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Consumers' Response to Food Fraud: Evidence from Experimental Auctions

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This study uses a laboratory valuation experiment to examine whether food fraud occurring in one country affects the valuation of products from that country as well as products from other countries. We use a between-subject experiment design to compare consumers' valuation of extra virgin olive oil (EVOO) from different countries with and without exposure to information about olive oil fraud occurring in one of the countries. Results show that information about olive oil fraud in one country negatively affects the valuation of EVOO not only from that country but also from other countries, indicating negative spillover effects of food fraud.

Key words: spillover effect, willingness to pay

Introduction

Over the last decade, food fraud scandals—such as the adulteration of Chinese milk with melamine, the discovery of horsemeat in many European meat products, and the mislabeling of Italian olive oils—have highlighted the vulnerability of the food system to intentional adulteration or misrepresentation of goods based on economic motives (Premanandh, 2013; Elliot, 2014; Lotta and Bogue, 2015). Food fraud is defined as an act of intentional misrepresentation, substitution, addition, or tampering of food products for economic gains at any stage of the food supply chain (Spink and Moyer, 2011). Food fraud is enabled by informational asymmetries between consumers and producers and by imperfect enforcement of laws regulating food production and labeling in markets for credence food products.

Food fraud causes welfare losses for consumers, which may simply be financial—paying for a mislabeled product—but can also include damages to their health in the event that foods have been adulterated with harmful substances. Incidents of food fraud may also reduce consumers' trust in labeling, which, in turn, creates financial and reputational damages to firms and the food industry as a whole (Giannakas, 2002; UK National Food Crime Unit, 2016). In fact, financial losses in the agri-food industry due to food fraud are felt at every stage of the supply chain, from farmers to retailers (UK National Food Crime Unit, 2016).

Confirmed cases of food fraud have markedly increased in recent years. According to the United States Pharmacopeial Convention, which monitors food fraud, 61% as many incidents of food adulteration were confirmed in the 2 years from 2011 to 2012 (792 recorded food fraud incidents) as had been identified in the 3 decades between 1980 and 2010 (1,305 recorded food fraud incidents), while media coverage of incidents increased by nearly 79%, from 251 (1980–2010) to 449 (1980–2012) media articles (Johnson, 2014). In the United Kingdom, confirmed food fraud incidents were 67% higher in 2012 compared to 2009 (Avery, 2014). In 2016, Operation Opson V, the largest food fraud investigation launched by Interpol and Europol to date, took place in 57 countries, resulting

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in the seizure of 1.44 million liters of mislabeled and adulterated beverages and 5.5 million units of mislabeled and adulterated food products (Europol, 2016).

According to Johnson (2014), olive oil is one of the food categories most vulnerable to food fraud. Most olive oil fraud cases involve the substitution or adulteration of extra virgin olive oil (EVOO) with less expensive or lower quality alternatives. Olive oil is differentiated by geographical region, olive type, and chemical and sensory characteristics (Gustafson and Lybbert, 2009)—attributes that include both experience goods and credence goods (Darby and Karni, 1973), creating informational asymmetries between producers and consumers. The wide range of prices at which olive oil is sold and costliness of monitoring the veracity of label claims provides an incentive to mislabel or adulterate EVOO with lower quality olive oils or cheap seed oils (Cercaci, Rodriguezestrada, and Lercker, 2003).

A number of recent investigations have identified mislabeling in widely sold EVOOs. Scientists from the University of California, Davis, Olive Center tested 186 samples of EVOO sold in California and found that 73% of the samples drawn from the top five imported EVOO brands (four of which were Italian brands) in the United States were either mislabeled or adulterated (Frankel et al., 2011). While the top-selling premium Californian and Australian brands met the EVOO standards, approximately 11% of top-selling premium Italian EVOO brand samples failed to meet these standards. There have been allegations in Italy that rules and regulations regarding olive oil standards are frequently ignored (Kirchgaessner, 2015). In 2012, Italian law enforcement authorities found that the largest Italian olive oil producer had mislabeled less expensive imported olive oil as domestic, high-quality EVOO. Some producers have been found to use chemicals to cover up sensory defects in lower quality olive oils (Kirchgaessner, 2015). In 2015, Italian anti-fraud authorities investigated top Italian olive oil companies for mislabeling, finding that 9 of the 12 top-selling brands mislabeled low-quality olive oil as EVOO (Squires, 2015). During an anti-food fraud investigation from November 2015 to February 2016, cooking oil—and EVOO in particular—was one of the largest categories of products seized, with the National Forestry Police of Italy seizing 7,000 tons of olive oil that had been fraudulently labeled as EVOO (Europol, 2016).

The spate of food fraud incidents over the last decade raises important questions about the impact of food fraud incidents on consumers' wellbeing and behavior. However, there is very little evidence thus far on the effects of food fraud on consumers and consumer behavior. A recent study in the Netherlands surveyed consumers about their attitudes toward food fraud in response to increasing concerns about food authenticity and safety (Polderman et al., 2016). Results reveal a mismatch between consumers' perceptions about the frequency of food fraud in different food categories and findings from tests of product mislabeling. For example, the survey found that consumers are suspicious about meat, but mislabeling is more common among milk products, dried herbs, and honey in the Netherlands.

A second study examined Chinese consumers' perceptions of and attitudes toward food fraud incidents (Kendall et al., 2019). They found that consumers develop a set of risk-reducing consumption strategies in the presence of food fraud to minimize their exposure to adulterated food products, which include pre- and post-consumption risk-reducing strategies such as additional information search and use of authenticity cues. Broadening this line of research, El Benni et al. (2019) studied the effectiveness of authenticity cues in providing assurance of food safety and authenticity to Chinese consumers. Results reveal that consumers consider authenticity cues (such as price, origin, hologram stickers, security packaging, and QR codes) as indicators of food safety and quality.

Agnoli et al. (2016) used online survey data from six European countries (France, Germany, Italy, Norway, the Republic of Ireland, and Spain) to examine consumers' hypothetical choices among selected ready-to-eat meals, all of which contained meat, after the 2012 European horsemeat scandal. They found that while European consumers are highly concerned about the safety and authenticity of meat in ready-to-eat meals, consumers' WTP for food safety standards varies across countries. An important limitation of this study is that data were collected only after the 2012

European horsemeat scandal. Therefore, there are no data from before the scandal to examine how consumers' valuation changed upon exposure to information about the 2012 European horsemeat scandal.

An important potential outcome of increasing incidents of—or attention to—food fraud is that consumers may begin to avoid implicated products in general, beyond simply the products identified as fraudulent. Although in a different context—a food safety incident—a recent study by Toledo and Villas-Boas (2019), which used a scanner dataset from a national grocery chain, examined changes in consumers' egg purchasing behavior after the largest voluntary egg recalls in U.S. history during a 2010 salmonella outbreak.[1] While the boxes of contaminated eggs were traced and removed from Northern California stores, they found that total egg sales decreased by 7%–9% in these stores following the recalls. Intriguingly, sales of speciality eggs (i.e., organic, brown, cage-free, and nutrient enhanced) in Northern California stores, which had not been implicated in the food safety event, also decreased by 6%. Moreover, they found that total egg sales in Southern California stores experienced a drop around half as large as the decrease in Northern California despite the fact that there were no contaminated eggs in these stores and traceablity information was available to consumers, indicating that negative spillover effects occurred following a voluntary food recall. Li et al. (2017) used pre- and post-recall valuation experiments to examine the responses of consumers in the Mid-Atlantic region of the United States to the same salmonella outbreak studied in the Toledo and Villas-Boas (2019) article. While the authors found no aggregate effects of the outbreak on consumer valuation—perhaps due to the study site being outside of the area affected by the recall—the authors did find significant decreases in valuation among consumers who had previously been affected by a food safety event.

The results of Giannakas (2002); Meerza, Giannakas, and Yiannaka (2019); and Toledo and Villas-Boas (2019) raise interesting questions about how food fraud information attributable to one source—which could be a country, a region, an industry, a firm or a brand—affects consumers' valuations for products from that and other sources. However, there remain significant gaps in the empirical evidence needed to understand the effects of food fraud on consumer behavior. Given the unpredictable nature of food fraud incidents, obtaining real-world data to examine the causal effects of food fraud on consumer valuation is likely to be an on-going challenge.

Experiments offer a toolkit well-suited to overcoming the lack of real-world observations, allowing researchers to collect fine-grained data on changes in consumer valuation of products in response to information about food fraud (Lusk and Shogren, 2007). Experiments also provide an opportunity to inform future theoretical work: While the theory predicts how consumers will respond to negative information about products implicated in the food fraud scandal, it is not obvious theoretically how consumers will interpret that information with respect to related products for which no evidence of fraud has been established. Experiments allow researchers to directly elicit data that can guide theory.

In our study, we examine the effect of information about food fraud on consumer valuation. We study how information about food fraud occurring in one country affects consumer willingness to pay (WTP) for products from the country implicated in the food fraud scandal as well as for products from other countries that were not implicated in the scandal. Results show that information about food fraud in one country negatively affects the valuation of EVOO from that country, but also—though to a lesser extent—from other countries, indicating that consumers' response to fraudulent behavior in one country can negatively spill over to other countries.

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[1] In 2010, two major egg producers in the United States voluntarily recalled more than 500 million eggs due to a salmonella outbreak. These contaminated eggs were distributed in at least 14 states in the United States. Both producers recalled their products using specific plant numbers and codes. Therefore, they were able to trace the contaminated eggs to the box level, leaving no contaminated eggs in the market.

Experimental Design and Procedure

To examine the effect of food fraud on consumer valuation, we conducted a between-subject laboratory experiment based on the demand-revealing Becker–DeGroot–Marschak (1964), or BDM, mechanism. In the BDM mechanism, research participants are presented with one or more goods and submit bids representing the most money the participant would be willing to pay for each good. Then, an "experiment" price is randomly drawn from a distribution of prices. If the participant's bid is higher than the randomly drawn—and therefore exogenous—experiment price, the participant purchases the good and pays the experiment price. Since the amount the participant pays does not depend on their bid, it is in the participant's interest to value the good truthfully: Bidding truthfully is a weakly dominant strategy (Becker, DeGroot, and Marschak, 1964).

One of the strengths of the BDM mechanism is that the individuals' bids are free from bid affiliation, a phenomenon in which others' bids influence the participant's bid. Bid affiliation can arise when winning bids are announced in laboratory experiments in which experiment prices are drawn from the distribution of participants' bids (Corrigan and Rousu, 2006). Posting the winning bids provides information to all participants about the valuation of a subset of participants, which may be interpreted by other participants as providing relevant information about the quality of the goods. Two common alternatives to the BDM auction mechanism, the Vickrey (or second price) auction (Vickrey, 1961) and random *n*th price auction (Shogren et al., 2001), both establish the market price in the experiment from the distribution of bids submitted by participants. Since the main objective of this study is to evaluate consumers' individual willingness to pay for products when exposed to information about the occurrence of food fraud, we use the BDM mechanism to avoid bid affiliation, which could have confounded estimates of consumer response to information, particularly given that participants may have different prior awareness of food fraud in general.[2]

We recruited 177 olive oil consumers to participate in a laboratory valuation experiment on olive oil. Researchers recruited adult consumers in this research through a flyer, which we posted in supermarkets and speciality food stores, with information about how to register to participate in the experiment. Eligibility criteria were that participants had to be 19 years of age or older and that they had to be olive oil consumers. Once a person registered and we verified his/her eligibility, they received an email allowing them to choose a specific session. Research sessions were conducted in laboratories at the University of Nebraska-Lincoln from September 2017 to October 2018. Importantly, food fraud was not mentioned in the recruitment materials. Participants received a participation fee of $30, which was paid in cash as compensation for participating in the experiment. Each session lasted 30–45 minutes.

For this study, we used three 500 ml EVOO bottles produced by olive oil producers from Italy, Greece, and the United States (California). Since the occurrence of olive oil scandals has been well documented in Italy, we provided general information about incidents of fraud in the Italian olive oil industry to participants to examine how olive oil fraud occurring in Italy affects the valuation of EVOO from Italy and other countries, such as Greece and the United States.[3] The information about Italian olive oil fraud provided did not name specific brands and the brands used in the experiment have not—to our knowledge—been implicated in mislabeling or adulteration (see the Online Supplement (www.jareonline.org)). The shelf prices of EVOO bottles used in the experiment range from $7.99 to $8.99 (see Table 1).

Participants completed the research process at private desktop computer terminals and viewed information about the three products—including brand name, label design, and bottle shape—in the experiment on the computer screen. The country of origin was displayed alongside the image of the bottle. To eliminate order effects, products featured in the experiment were displayed in a random order to each participant. Participants submitted full bids for all three EVOO bottles (Alfnes, 2009).

[2] Bid affiliation can also be avoided in Vickrey or *n*th price auctions by not announcing the winning bid after each round.

[3] Since olive oil scandals related to Greek and U.S. brands have not occurred, we selected EVOO bottles produced by Greece and the United States to examine whether spillover effects resulted from the Italian olive oil scandal.

Table 1. Descriptive Information of EVOO Used in the Experiment

Country of Origin	Bottle Size	Shelf Price
Greece	500 ml	$8.99
Italy	500 ml	$7.99
United States	500 ml	$7.99

Notes: Prices reflect nonsale shelf prices observed in the study area during the data collection period.

Table 2. Experiment Design

Group Name	Treatment	Number of Participants
Group A	No information about food fraud	107
Group B	Information about food fraud	70
Total		177

Notes: The terms *no information about food fraud* and *information about food fraud* are abbreviated names that indicate whether participants received information about Italian olive oil fraud.

At the end of the session, one bottle of EVOO was selected at random for each participant. An experiment price was randomly drawn for that EVOO, and the participant's bid for that bottle of EVOO was compared to the experiment price. Therefore, participants purchased at most one bottle of EVOO during the experiment session.

Our experimental design used between-subject comparisons of WTP for EVOO (see Table 2 for a representation of the design). Participants were randomly assigned to one of two treatments: Group A received no information about food fraud, and Group B received information about Italian olive oil fraud. Treatment was assigned at the session level, so all participants in a given experiment session received the same treatment.

The steps of the research process for each group are described below. Common elements for Groups A and B were:

i. The researcher explained the experimental procedure to the participants.
ii. Participants completed a practice round to familiarize them with the valuation mechanism and the computer interface.

At this point, the experiment diverged for Groups A and B. For Group A, the next steps were:

iiiA. Participants submitted their maximum WTP for bottles of EVOO produced in Greece, Italy, and the United States. Participants did not receive any information about food fraud in the olive oil industry.
ivA. Participants completed a short survey on prior knowledge of food fraud. Note that this was conducted *after* they had submitted their bids.
vA. Participants completed standard surveys to collect demographic data (e.g., age, gender, education level, income) and olive oil purchasing behavior (e.g., number of EVOO bottles purchased per month, average bottle size, average price spent per bottle, and types of olive oil purchased).
viA. The random bottle and experiment price were drawn to determine the outcome of the experiment for each participant.

For Group B, the next steps were:

iiiB. Participants completed a short survey on prior knowledge of food fraud. Note that this was conducted *before* researchers provided any indication that food fraud was a focus of the study.
ivB. Participants read an article about the Italian olive oil industry and labeling scandals.
vB. Participants submitted bids for bottles of EVOO produced in Greece, Italy, and the United States. The same set of EVOOs were used for Groups A and B.
viB. Participants completed the same demographic and olive oil purchasing behavior surveys.

viiB. The random bottle and experiment price were drawn to determine the outcome of the experiment for each participant.

Hypotheses

We base our hypotheses on theoretical work by Giannakas (2002) and Meerza, Giannakas, and Yiannaka (2019). In these models, consumer trust in labeling and certification declines in the presence of food fraud. When food fraud incidents are reported, consumers' subjective probability that fraudulent products are sold in the market increases, leading to a decrease in the value of the high-quality label. Following Meerza, Giannakas, and Yiannaka, we examine a scenario in which two types of a food product—high-quality and low-quality—are available with a labeling regime in place. These two products are marketed separately, and consumers have a choice between a unit of the high-quality product and the low-quality product. In this context, the consumer utility function can be written as

(1)
$$U_h = U - P_h + \lambda_h \alpha \text{ if a unit of the high-quality product is consumed;}$$
$$U_l = U - P_l \text{ if a unit of the low-quality product is consumed;}$$

where U_h and U_l represent the utility associated with the consumption of high- and low-quality products and P_h and P_l are prices of the high- and low-quality products, respectively. The per unit base-level utility is captured by U (which is greater than P_h and P_l); λ_h is the utility enhancement factor associated with the consumption of the high-quality product. The parameter $\alpha \varepsilon [0,1]$ represents differences in consumer preferences for the attributes offered by the high-quality product. Without loss of generality, it is assumed that consumers are uniformly distributed between the polar values of α. In this context, $U + \lambda_h \alpha$ and U denote the maximum consumer WTP for a unit of the high- and low-quality products, respectively. Moreover, to allow for positive market shares of all quality-differentiated food products, it is assumed that $P_h > P_l$, and the valuation of the quality difference exceeds the high-quality price premium (i.e., $\lambda_h > P_h - P_l$).

When consumers observe reports that products labeled as the high-quality product are in reality the low-quality product, they assign a probability for the presence of the mislabeled product in the market. In this case, the utility derived from the consumption of the high-quality product in the presence of mislabeling can be written as

(2)
$$U_{h,m} = \mu (U - P_h + \lambda_h \alpha) + (1 - \mu)(U - P_h) = U - P_h + \mu \lambda_h \alpha,$$

where the parameter μ is the probability that the food product is of high quality, while $(1 - \mu)$ is the probability that a food labeled as high-quality is fraudulent. The term $U_{h,\,m}$ is the utility associated with the consumption of the high-quality product in the presence of mislabeling. Therefore, under mislabeling, $U + \mu \lambda_h \alpha$ denotes the maximum WTP for a unit of the high-quality product. All other variables are as previously defined. Since consumers assign a probability for the presence of the mislabeled product, consumers' WTP for the high-quality product decreases by $(1 - \mu)\lambda_h \alpha$ (the direct effect of mislabeling). A primary aim of this research is to estimate the impact of food fraud on WTP, which we capture in the following hypothesis:

HYPOTHESIS 1. *Direct Effects. Participants will reduce their WTP for Italian EVOO when they receive information about Italian olive oil scandals.*

A second aim of this study is to investigate the presence of spillover effects in the presence of food fraud. While the theory laid out in Giannakas (2002) and Meerza, Giannakas, and Yiannaka (2019) predicts the direct effect of food fraud, it does not provide guidance on expected effects of fraud information on other products. Toledo and Villas-Boas (2019) document that consumers reduced purchases of unaffected eggs in response to a salmonella outbreak even though traceability permitted the targeted removal of affected eggs. This aim leads to a second hypothesis:

HYPOTHESIS 2. *Spillover (Indirect) Effects. Participants will reduce their WTP for Greek and/or U.S. EVOO when they receive information about Italian olive oil mislabeling.*

Data and Estimation Strategy

We collected data from 177 participants. Table 3 presents the summary statistics by treatment group along with the results from a Fisher's Exact Test to examine whether randomization yielded participants with similar characteristics across treatment Groups A and B. According to Table 3, the composition across treatment Groups A and B is balanced in terms of gender, age, income, olive oil consumption behavior, and prior knowledge and perceptions of food fraud but unbalanced in terms of education. We control for this difference in our regressions.

Variables that might affect consumers' response to food fraud incidents include olive oil consumption behavior, participants' prior knowledge and perceptions of food fraud, and demographic characteristics. To assess participants' prior knowledge of food fraud, we asked participants to answer a question about whether they had previously heard of incidents of food fraud. Participants assigned to Group A (no information) answered this question after bidding on the bottles of EVOO. Participants assigned to Group B (food fraud information) answered the question before receiving the food fraud information or any other indication that food fraud would be a focus of the study. The laboratory experiment data show that only 33% of participants reported having knowledge of food fraud before the study.

We use seemingly unrelated regression (SUR) to estimate the effect of information on WTP for Italian, Greek, and U.S. EVOO. Participants submitted their WTP for Italian, Greek, and U.S. EVOO simultaneously. Therefore, we cannot exclude the possibility that the WTP functions for Italian, Greek, and the U.S. EVOO are correlated through their errors. In this context, Zellner (1962) suggested the use of seemingly unrelated regression (SUR), which assumes that the random error terms are correlated across equations but not across individuals. Therefore, it defines a linear system without cross-equation restrictions. In this study, a three-equation linear system was estimated to determine the effects of Italian olive oil fraud information on consumers' valuation of EVOO from Italy, Greece, and the United States. Consider a model to explain participant i's WTP for the jth EVOO:

$$WTP_{ij} = \beta_{0j} + \beta_{1j} Information_{ij} + \boldsymbol{X}_{ij}^{\prime} \boldsymbol{\theta}_j + \varepsilon_{ij}, \tag{3}$$

where WTP_{ij} represents individual i's WTP for product j, and $j = 1$ (Italian EVOO), 2 (Greek EVOO), or 3 (U.S. EVOO). The β_j are coefficients to be estimated and $\boldsymbol{X}_{ij}$ is a vector of control variables describing characteristics of participant i. When all observations are stacked over EVOO products j, the seemingly unrelated regression model can be written as

$$WTP_j = \beta_{0j} + \beta_{1j} Information_j + \boldsymbol{X}_j^{\prime} \boldsymbol{\theta}_j + \varepsilon_j. \tag{4}$$

In this model, $\beta_{11} < 0$ would support Hypothesis 1, while $\beta_{12} < 0$ and/or $\beta_{13} < 0$ would support Hypothesis 2.

Results

Table 4 presents simple univariate tests of Hypotheses 1 and 2. Among participants who did not receive food fraud information (Group A), WTP was highest for Italian EVOO ($7.53), followed by Greek ($6.99) and U.S. ($5.96) EVOOs. The WTP of participants for Italian EVOO in Group B was 47% lower than that of participants in Group A ($3.99 vs. $7.53, $p < 0.001$). This result supports Hypothesis 1. We next examine whether there is evidence of a spillover effect from information about Italian EVOO to Greek and U.S. EVOOs. If participants who receive information about

Table 3. Summary Statistics

Variables	Treatment Group Group A	Group B	Total	*p*-Value
Female (%)	60	60	60	0.553
Education (%)				0.047**
Graduate degree	30	39	33	
Bachelor's degree	21	29	24	
Associate degree/some college	23	23	23	
No college	26	10	20	
Age (%)				0.107
19–35 years	88	90	89	
36–49 years	9	3	7	
50+ years	3	7	4	
Income (%)				0.29
< \$60,000	66	71	69	
\$60,000–\$99,999	9	11	10	
$\geq$ \$100,000	9	11	10	
Prefer not to answer	16	6	11	
Olive oil consumption (monthly)				0.472
> 1 liter	9	14	11	
$\leq$ 1 liter	91	86	89	
Types of olive oil purchased (%)				0.243
EVOO	67	76	71	
Other types but not EVOO	33	24	29	
Average price paid per bottle (%)				0.285
$\leq$ \$10	52	60	55	
\$10–\$20	45	34	41	
$\geq$ \$20	3	6	4	
Olive oil purchased from (%)				0.442
Supermarket, box store or grocery store	89	93	90	
Other	11	7	10	
Prior knowledge of food fraud (before the study) (%)				0.515
Yes	36	30	33	
No	64	70	67	
Participants' perceptions of the percentage of mislabeling (%)				0.514
0%–50%	94	90	93	
51%–75%	5	9	6	
$\geq$ 75%	1	1	1	
Participants' perceptions of the percentage of domestically (U.S.) produced food products tested by the U.S. Food and Drug Administration (FDA) (%)				0.137
0%–50%	50	66	56	
51%–75%	31	20	27	
$\geq$ 75%	19	14	17	
Participants' perceptions of the percentage of imported food products tested by the FDA (%)				0.276
0%–50%	61	71	65	
51%–75%	23	20	22	
$\geq$ 75%	16	9	13	

Notes: The reported *p*-values are from Fisher's Exact Test. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% levels.

Table 4. Tests of Differences in WTP With or Without Exposure to Food Fraud Information

Country	Group A: Mean WTP (no information)	Group B: Mean WTP (information)	Percentage Difference in Mean WTP	Prob (|T| > |t|)
Italy	$7.53	$3.99	47%	< 0.001
Greece	$6.99	$5.06	27%	< 0.001
United States	$5.96	$4.71	21%	0.001

Notes: The reported *p*-values test equivalency between treatment Groups A and B using Welch's *t*-test. The terms *no information* and *information* are abbreviated names that indicate participants received no information about food fraud and received information about Italian olive oil fraud, respectively.

Table 5. Effects of Italian Olive Oil Fraud on Consumers' WTP (*N* = 177)

		SUR 1	
Independent Variables	WTP Italian EVOO a	WTP Greek EVOO b	WTP U.S. EVOO c
Constant	6.290***	3.227**	4.723***
	(1.746)	(1.685)	(1.906)
Information (1,0)	−3.702***	−2.302***	−1.319**
	(0.508)	(0.454)	(0.612)
Consumption habits	×	×	×
Perceptions and prior knowledge of food fraud	×	×	×
Demographic characteristics	×	×	×
R^2	0.31	0.20	0.10

Notes: Reported values are the estimated coefficients. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% levels. Values in parentheses are robust standard errors. Controls for individual characteristics are included but not displayed (see Appendix for full results).

Italian olive oil fraud value the Greek and U.S. EVOOs less than those receiving no information, it would suggest that the actions of one producer (at the country level, in this case) may create negative externalities for other producers. Results show that participants who receive information about Italian olive oil fraud value Greek EVOO 27% less ($5.06 vs. $6.99, $p < 0.001$) and U.S. EVOO 21% less ($4.71 vs. $5.96, $p = 0.001$) than those receiving no information. The data support Hypothesis 2 and suggest that consumers' reaction to information about food fraud in one country can negatively spill over to perceptions of other countries' industries.

Table 5 reports the results of the SUR model analyzing the effect of information about Italian olive oil fraud on consumers' valuation for EVOO from Greece, Italy, and the United States. Since unobservable variables affecting participants' WTP for Italian, Greek, and U.S. EVOO may be correlated, we run the Breusch–Pagan Lagrange multiplier test for error independence. Results of this test indicate statistically significant correlations between the errors, justifying the SUR analysis.[4] All the individual level controls (i.e., demographic characteristics, olive oil consumption behavior, and participants' prior knowledge and perception of food fraud) are included in the SUR regressions but are not displayed in Table 5 (see the Online Supplement for full results). However,

[4] The null hypothesis of the Breusch–Pagan Lagrange multiplier test is error independence, which we reject at 1% significance level.

since the SUR model reduces to ordinary least squares (OLS) if the same set of independent variables appears in each equation, we drop percentage of domestically (U.S.) produced food products tested by FDA from column 1b and quantity consumed per month from column 1c.[5]

The SUR regression results in Table 5 reinforce the univariate results. Participants who receive information about Italian olive oil fraud not only reduce their WTP for Italian EVOO but also lower their WTP for Greek and U.S. EVOO. After controlling for demographic and purchasing data, the results suggest that consumers who are exposed to food fraud information decrease their WTP for Italian EVOO by $3.70. Consumers' WTP for Greek EVOO is $2.30 lower when exposed to information about Italian EVOO mislabeling, while WTP for U.S. EVOO is $1.32 lower. Estimates of the effect of food fraud information on WTP for Italian and Greek EVOO are statistically significant at the 1% level, while the parameter estimate in the U.S. EVOO regression is significant at the 5% level. The estimated effects of food fraud information on WTP for the three EVOOs are quite similar to—though slightly larger than—the unconditional differences reported in Table 4. The regression results of tests of Hypotheses 1 and 2 exhibit sizable drops in WTP for the Italian EVOO; participants exposed to information about Italian olive oil mislabeling value Italian EVOO only half as much as those who were not exposed to information. Our results also show that consumers' reaction to information about olive oil fraud in one country negatively spills over to perceptions of other countries' olive oil industries.

Policy Implications and Conclusions

Despite growing evidence of widespread occurrence of food fraud, there is relatively little empirical work documenting the impacts of fraudulent behavior in food markets. To fill this knowledge gap, we examine how consumers' valuation of products changes with exposure to food fraud information, providing the first estimates of the effect of information about food fraud on consumer valuation using data generated in an incentivized, nonhypothetical experiment. In this article, we (i) measure the effect of information about fraud scandals in Italy on consumers' valuation of Italian EVOO and (ii) examine whether information about Italian olive oil fraud affects valuation of Greek and U.S. EVOO in a between-subjects experimental auction. Information about olive oil fraud in Italy leads to a 50% decrease in WTP for Italian olive oil but also significantly diminishes consumer valuation of Greek and U.S. EVOO. These results indicate that, in the presence of food fraud, consumers reduce their valuation of food products linked to the fraud incident and that consumers' perception of fraud may negatively spill over to other countries.

These findings have policy implications for policy makers, industry groups, brands, and supply chain managers. Information about the effects of food fraud on consumer valuation of products helps policy makers better understand the benefits that costly monitoring and enforcement efforts provide to consumers, honest producers, and the market. This information helps justify investments in fraud monitoring. The results can help supply chain managers understand and develop appropriate strategic responses to regain consumer trust and protect their brands by providing evidence of consumer reactions to information about food fraud. For example, evidence of spillover effects indicates that the supply chain managers of brands not implicated in the food fraud scandal may need to develop strategic responses to counteract negative spillover effects. Evidence of spillover effects also indicates that efforts may need to be coordinated among countries to prevent or address widespread negative effects of food fraud incidents in the agri-food marketing system. Operation

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[5] In the initial model, all independent variables were simultaneously introduced; we found that the coefficients for percentage of domestically (U.S.) produced food products tested by FDA in column 1b and quantity consumed per month in column 1c were approximately 0 and not statistically significant. Therefore, in the final SUR analysis, we dropped percentage of domestically (U.S.) produced food products tested by FDA and quantity consumed per month from columns 1b and 1c, respectively. We used bootstrap methods to estimate cluster robust standard errors. Efron and Tibshirani (1993) suggest that 50 bootstrap replications are often enough to get an accurate estimate of the standard errors. However, following Cameron and Trivedi (2009), 400 bootstrap replications were performed in this study to estimate the robust standard errors.

Opson is an example of international coordination to combat food fraud. Specifically, it is an annual law enforcement operation targeting mislabeled and adulterated food and beverage products in 57 countries from Africa, the Americas, Asia, Europe, and the Middle East (Europol, 2016).

While this is the first study measuring consumers' response to food fraud incidents using a nonhypothetical laboratory experiment, there are several limitations to this study that bear noting. An important caveat of this study is that it only captures consumers' immediate response to food fraud scandals. Since it is not a long-term study, the results do not capture participants' behavior over time, which might differ from their immediate responses. Several studies have examined consumers' response to food safety information over time, which may hold relevant lessons for incidents of food fraud. For instance, Dillaway et al. (2011) and Beach et al. (2008) found that negative media information has an effect on consumers' WTP and that this effect persists well beyond the initial exposure to media information, while Liaukonyte, Streletskaya, and Kaiser (2015) found decaying effects of negative information over time in an experimental auction setting.

On the other hand, there may be dosage effects to food fraud information. Increasing exposure to reports of food fraud may have a cumulative effect on consumer trust in food manufacturers, the fidelity of labeling systems, or government regulators. This effect might exacerbate consumers' response to information about food fraud occurring in a particular industry. Further research on these issues will help develop a more complete understanding of how consumers' response to food fraud scandals will likely change over time and with repeated exposure to information about fraud events.

This paper identifies multiple future directions for research on the effects of food fraud. Gustafson and Lybbert (2009) present a conceptual paper on consumer behavior in the olive oil market under different labeling regimes. In this work, consumers are differentiated by how much knowledge they have about olive oil. Knowledge has been shown to be important in explaining differences in consumer response to information in other markets for quality-differentiated products, such as wine (Gustafson, Lybbert, and Sumner, 2016). Knowledgeable consumers may feel that they can successfully avoid falling prey to unscrupulous EVOO sellers in the real world. On the other hand, stronger preferences may lead to greater knowledge among consumers, particularly for quality-differentiated products like olive oil. In this case, knowledgeable consumers may react more strongly than unknowledgeable consumers to negative information.

This article provides an initial estimate of the effect of information about food fraud on consumers' valuation of products implicated by this information as well as products that have not been implicated in labeling scandals. The results indicate a potentially large effect of food fraud information on consumer valuation: WTP for olive oil from Italy, which has experienced a number of labeling scandals, drops by approximately 50% when consumers receive information about food fraud occurring in Italy. Even olive oils from countries that were not implicated in the food fraud information provided to consumers saw significant decreases in consumer WTP, falling by 20%–25%.

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Online Supplement: Consumers' Response to Food Fraud: Evidence from Experimental Auctions

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Online Supplement A: Instructions about bidding in the BDM

- You will be given the opportunity to potentially purchase bottles of olive oil. You will submit an amount that represents the most you are willing to pay for each of the bottles of olive oil.
- At the end of the research, we will select one of the bottles at random, and compare the amount you state you are willing to pay with a randomly drawn experiment price.
- If the amount you are willing to pay for that bottle is greater than the experiment price, you will purchase the bottle at the experiment price.
- If the most you are willing to pay is less than the experiment price, you will not purchase the bottle.
- Note that you will purchase at most one bottle of olive oil during this research session.

Why do we use this research approach?

- Previous research has shown that when people state how much they are willing to pay for items that they are not potentially bound to purchase—that is, when their responses are hypothetical, people (on average) overstate their values.
- The fact that you may wind up purchasing a bottle of olive oil encourages you to consider seriously how much you value the different olive oils you will see during the research.

Importance of expressing your true valuation

- Before we conduct the practice auction and begin the session, we would like to take a look at the importance of bidding your true valuation by considering your outcomes when you do and do not submit your true maximum willingness to pay for a good.
- Let's consider valuing a gallon of milk in the context of the research design will we be using today. Assume that you are willing to pay $4 for a gallon of milk.

Scenario	Your true valuation	Your bid	Randomly drawn price	Outcome
Overstate	$4	$4.5	a. $4.3	a. Pay $4.3, lose $0.30 in value because price > your true value.
			b. $3.6	b. Pay $3.6, receive surplus = $0.40 (Optimal outcome)
TRUE	$4	$4	a. $4.3	a. Do not buy (Optimal outcome)
			b. $3.6	b. Pay $3.6, receive surplus = $0.40, (Optimal outcome)
Understate	$4	$3.5	a. $4.3	a. Do not buy (Optimal outcome)
			b. $3.6	b. Do not buy, but could have purchased at a price you would have been happy to pay: forego $0.40 in value.

- Now, we will conduct a practice session. In this practice session, you will submit the maximum value you are willing to pay for each of three types of chocolate bar: Kit Kat, 3 Musketeers, and Snickers.

[Participants submitted bids.]

- Now, I will draw a price and a chocolate bar randomly. If your maximum willingness to pay for the randomly drawn chocolate bar is higher than the randomly drawn price, you will buy the chocolate bar at the randomly drawn price. Since this is a practice session, you will use token money, rather than your participation fee, to buy the chocolate bar.

Online Supplement B: OLS and Full SUR Regression Results

Table S1. Effects of Italian olive oil fraud on consumers' WTP (SUR model)

Independent variables	WTP Italian EVOO	WTP Greek EVOO	WTP US EVOO
Information (1,0)	-3.702*** (0.508)	-2.302*** (0.454)	-1.319** (0.612)
Consumption Habit			
Olive Oil Type (1,0)	0.693 (0.549)	1.056** (0.535)	-0.39 (0.576)
Quantity Consumed (per month)	-0.0001 (0.0003)	0.001** (0.0002)	
Price Paid Per Bottle (on average)	0.113* (0.063)	0.128*** (0.052)	0.099* (0.057)
Olive Oil Purchases from (1,0)	-0.291 (0.938)	0.149 (0.81)	-0.243 (0.936)
Perceptions and Prior Knowledge of Food Fraud			
Prior Knowledge of Food Fraud (1,0)	0.1001 (0.544)	-0.025 (0.534)	0.125 (0.499)
Percentage of Mislabeling	0.003 (0.013)	0.005 (0.013)	0.003 (0.012)
Percentage of Domestically (U.S.) Produced Food Products Tested by FDA	-0.010 (0.007)		0.006 (0.007)
Percentage of Imported Food Products Tested by FDA	0.002 (0.009)	0.003 (0.008)	0.005 (0.01)
Demographic Characteristics			
Gender (1,0)	-0.064 (0.505)	0.229 (0.473)	-0.130 (0.43)
Age	0.040 (0.044)	0.022 (0.032)	0.032 (0.033)
Education (reference: no college education)			
Graduate Degree	-0.666 (0.790)	0.089 (0.800)	-0.762 (0.79)
Bachelor's degree	-0.719 (0.74)	-0.052 (0.688)	-0.432 (0.714)
Associate Degree/Some College	0.097 (0.686)	0.877 (0.688)	-0.499 (0.642)
Income (reference: prefer not to answer)			
<60,000	-0.589 (0.797)	0.050 (0.713)	-0.122 (0.844)
60,000-99,999	-0.702 (1.095)	-0.121 (0.836)	-0.213 (0.937)
100,000 and above	0.417 (1.055)	0.436 (0.927)	0.447 (0.916)
Constant	6.290*** (1.746)	3.227** (1.685)	4.723*** (1.906)
R^2	0.31	0.20	0.10
Number of observations	177	177	177

Notes: Reported values are the estimated coefficient and, in parentheses, cluster robust standard errors.
*** significant at 1%, ** significant at 5%, * significant at 10%. Superscript a indicates that joint significances are estimated based on the coefficients.

Table S2. Effects of Italian olive oil fraud on consumers' WTP (OLS regression)

Independent variables	WTP (without control variables)	WTP (with control variables)
Information (1,0)	-3.532*** (0.435)	-3.590*** (0.457)
Greece EVOO (1,0)	-0.538*** (0.175)	-0.596** (0.304)
United States EVOO (1,0)	-1.567*** (0.225)	-2.234*** (0.397)
*Greece EVOO * Information (1,0)*	1.609*** (0.305)	1.598*** (0.316)
*United States EVOO * Information (1,0)*	2.282*** (0.385)	2.347*** (0.393)
Consumption Habit		
Olive Oil Type (1,0)		0.407 (0.440)
Quantity Consumed (per month)		0.0002 (0.0003)
Price Paid Per Bottle (on average)		0.111** (0.052)
Olive Oil Purchases from (1,0)		-0.170 (0.729)
Perceptions and Prior Knowledge of Food Fraud		
Prior Knowledge of Food Fraud (1,0)		0.059 (0.475)
Percentage of Mislabeling		0.003 (0.012)
Percentage of Domestically (U.S.) Produced Food Products Tested by FDA		-0.011 (0.001)
*Percentage of Domestically (U.S.) Produced Food Products Tested by FDA * United States EVOO*		0.012** (0.006)
Percentage of Imported Food Products Tested by FDA		0.009 (0.010)
*Percentage of Imported Food Products Tested by FDA * Greece EVOO*		0.001 (0.005)
Demographic Characteristics		
Gender (1,0)		0.056 (0.423)
Age		0.037 (0.027)
Education (reference: no college education)		
Graduate Degree		-0.557 (0.686)
Bachelor's degree		-0.483 (0.654)
Associate Degree/Some College		0.039 (0.580)
Income (reference: prefer not to answer)		
<60,000		-0.342 (0.709)
60,000-99,999		-0.400 (0.798)
100,000 and above		0.140 (0.800)
Constant	7.526*** (0.304)	5.732*** (1.567)
R^2	0.17	0.22
Wald χ^2		
P-values:		
H1: inf_fraud=0	<0.001	<0.001
H2[a]*: inf_fraud+gr_evoo*inf_fraud=0*	<0.001	<0.001
*inf_fraud+ca_evoo*inf_fraud=0*	0.002	0.003
Number of observations	177	177

Notes: Reported values are the estimated coefficient and, in parentheses, cluster robust standard errors.
*** significant at 1%, ** significant at 5%, * significant at 10%. Superscript a indicates that joint significances are estimated based on the coefficients.

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