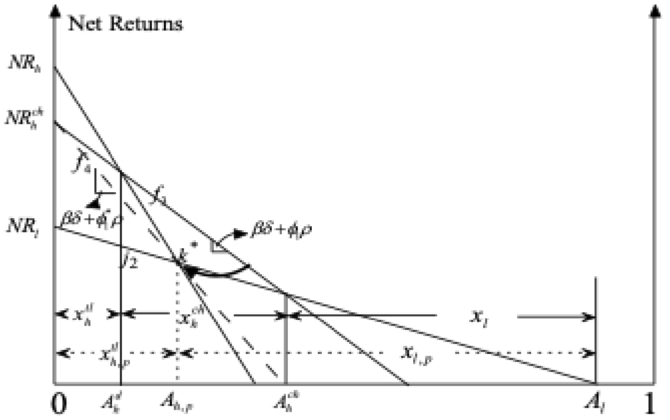

Figure 4. Effects of Monitoring and Enforcement under Scenario 2 When the Supply Effect Dominates the Demand Effect of Food Adulteration

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COROLLARY 1. *The optimal policy response to deter food fraud depends on the efficiency of dishonest producers. When it is more-efficient producers that are more likely to commit fraud, the only way to completely deter fraudulent behavior is through a strict monitoring and enforcement system. In contrast, when less-efficient producers are engaged in fraudulent behavior, both mechanisms (i.e., increased certification costs and monitoring and enforcement) can effectively deter food fraud.*

Results 1, 2, and 3 reveal that the optimal regulatory response to combat food fraud depends on the efficiency of dishonest producers. While a strict monitoring and enforcement system reduces the net expected benefits of fraudulent behavior regardless of the relative efficiency of different producer groups, the effectiveness of an increase in the certification costs in deterring food fraud depends on the efficiency of dishonest producers. Specifically, while an increase in the certification costs can deter food fraud when less-efficient producers are engaged in fraudulent behavior, it cannot reduce food fraud when it is more-efficient producers that are engaged in fraudulent behavior. Therefore, when more-efficient producers commit fraud, the optimal policy response is the monitoring and enforcement system. In contrast, both an increase in certification costs and the monitoring and enforcement system can deter food fraud when less-efficient producers are engaged in fraudulent behavior, with the relative desirability of the two approaches determined by their relative costs and efficiency ranking.

RESULT 4. *When the government wants to increase the average product quality in the market while combating food adulteration, strict monitoring and enforcement is more effective than increased certification costs.*

While both monitoring and enforcement and an increase in certification costs reduce the net expected benefit of fraudulent behavior, the latter increases also the production cost of the high-quality product. Therefore, while monitoring and enforcement always increase the average product quality, the effect of increased certification costs on the average product quality depends on the efficiency of dishonest producers.

When the more-efficient producers engage in fraudulent behavior (Scenario 1), an increase in certification costs reduces the average product quality. For example, increasing certification costs by cf raises the production cost of high-quality food, and honest producers with differentiating attribute $A\varepsilon(A_{h,cf}^d, A_h^d)$ find it optimal to switch their production from the high-quality to the low-quality product. Therefore, increasing the certification costs by cf reduces the total supply of high-quality product by $A_h^d - A_{h,cf}^d$, which (with the total supply of adulterated product remaining the same), results in lower average product quality in the market (see Figure 1).

On the other hand, under Scenario 1, monitoring and enforcement reduces fraudulent behavior while increasing the average product quality in the market. For instance, an increase in the audit probability from ϕ_1 to $\phi_1^{'}$ shifts the net returns function associated with the production of adulterated product from f_1 to f_2, decreasing the extend of food adulteration. Consequently, the total supply of high-quality product increases by $A_h^{ch} - A_{h,p}^{ch}$ (see Figure 3), improving average product quality. Therefore, when the government wants to increase the average product quality in the market while combating food adulteration under Scenario 1, monitoring and enforcement is the only way to do so.

When less-efficient producers engage in fraudulent behavior (Scenario 2), an increase in certification costs increases the average product quality in the market. For instance, when the supply effect dominates the demand effect of food adulteration under Scenario 2, an increase in certification costs by cf reduces the total supply of adulterated product, improving the average product quality in the market. Food adulteration can be completely deterred when the increase in certification costs is such that the net returns curves associated with the production of low-quality and adulterated food intersect at point j_2 in Figure 2. In such a case, while the total supply of high-quality food remains the same (i.e., A_h^d), the total supply of low-quality food increases by $A_h^{ch} - A_h^d$ and total supply of adulterated product falls to 0 (see Figure 2).

When the government increases the audit probability to combat food adulteration, the average product quality also increases. Specifically, when the supply effect dominates the demand effect of food adulteration under Scenario 2, fraudulent activities can be completely deterred by increasing the audit probability in such a way that $\phi_1 = \phi_1^*$ in equation (11). Increasing the audit probability to ϕ_1^* results in either 0 or negative net expected benefit of fraudulent behavior regardless of the efficiency of producers and increases the total supply of high- and low-quality products by $A_{h,p} - A_h^d$ and $A_h^{ch} - A_{h,p}$ in Figure 4, respectively. Compared to the case of increased certification costs, the analysis reveals that, while fraudulent activities can be completely deterred by increasing either certification costs or producer monitoring under Scenario 2, the latter increases the average product quality more since it increases the total supply of high-quality product by $A_{h,p} - A_h^d$ more than the former. Therefore, monitoring and enforcement is the optimal choice when the government wants to increase the average product quality in the market while combating food adulteration.

RESULT 5. *The purity of labeling can be improved through an increase in either certification costs and/or monitoring and enforcement when less-efficient producers engage in fraudulent behavior. However, when more-efficient producers engage in fraudulent behavior, an increase in certification costs decreases the purity of labeling.*

According to Hamilton and Zilberman (2006), the purity of labeling can be defined as the ratio of the quantity of the high-quality product over the total quantity of the product marketed as high quality:

$$p = \frac{x_h^t}{x_h^t + x_h^{ch}}, \tag{12}$$

where p is the level of purity taking values between 0 and 1 and x_h^t and x_h^{ch} are the equilibrium quantities of high-quality product and adulterated product, respectively.

When more-efficient producers engage in fraudulent behavior (Scenario 1), an increase in certification costs does not reduce fraudulent behavior but rather decreases the purity of labeling. Specifically, as noted earlier, when certification costs increase by cf, producers with differentiating attribute $A\varepsilon(A_{h,cf}, A_h]$ switch from producing high-quality product to producting low-quality product, while all dishonest producers (i.e., producers with differentiating attribute $A\varepsilon[0, A_h^{ch}]$) continue to adulterate their product (see Figure 1). Therefore, an increase in certification costs under

Scenario 1 decreases the purity of labeling by

$$(13)\quad \Delta p_{cf} = p_{cf} - p_1 = \frac{-\overbrace{(w_h - \beta w_h - \phi_0\rho)(\delta-\gamma)cf}^{+}}{\underbrace{\{(\beta\delta+\phi_1\rho)-\delta\}}_{+}\underbrace{\{(P_h^f - P_l^f)-(w_h-w_l)-cf\}}_{+}\underbrace{\{(P_{h,cf}^f - P_{l,cf}^f)-(w_h-w_l)-cf\}}_{+}} < 0,$$

where p_1 and p_{cf} represent the level of purity in the market before and after increasing certification costs under Scenario 1, respectively. As shown previously, monitoring and enforcement reduce fraudulent behavior under Scenario 1, which, in turn, increases the purity of labeling (see Figure 3). Specifically, when the government increases the audit probability from ϕ_1 to $\phi_1^{'}$, the purity of labeling increases by

$$(14)\qquad \Delta p_{mp} = p_{mp} - p_2 => \Delta p_{mp} = \overbrace{\rho(\delta-\gamma)}^{+}\ \overbrace{(\phi_1^{'}-\phi_1)}^{+} > 0,$$

where p_2 and p_{mp} represent the purity of labeling under audit probability ϕ_1 and $\phi_1^{'}$, respectively.

When less-efficient producers engage in fraudulent behavior (Scenario 2), both an increase in certification costs and monitoring and enforcement increase the purity of labeling. Maximum levels of purity can be achieved either by increasing certification costs by cf^* in equation (9) or by increasing the audit probability to ϕ_1^* in equation (11).

COROLLARY 2. *When the government's goal is to increase the average product quality while combating food fraud, the optimal policy is strict monitoring and enforcement.*

Results 4 and 5 determine the effects of an increase in certification requirements and the level of monitoring and enforcement on the average product quality and the purity of labeling. As shown in Table 1, when more-efficient producers engage in fraudulent behavior, an increase in certification costs reduces the purity of labeling, while an increase in the level of monitoring and enforcement improves the purity of labeling which, in turn, raises the average product quality. In contrast, when less-efficient producers engage in fraudulent behavior, both an increase in certification costs and the level of monitoring and enforcement improve the purity of labeling. As mentioned earlier, maximum levels of purity can be achieved either by increasing certification costs to cf^* or by increasing the audit probability to ϕ_1^*. However, the market share of high-quality products decreases with a rise in the certification costs while it increases with the level of monitoring and enforcement. Consequently, comparing the increase in average product quality with a rise in certification costs to cf^* and the level of monitoring and enforcement to ϕ_1^* reveals that monitoring and enforcement increases the average product quality more than the certification costs. Thus, when the government aims at increasing average product quality in the market while combating food fraud, the optimal policy is the strict fraud-deterring monitoring and enforcement.

Special Case: Mislabeling

Unlike the case of food adulteration, the probability of getting sick when consumers buy a mislabeled product is assumed to be 0 (as low quality, but safe, products are mislabeled as being of high quality in the case of mislabeling).[7] Equating the term *PH* to 0 in equation (1), gives the government's problem in the presence of mislabeling.[8]

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[7] Since producers sell the low-quality product as high quality in the presence of mislabeling, the producer net return function of mislabeling is $NR_{h,m}^{ch} = P_h^f - (w_l + \gamma A) - \phi(A)\rho$.

[8] In this context, we can get the first order conditions by substituting $m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial cf} = 0$ and $m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial \phi_1} = 0$ in equations (7) and (8), respectively.

Table 1. Policy Impacts of Different Regulatory Instruments under Scenarios 1 and 2

Policy Instruments under Different Scenarios	**Purity of Labeling** $p = \frac{x_h^t}{x_h^t + x_h^{ch}}$		**Average Product Quality** $APQ = \frac{x_h^t}{x_h + x_l} q_h + \frac{x_h^{ch}}{x_h + x_l} q_{ch} + \frac{x_l}{x_h + x_l} q_l$; $q_h > q_l > q_{ch}$	
Policy type	Certification (CF)	Monitoring and enforcement (ME)	Certification (CF)	Monitoring and enforcement (ME)
Scenario 1	↓	↑	↓	↑
	$P_{CF,\,1} < P_{ME,\,1}$		$APQ_{CF,1} < APQ_{ME,1}$	
Scenario 2	↑	↑	↑	↑
	$P_{CF,\,2} = P_{ME,2}$		$APQ_{CF,\,2} < APQ_{ME,2}$	

RESULT 6. *When the monitoring and enforcement costs are the same under food adulteration and mislabeling, the optimal level of monitoring and enforcement is greater under food adulteration than under mislabeling.*

Comparing the marginal social benefits of monitoring and enforcement under mislabeling, MSB_m, and food adulteration, MSB_d, reveals that the marginal social benefit of an increase in monitoring and enforcement is higher under food adulteration than under mislabeling:[9]

$$MSB_d = \left(k\frac{\partial CS}{\partial \phi_1} + l_1 \frac{\partial PS_h}{\partial \phi_1} + m\frac{\partial PH}{\partial A_h^{ch}} \frac{\partial A_h^{ch}}{\partial \phi_1} + m\frac{\partial \omega}{\partial \phi_1} \rho n \right) > MSB_m$$

(15)

$$= \left(k\frac{\partial CS}{\partial \phi_1} + l_1 \frac{\partial PS_h}{\partial \phi_1} + m\frac{\partial \omega}{\partial \phi_1} \rho n \right).$$

This occurs because food adulteration results in increased costs to society (relative to mislabeling), making the marginal social benefits of fraud deterrence (due to an increase in monitoring and enforcement) greater under food adulteration. Consequently, when the monitoring and enforcement costs are the same under both types of food fraud, greater marginal social benefits of fraud deterrence under food adulteration result in higher optimal levels of monitoring and enforcement under food adulteration (compared to mislabeling). This result is consistent with observed government behavior in countries severely affected by food fraud, such as China, India, Bangladesh, and Taiwan. In these countries, the maximum penalty for food adulteration (which is injurious to health) is significantly higher than that for the case of mislabeling (Danovich, 2015; BBC News, 2014; Bangladesh Ministry of Law, Justice and Parliamentary Affairs, 1974).[10]

COROLLARY 3. *The optimal policy response to fraudulent behavior depends on the type of food fraud.*

Result 6 shows that the marginal social benefits of an increase in monitoring and enforcement are greater under food adulteration than under mislabeling. Therefore, when monitoring and enforcement costs are the same under both types of food fraud, the optimum level of monitoring and enforcement is greater under food adulteration. Similarly, when certification costs are the same under both types of food fraud, it follows that the optimal level of certification requirements is greater under food adulteration than under mislabeling. Thus, the optimal policy response to fraudulent activities depends on the type of food fraud.

[9] Similarly, the marginal social benefits of an increase in certification costs under food adulteration (i.e., $MSB_{d,certi} = k\frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial cf} + l_1\frac{\partial PS_h}{\partial cf} + m\frac{\partial PH}{\partial A_h^{ch}}\frac{\partial A_h^{ch}}{\partial cf}$) are higher than under mislabeling (i.e., $MB_{m,\,certi} = k\frac{\partial CS}{\partial \mu}\frac{\partial \mu}{\partial cf} + l_1\frac{\partial PS_h}{\partial cf}$).

[10] For example, in India, while the maximum penalty for food adulteration ranges from 6 years of imprisonment to life imprisonment, the maximum penalty for mislabeling is 3 years of imprisonment. In China, the maximum penalty for food adulteration is the death penalty, while the penalty for mislabeling ranges from paying a fine to imprisonment.

Public-Sector Corruption

The previous analysis and results are based on the assumption that there is no corruption in the public sector (i.e., when producers are caught mislabeling or adulterating their product, they face the relevant penalty). However, recent food fraud scandals indicate the existence of corruption in the public sector. For example, in 2017, the Brazilian federal police found that government food safety inspectors allowed rotten meat products to be sold in both domestic and international markets in exchange for bribes. They also identified that these bribes often channeled to political parties, indicating both political and bureaucratic corruption (Romero, 2017). Political corruption takes place when policy makers use their political power to sustain their status, power, and wealth (Amundsen, 2019). Bureaucratic corruption is defined as corruption in public administration, where public officials allow private agents privileges that they are not legally entitled to in return for a payment (Rose-Ackerman, 1999). A key distinction between political and bureaucratic corruption is that the former occurs at the stage of policy design, while the latter occurs at the stage of policy implementation. Consistent with real-world examples, we consider the case of a corrupt public sector in which corruption can be either political or bureaucratic.

RESULT 7. *When the weight the government places on the welfare of dishonest producers, l_2, is such that the marginal costs of enforcement exceed the marginal benefits, the optimal government choice is to not combat food fraud. The presence of high-quality product in the market depends, then, on whether penalties are endogenous or exogenous to policy makers.*

When policy makers are corrupt, dishonest producers can influence government policy through lobbying, resulting in laws and regulations being systematically abused, ignored, or tailored to maximize the welfare of dishonest producers. In the context of our model, this would result in the corrupt policy makers placing a relatively high weight on the welfare of dishonest producers. In such a case, the costs of enforcement can exceed the benefits resulting in complete allowance of fraudulent behavior. When the penalties are endogenous to corrupt policy makers, the government can allow fraudulent behavior by setting $c = \phi_1 = \rho = 0$ (i.e., no enforcement). In this case, all product marketed as high quality is actually adulterated/mislabeled product. Consumers will not pay the premium for the product marketed as high quality and, at equilibrium, only the low-quality product is supplied to the market. When the penalties on detected food fraud are set elsewhere in the legal system (i.e., are exogenous to policy makers), the only way the government can allow fraudulent behavior is by setting $c = \phi_1 = 0$. While the government does not spend resources to detect fraudulent behavior in this case, the probability that dishonest producers will be detected by third parties is still positive (i.e., $\phi_0 > 0$). As a result, the product marketed as high quality includes both high-quality and adulterated/mislabeled products.[11]

RESULT 8. *When the government increases the audit probability to combat food fraud without reducing bureaucratic corruption in the public enforcement agency, the incentive for collusion between dishonest producers and corrupt enforcers increases.*

Consider now the situation in which public law enforcement agents may accept payment from producers so that they do not report their detected fraudulent behavior. Incorporating the possibility of corruption in the enforcement agency changes the net returns associated with the production of adulterated/mislabeled product. In particular, the producer net returns associated with the production of adulterated/mislabeled product in the presence of bureaucratic corruption become

(16) $$NR^{ch}_{h,br} = P^{f}_{h,br} - \beta(w_h + \delta A) - (\phi_0 + \phi_1 A)B,$$

[11] When consumers know that the corrupt government allows fraudulent behavior and the penalty is exogenous to the government, consumers' perceptions about food fraud depend on the role of the media as a watchdog. If consumers believe that the media is actively involved in detecting food fraud, the demand for high-quality product can remain positive.

where B is the cost of the bribe to the producer. While dishonest producers are willing to pay a bribe when B is less than the penalty for detected fraudulent behavior, ρ, in the absence of control of corruption the corrupt policy enforcers are willing to accept the bribe whenever their net expected gains from corruption are positive. The necessary condition for collusion between dishonest producers and corrupt policy enforcers, $0 < B < \rho$, also results in increased food fraud as the expected costs of fraudulent behavior are reduced when bribery of policy enforcers is possible (i.e., $(\phi_0 + \phi_1 A)B < (\phi_0 + \phi_1 A)\rho$).

It is important to note that when the government increases the audit probability, ϕ_1, to combat food fraud without controlling corruption in the enforcement agency, it also increases the difference in the expected penalty under food adulteration with and without bribery and, through this, it increases the incentive for collusion between dishonest producers and corrupt policy enforcers. The difference between the expected penalty of food adulteration with and without bribery also increases with an increase in the penalty for fraudulent behavior, ρ. Thus, in the presence of bureaucratic corruption, an increase in the level of monitoring and enforcement results in increased incentives for collusion between dishonest producers and corrupt policy enforcers.

Conclusions

Despite the increased relevance of food adulteration and mislabeling, an economic analysis of the optimal policy response to food adulteration has not been considered previously. This study develops a theoretical model to determine the optimal regulatory response to food adulteration and mislabeling, identify the fraud-combating policy impact, and investigate the effectiveness of fraud-deterring policies in the presence of public-sector corruption. In addition to analyzing the optimal regulatory response to food adulteration, key differentiating attributes of our approach (and contributions of this study) are that it explicitly accounts for the asymmetric impacts of food fraud, endogeneity in producer quality choices, and asymmetries in the probability of detecting food fraud when considering the optimal policy of the government.

The analysis shows that the optimal policy response depends on the efficiency of dishonest producers, the type of food fraud, the political objectives of the government, and the relative costs of different fraud-combating mechanisms. For instance, when it is the more-efficient producers of the high-quality product that are more likely to commit fraud, the only way to completely deter fraudulent behavior is through a strict monitoring and enforcement system. In contrast, when the less-efficient producers are engaged in fraudulent behavior, both mechanisms (i.e., increased certification costs and monitoring and enforcement) can effectively deter food fraud, with their efficiency ranking (and desirability) determined by the relative costs involved. When the costs of fraud-combating mechanisms are the same under food adulteration and mislabeling, the optimal policy response is stronger under food adulteration than under mislabeling.

In addition to capturing the asymmetric effects of food fraud, the explicit consideration of agent heterogeneity and endogenous producer quality choices enables the identification of a critical link between the efficiency of dishonest producers and the policy impact on the purity of labeling and the average product quality in the market. When the government wants to increase the average product quality in the market while combating food adulteration, strict monitoring and enforcement is more effective than increased certification costs because—while monitoring and enforcement always increase the average product quality—the effect of increased certification costs depends on the efficiency of dishonest producers; when it is the more-efficient producers that engage in fraudulent behavior, an increase in certification costs results in reduced (rather than increased) average product quality in the market. Regarding the purity of labeling, it can be improved through an increase in either certification costs or monitoring and enforcement when less-efficient producers engage in fraudulent behavior. However, when more-efficient producers engage in fraudulent behavior, an increase in certification costs decreases the purity of labeling.

Finally, incorporating public-sector corruption (in the form of both political and bureaucratic corruption) in this study is critical for understanding the role of a corrupt public sector in food fraud. By reducing the expected costs associated with fraudulent behavior, corruption of the enforcement agency provides increased incentives for food adulteration and mislabeling. When enforcement agency officials engage in bribery, increasing monitoring and enforcement results in increased (rather than reduced) incentives for collusion between dishonest producers and corrupt policy enforcers. This finding is important, as many developing and developed countries are plagued by corruption.

In addition to providing insights on the determinants of the optimal policy response to food fraud, the results of this study can help explain differences in the type and degree of efforts to combat food fraud observed in different countries. The analysis can also provide a theoretical grounding to empirical studies on the impact of policy choices on producers' decision to engage in food adulteration and mislabeling.

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