UNDERSTANDING HOW CONSUMERS AND PRODUCERS EVALUATE TRADEOFFS RELATED TO FOOD AND AGRICULTURE USING EXPERIMENTAL AUCTIONS

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ABSTRACT

UNDERSTANDING HOW CONSUMERS AND PRODUCERS EVALUATE TRADEOFFS RELATED TO FOOD AND AGRICULTURE USING EXPERIMENTAL AUCTIONS

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Experimental auctions are increasingly used to estimate consumer demand for non-market goods and intangible characteristics of goods. The main advantage of experimental auctions over other value elicitation methods is that they are non-hypothetical and flexible. Experimental auctions are binding in the sense that subjects exchange real money for real goods, yet they allow researchers to collect detailed information about subjects, present subjects with information treatments, and observe changes in bidding behavior. By pushing experimental auctions further into field settings we can enrich the context of the research and be able to explore more complex tradeoffs consumers are required to make. The following research uses experimental auctions to explore tradeoffs in two very different contexts.

In the first paper, experimental auctions were used to explore farmers' perceptions of the tradeoffs between biofortification and yield of new common bean varieties (*Phaseolus vulgaris*) in Rwanda. Biofortification of staple crops such as common bean in Rwanda has the potential to improve nutrition outcomes among subsistence farmers, although farmers are often slow to adopt new varieties. Experimental auctions were conducted with 80 farmers who participated in on-farm agronomic trials of common bean varieties in traditional intercrop systems and in monocrop and 180 farmers from the same regions who were only shown the nutrient and yield content information. The main

conclusion is that on-farm participatory crop research is essential to understanding how farmers evaluate tradeoffs since experimentation provides them with full information about the new varieties. Farmer WTP for new varieties is largely based on how varieties perform in traditional intercrop systems rather than the monocrop, which is required by new agricultural policy in Rwanda. Another important finding was that non-binding preference elicitation methods can mischaracterize farmers' preferences depending on the context so binding methods may have a role in future participatory crop research.

The second and third papers explore how individuals make choices involving tradeoffs between health risk and product quality in the market for artisan cheese in the United States. In cheesemaking, pasteurization of milk can eradicate pathogenic bacteria that cause illness as well as beneficial bacteria that contribute to ripening and flavor development in aged cheese. This issue is at the center of an ongoing debate over the regulation of unpasteurized cheese with welfare implications for both producers and consumers. Experimental auctions were conducted with 347 artisan cheese consumers to understand their attitudes towards pasteurization and aging unpasteurized cheese and their response to scientific information surrounding this food safety debate. After accounting for taste preferences, underlying demographics, and attitudes about food safety only a very small portion of consumers were willing to pay more for pasteurized cheese. Consumers weighted their taste preferences more heavily than whether or not the cheese was pasteurized and their decisions about whether to purchase pasteurized cheese were largely ideologically driven. Participants that were more likely to choose pasteurized cheese were more responsive to information regardless of the nature of the information.

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Chapter 1: Introduction

Policymakers and market analysts often want to estimate the potential demand for goods that have not yet entered the marketplace or intangible attributes of goods that have benefits and costs to society. Several methods exist for eliciting consumer preferences and each has unique advantages and disadvantages. Revealed preference methods use existing market data such as retail purchases to derive implicit values while stated preference methods such as contingent valuation surveys ask consumers to state their values for a good or attribute. Choices among competing methods of preference elicitation largely have to do with balancing the richness of context and researcher control over the experimental design (Lusk and Shogren, 2007). Retail data have high internal validity since they are observed transactions but are limited in the sense that not much information is available about the consumers who make those purchases or why they make them. Revealed preferences are not very useful for understanding non-market goods since we do not observe transactions that do not take place. Stated preference methods typically involve hypothetical decisions, so a wide range of questions can be asked but there is no guarantee that the responses are the same as those that would occur under more realistic circumstances due to hypothetical bias (List and Gallet, 2001).

Experimental auctions are powerful because they combine the advantages of revealed and stated preference elicitation. In experimental auctions consumer preferences are elicited with incentive compatibility, since real goods and money are exchanged in a competitive and binding market format. There is a balance of internal validity and flexibility since experimental auctions allow researchers to collect detailed information about the participants, introduce information shocks and observe changes in bidding behavior (Lusk and Shogren, 2007). For these reasons

experimental auctions are particularly useful for valuing consumer preferences for new products or competing attributes when a tradeoff is required.

There has been a range of applications of experimental auctions designed to estimate consumers' willingness to pay (WTP) for credence attributes, including organic and eco-labels for vegetables, (Soler and Sanchez, 2002), corn versus grassfed beef, (Umberger et al., 2002), and country of origin designation (Umberger et al., 2003). Many WTP applications focus on the label itself rather than the interaction of the label with other attributes of the product, which are likely to be part of a consumer's purchasing decision. Experimental auctions have been used to examine how people make tradeoffs between quality and safety for a good of ambiguous quality (Buhr et al., 1993), or the tradeoff between information on food safety attributes and intrinsic sensory attributes (Combris et al., 2007). These types of interdisciplinary applications are rare and few studies explore contexts where the tradeoffs required are intrinsically related.

Experimental auctions have also become increasingly common in looking at consumer and producer demand for new crop technologies in the developing world. There are numerous studies exploring the tradeoffs between positive attributes such as biofortification or disease resistance and negative attributes such as non-traditional color or lower yield. Studies have looked at preferences for improved staple crops including biofortified white and yellow maize meal in Kenya (De Groote et al., 2011), biofortified orange maize meal in Mozambique (Stevens & Winter-Nelson, 2008), biofortified orange maize in Ghana (De Groote et al., 2010), and biofortified "golden" rice in the Philippines (Corrigan et al., 2009). Many of these studies focus on information about the appearance and the fortification or acceptance of the new crops from a consumer perspective. This ignores the preferences of subsistence farmers, who are often the

overwhelming majority of the population in developing countries and who are both consumers and producers.

In many previous applications, the product attributes of interest are isolated from other attributes of the product in order to establish clear causal identification. Focusing on a single attribute however can lose the richness of context and potentially ignores an attribute that may be more important to consumers (or producers) than the attribute that is isolated in the experiment. My research concerns how people evaluate tradeoffs around production and consumption decisions related to food and the environment in a context where special attention is paid to the relationship of multiple attributes. This dissertation explores tradeoffs economic actors face in the agrifood system and the implications of their behavior for policy in two very different contexts. The first paper looks at producer preferences for improved seed varieties in Rwanda with special attention to farmers' perceptions of the tradeoff between biofortification and yield performance in two cropping systems. The second and third papers explore the consistency of federal safety regulation governing the pasteurization of milk used in cheese making with consumers' perceptions of the safety of artisan cheese in the United States.

Chapter 2, *Combining participatory crop trials and experimental auctions to estimate farmer preferences for improved common bean in Rwanda,* looks at producer preferences for improved seed varieties. With the backdrop of prescriptive agricultural intensification policies in Rwanda we looked at farmers' preferences for improved varieties of common beans (Phaseolus vulgaris). Since subsistence farmers are both producers and consumers of goods they have more complex preferences for new crops and must make more explicit tradeoffs between consumption and production attributes. Experimental auctions were conducted with farmers to examine the effect of participation in on-farm trials on preferences for new bean varieties. The agronomic

trials for the bean varieties involved a traditional intercrop of beans and maize and the now government-mandated monocrop system. In this research we combined experimental auctions with participatory crop trials to see if information that farmers gleaned from engaging in participatory research had different effects than showing farmers basic nutrient content and yield information. We also tested whether non-binding methods of preference elicitation yield the same results as binding methods. The crop trials and the information treatments emphasized the difference between the intercrop performance of the varieties and the monocrop performance in order to see if preferences were more related to one than the other.

In chapters 3 and 4, we evaluated consumer demand for the pasteurization and age of cheese as safety attributes. We examine the tradeoffs consumers make and consumer behavioral responses to information about the science behind this policy. The Food and Drug Administration (FDA) requires that cheesemakers pasteurize milk used in cheese making or age it for 60 days before selling it but the policy is not consistent with recent scientific evidence about food safety and precludes small scale cheese makers from producing the most lucrative types of cheese.

Chapter 3, *Consumers' perceptions and tradeoffs between the safety and quality of artisan cheese* combines hedonic analysis of retail prices of artisan cheese with analysis of experimental auction data. Experimental auctions using a Becker-DeGroot-Marschak (BDM) auction mechanism were conducted on computer tablets with consumers at farmers markets in Michigan, New York, and Vermont. Along with the auctions, participants were asked to taste different varieties of cheese and provide sensory evaluations. Participants received pre-auction questions about demographics and post-auction questions about risk preferences and food safety attitudes. Retail data was also used to examine the marginal value of pasteurization and age as it

is currently distinguished in the marketplace. In this chapter we address two key research questions: how do artisan cheese consumers perceive tradeoffs between safety and quality? To what extent do they perceive pasteurization and aging to be food safety attributes?

Chapter 4, *The impact of information about the safety of pasteurization on demand for artisan cheese,* looks at how consumers react to positive and negative information about the science behind pasteurization and aging cheese. There is an ongoing debate about role of bacteria in our food system, particularly natural bacteria and the growing number of artisan cheesemakers presents new challenges for policymakers. In this research participants are provided with either information advocating pasteurization of milk used in cheesemaking or information about the benefits of raw milk cheese, or both of these information treatments together. We examine the differences in their willingness to pay for pasteurized and unpasteurized cheese before and after receiving the information treatment. We are also looked at how the information relates to the underlying characteristics of the participants in the study. From this we computed the consumer surplus and the expected value of this information to the public.

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Chapter 2: Combining participatory crop trials and experimental auctions to estimate farmer preferences for improved common bean in Rwanda

Introduction

Improved varieties of staple crops can be an important development tool simultaneously targeting malnutrition and chronic low yields (Becerril & Abdullai, 2010). However, successful introduction of improved varieties in developing countries can be hindered by the challenges associated with the heterogeneous microclimates found throughout the tropics (Morris & Bellon, 2004). Identifying varieties that farmers are likely to adopt is also complicated by the complexity of traditional cropping systems, suboptimal conditions found on farmers' fields and a lack of understanding of farmers' preferences.

Classic plant breeding typically focuses on improving the biological attributes of a crop rather than specifically trying to understand "the specialized production and consumption requirements of people who live in these environments" (Morris & Bellon, 2004, p.22). Participatory crop improvement methods emerged as a way to collaborate with farmers in order to better understand their preferences for new varieties and improve adoption. Two specific forms of participatory crop improvement research are Participatory Plant Breeding (PPB) where farmers evaluate plant characteristics during the breeding process and Participatory Variety Selection (PVS) where farmers evaluate varieties emerging from breeding programs (Witcombe et al., 1996). Both methods seek to identify plant trait preferences and generate plant varieties to better meet farmers' needs. Engaging farmers in participatory variety selection is particularly important when on-farm conditions are likely to be different from those on research stations, which is common in areas with diverse agroecological environments and low input systems (Morris & Bellon, 2004).

One potential challenge with participatory variety selection is that it may still remain difficult to obtain information from the participating farmers on which varieties they actually prefer. Improved attributes of staple crops are often accompanied by negative attributes such as poor taste or unorthodox color that hamper adoption. Understanding how farmers evaluate multiple attributes is essential for more efficient plant breeding, policymaking, and resource use. Depending on their relationship, however, farmers may be inclined to tell the researchers what they think the researchers want to hear, a form of social desirability bias (Norwood & Lusk, 2011). In such a situation, which appears to describe the case we investigate in this article, more sophisticated elicitation methods may be required. In this research we compare two elicitation methods for improved varieties: stated nonbinding rankings common in participatory methods and revealed bids from binding experimental auctions.

The research reported in this paper engages bean and maize subsistence farmers in Northern Rwanda by combining on-farm agronomic trials with experimental auctions for improved varieties of common bean. This paper addresses two main questions regarding the quality of information that researchers can obtain about farmer preferences among different varieties: 1) What is the effect of the method of preference elicitation? 2) Does taking part in on-farm participatory crop improvement research influence farmer preferences for the varieties?

Background

Experimental auctions for improved staple crops

In recent years, researchers have used experimental auction techniques in developing countries to estimate preferences for improved staple crops including biofortified white and yellow maize meal in Kenya (De Groote et al., 2011), biofortified orange maize meal in Mozambique (Stevens & Winter-Nelson, 2008), biofortified orange maize in Ghana (De Groote

et al., 2010), and biofortified "golden" rice in the Philippines (Corrigan et al., 2009). These papers look specifically at the tradeoff consumers make between a positive attribute (fortification) and a negative attribute (unorthodox color). For example, De Groote et al. (2011) found that the premium consumers were willing to pay for fortified maize (24%) was higher than the discount they required to buy yellow maize (11%). One limitation of such applications of experimental auctions is that they tend to focus exclusively on consumer behavior even though in some of the countries where they are undertaken, up to 90% of the population is also involved in production, which is the case in Rwanda.

If subsistence farmers' consumption and production decisions are interdependent as economic theory predicts, their preferences for a new crop variety should be based on consumption and production characteristics including nutrient content, taste, color, yield, and possibly others. Studies that concentrate only on production attributes (Asrat et al., 2010) and do not provide farmers with information on the consumption attributes do not capture the interdependency of decision-making. Two papers that specifically look at both consumption and production traits find evidence that both are determinants of farmer preferences. Dalton (2003) concludes that evaluating only on production characteristics in research with rice farmers in West Africa leads to 19.1% of all varieties being miscategorized as inferior. Asfaw et al. (2012) conclude that combining drought tolerant attributes with marketability and attractive culinary traits is most important to common bean farmers in Ethiopia.

This research extends previous work in the consumer choice literature by estimating farmer preferences for common beans in Rwanda based on consumption attributes (taste and nutrient content) and production attributes (locally specific yield data) through the use of information treatments in a field experiment. We also examine the differences in revealed

preferences between farmers who took part in participatory variety selection and those who only tasted the beans and received information treatments. We treat farmers as both consumers and producers and we use an incentive-compatible elicitation method to investigate the effect of participating in research and the effect of binding preference elicitation methods.

Improving common beans in Rwanda

Common bean (*Phaseolus vulgaris* L.*)* is a major grain legume crop in Rwanda produced mainly for subsistence agriculture but also to a limited extent for regional markets. Much of Rwanda's bean production is on small farms averaging 0.65 hectares, traditionally intercropped with maize or other crops (NIS, 2010). There are estimated to be at least 550 varieties of common bean in Rwanda (CIAT, 1993) and farmers traditionally plant mixtures containing as many as 30 varieties (Voss, 1992). The Rwandan Agricultural Board (RAB) reports that bean farmers' average yield is 25% of its potential as a result of rain variability, poor soil, and inadequate soil nutrients or inputs (RAB, 2012).

Common bean provides a valuable source of protein, minerals and vitamins with bean consumption in Rwanda estimated to be as high as 48 kg per capita per year (Broughton et al., 2003). Rwanda has the world's 10th highest percentage of population suffering from undernourishment at 40% in 2009 (FAO, 2012) as well as high rates of iron deficiency: 11% among women and 42% among school age children (World Bank, 2012). Common bean is conducive to biofortification of iron and zinc content because the baseline grain iron content is high and there is wide variability of mineral content, 30-110 ppm for iron and 25-60 ppm for zinc (Beebe et al., 2000). HarvestPlus estimates that an additional 40 ppm above baseline iron levels in common bean could meet a large proportion of the recommended daily intake of iron (Welch et al., 2000).

Adoption of bean varieties with improved nutrient content and yield performance has the potential to improve health outcomes and reduce poverty in rural areas of Rwanda. In the late 1980s and early 1990s, the low adoption rates of improved bean varieties in Rwanda led to extensive advancements in client-oriented plant breeding, where researchers collaborated with farmers to identify suitable varieties (Sperling et al., 1993). The success of participatory research with improved bean varieties allowed farmers to intensify bean production and gradually become part of the national agricultural research system in Rwanda. The institutionalization of methods like PVS makes it increasingly important to examine the contexts within which the participation is embedded. This is especially true in the current policy environment in Rwanda as the relationship between farmers and the Rwandan government is affected by sweeping changes in agricultural policy.

Multiplication and dissemination of improved varieties of crops is one component of phase II of the Strategic Plan for the Transformation of Agriculture in Rwanda (PSTA II), released in February 2009 (Ministry of Agriculture and Animal Resources, 2012). The plan incentivizes farmers with improved seeds and fertilizers, post harvest storage facilities, and extension services, to shift from diverse intercropping systems to monocropping. Previous research and anecdotal evidence paint a more authoritarian picture of local authorities destroying farmers' crops if they do not comply with the policy, effectively making intercropping illegal (Huggins, 2013). PSTA II is a radical departure from traditional farming in Rwanda and presents a challenging context to elicit farmers' preferences for improved crop varieties using participatory methods.

Methods

In this research, we are interested in whether the results of stated and revealed preference elicitation methods for improved common bean varieties are consistent given the policy context in Rwanda. We also want to understand the impact of taking part in the participatory research on farmers' preferences. To explore these issues we conducted experimental auctions and non-binding rankings with farmers who participated in on-farm crop trials and farmers with similar soil and climatic conditions who did not participate in the crop trials.

Data

Two types of data were used: 1) agronomic data collected through on-farm research of climbing bean varieties and 2) preference data collected through stated rankings, experimental auctions, and a brief survey with two subject pools of farmers. The agronomic data and a subset of the experimental auction data came from farmers who participated in an on-farm study of variety and cropping system interactions (Isaacs, 2013). These farmers grew each of the bean varieties on a single farm collectively, in a central location using a randomized complete block design of five bean varieties and one local mixture planted both in a monocrop and an intercrop with maize. The preference data were generated in experimental auction sessions for beans with bean and maize farmers who participated in the crop trials and farmers from neighboring communities who did not. The auction procedure is described in more detail below.

Sample

Rwanda is divided into five provinces: North, South, East, West, and Kigali. The sample consisted of farmers from five sectors (labeled A, B, C, D, and E to protect the identity of the farmers) across three districts around the central market town of Musanze, in Northern Province, Rwanda (see figure 1). A sector is an administrative division, which is a subdivision of a district,

which is a subdivision of a province in Rwanda. The topography of Northern Province is mountainous with altitude differences between the districts and sectors within each district ranging from 1,660 to 2,100 meters. Soils in the province are highly diverse, ranging from rich volcanic soils to nutrient-deficient clay soils.

Figure 1. Map of Rwanda

Farmers involved with the on-farm agronomic research were members of farmer associations that were randomly selected from a list of farmer associations actively working with a local NGO. The geographical distribution of these farmer associations roughly captures the diversity of agroecological conditions found in Northern Province. An auction was conducted with a single farmer association in each sector except for sectors B and E where one combined auction was conducted and in sector A where two farmer associations were combined due to the small size of the groups (see table 1). In total, four auctions were conducted with farmers that participated in the on-farm research (n=79).

Table 1. Descriptive statistics of socioeconomic information

	Men	Age	Edu	Class	HH num	HH farm	Other income	Land	Bean yield	Net seller	Net buyer	N
A1	0.00	45.35	5.18	1.59	6.00	2.59	0.12	0.52	38	11%	37%	19
A2	0.29	47.90	5.76	2.76	4.71	2.62	0.47	0.75	48	0%	33%	21
A3	0.19	41.63	5.81	2.50	5.13	2.44	0.13	0.63	58	0%	25%	16
B1	0.38	39.13	5.50	2.75	4.38	2.13	0.00	1.00	84	13%	75%	8
B2	0.47	40.06	4.76	2.88	5.53	2.18	0.18	0.90	154	44%	11%	18
B3	0.37	53.32	3.95	2.63	5.68	3.95	0.16	0.53	74	17%	61%	18
C1	0.16	52.74	3.28	2.68	5.16	2.63	0.11	0.31	129	37%	26%	19
C2	0.47	45.80	5.50	2.94	4.80	2.50	0.35	1.00	121	24%	24%	17
C3	0.00	44.39	4.33	2.61	4.72	2.33	0.00	0.30	53	6%	83%	18
D1	0.44	39.48	3.04	2.76	5.28	2.28	0.04	0.48	54	12%	60%	25
D2	0.65	36.65	4.65	2.85	4.55	3.05	0.20	0.51	58	0%	65%	20
D3	0.38	34.19	3.75	2.88	4.63	3.00	0.25	0.45	68	6%	38%	16
E1	0.25	47.43	4.71	2.88	6.38	2.88	0.13	0.83	123	25%	38%	8
E2	0.47	42.65	3.82	2.88	5.06	2.12	0.18	0.64	103	35%	18%	17
E3	0.13	54.25	2.56	2.44	4.19	2.38	0.06	0.46	30	65%	12%	17
AV	**0.31**	**44.33**	**4.44**	**2.67**	**5.08**	**2.60**	**0.16**	**0.62**	**80**	**20%**	**40%**	**17**
SD	0.18	6.07	1.02	0.33	0.61	0.47	0.13	0.23	37	0.19	0.23	4.3

Note: Auction 1 in each location only consisted of farmers who participated in the crop research, while auctions 2 & 3 consisted of farmers who were otherwise unfamiliar with the bean varieties.

The second group of farmers (n=182) belonged to farmer associations in the same five sectors as the farmers that participated in the on-farm research. Two farmer associations were randomly selected from a list of all farmer associations in each of the five sectors with the help of a local NGO extension agent. Due to the rugged terrain, long distances and poor communications between communities in this part of Rwanda it can be safely assumed that the new group of farmers did not have prior knowledge about the varieties from interaction with the original group. The NGO extension agent invited the entire farmer association, which ranged between 15 and 25 farmers (average of n=17), to participate in a two-hour session in which bean

varieties would be discussed. All members of the farmer association that attended the session participated in the auction. In total, three auctions were conducted in each sector, except for the two combined auctions mentioned above for a total of 14 auctions and total sample of n=262 participants.

Experimental auction mechanism and procedure

The experimental auctions used a Vickrey (1961) third price mechanism, where the third highest bidder's bid was selected as the "market price" for each bean variety and the participants who offered higher bids won the auction and paid the market price. The quantity of bean seed auctioned was 500 grams which is roughly equivalent in value to the daily wage for unskilled labor and enough to plant what is locally considered to be an average plot (10m x 10m). The Vickrey auction mechanism is designed such that it is optimal for farmers to reveal their true preferences since overbidding can result in paying too much and underbidding can result in missing out on a good deal (Lusk & Shogren, 2007). The following eight steps were used for all auction groups.

In Step 1, prior to the start of the auction, each participant completed a short survey including basic demographics. Farmers received a set of bid sheets for each round stapled together and labeled with a unique ID number. The moderator read an oral informed consent statement to each participant explaining the confidentiality agreement and their rights as participants.

In Step 2, the monitor described the practice auction procedure and third price Vickrey mechanism to the participants and then they received 200 RWF (1 USD is approximately 600RWF). Participants learned that they could bid on either or both of the items in the practice round. One item was a bag of peanuts (worth approximately 100 RWF) and the other was a

package of biscuits (worth approximately 100 RWF). Participants were informed that if they won the auction(s) they would be expected to pay the third highest bidder's bid. Bid sheets were collected and ranked from highest to lowest; winners were announced and they exchanged money for the goods if they won the auction.

In Step 3, farmers visually inspected the five varieties of beans placed in bowls at the front of the room labeled in Kinyarwanda by the name the research farmers created for them (the names reflected the color of the beans). Samples of the beans weighing 500 grams were lined up behind each bowl in plain brown paper bags labeled with the variety name and weight. The beans were arranged in a random order at each auction by blindly selecting the sample bags from a larger bag and placing them on the table from left to right.

In Step 4, participants received a plastic cup and were served approximately one tablespoon of each variety of bean, prepared in a traditional way (salt and oil), in the same order they were lined up on the table in the previous step.

In Step 5, farmers received a participation fee of 700 RWF bringing the total amount they received to 900 RWF (approximately $1.50). The average daily unskilled wage in Musanze at the time of the auction was between 800 and 1000 RWF and a kilogram of the traditional local mixture sold for 150 RWF. Auction participants were told they could choose to use this money in the auction and they would take home whatever money they did not spend. The purpose of giving each farmer the participation fee is that most farmers did not have cash on hand and might not be comfortable participating in the auction otherwise. Participation fees can create a "house money effect" (List and Rondeau, 2003), where participants make riskier decisions because they are bidding with money they do not perceive as their own. At the same time participation fees can also mitigate the effect of "field substitutes" or product substitutes found outside the

experiment and focus the participant on the task at hand (Lusk & Shogren, 2007). We felt that the advantages of the participation fee outweighed the disadvantages.

In Step 6, participants were presented with a simple bar graph displaying the zinc and iron content in each of the five varieties. The significance of zinc and iron for human health was explained to the farmers as well as the interpretation of the simple bar graphs. Because it was essential for farmers to understand the concept of biofortification this step of the auction was explained once, clarification questions were taken and then it was explained a second time in a slightly different way. Farmers then ranked their top three preferred varieties. After the rankings were collected farmers were asked to write on a single bid sheet their maximum willingness to pay for all five varieties. The bid sheets were collected.

In Step 7, participants were presented with simple bar graphs on how the five varieties performed in on-farm trials in neighboring farmer associations' fields for both monocrop and intercrop. At each auction farmers were shown only the yield of the on-farm trial that was located closest to their farmer association. These yield graphs were explained to participants in the same way as the nutrient graphs. Following this information, farmers were asked to rank their top three preferences and after the rankings were collected farmers were asked to write their maximum willingness to pay for the five varieties on a single bid sheet. The bid sheets were collected.

In Step 8, a coin toss determined which round was binding. The bids were ranked from highest to lowest for each of the five varieties in that round. We departed from the convention of randomly selecting one product as binding in each round and made all five varieties binding in a single randomly selected round. This decision may have decreased the overall magnitude of the bids but should not have affected the relative valuation of the five varieties, which is the focus of

this paper.

The third highest bidders' bid was selected as the "market price" for each variety and the participants who bid higher than this price won 500 grams of the improved bean variety and paid the researcher the effective market price. Due to the frequency of tied bids we implemented a tie-breaking rule. If the third highest bidder's bid was tied with either the second or second and first highest bidders' bid a random coin flip decided who was effectively the second highest bidder. In each case the participant was still required to pay the third highest bidders' bid even though in some cases it was equivalent to what they bid. With the tie-breaking rule the price the winner paid was still independent of their bid and it is still a weakly dominant strategy to bid one's true value.

Summary statistics of farmers by auction

The sample was more heavily weighted towards women, who tend to do most of the bean production and in one site (A1) the entire farmer association was women (see table 1). The average participant was 44 years old with 4 years of schooling, and 26 percent of the sample was illiterate. The average wealth class score reported was 2.67, where 1 is food-poor and 5 is food-rich (Howe & McKay, 2007). The average household consisted of 5.08 people with 2.60 working on the farm and 0.13 people earning off-farm income. The average farm size was 0.62 hectares, close to the estimate from the latest National Agricultural Survey of 0.65 hectares per household in Northern Province (NIS, 2010). Farmers reported an average bean harvest of only 37 kg per farm in the past season, far short of the 48 kg per capita annual bean consumption figure reported by Broughton et al. (2003). Twenty percent of the sample was net sellers of beans in the previous season, 40% were net buyers and 40% did not buy or sell any beans in the last season.

Results of an ANOVA test revealed that in an overall model using all the independent variables in table 1, research farmers were not statistically different from non-research farmers. However, the variable *wealth class* was different between the research and non-research farmers at the 5% level indicating that the mean wealth group between the two groups was in fact different. The on-farm research group was slightly poorer which is likely attributed to the group A1, which was by far the poorest group in the sample where most farmers reported being in the poorest wealth category.

Summary of bean performance

At each location a randomized complete block variety by cropping system design was set up for the five improved varieties (B1-5) and the traditional local mixture (B6) in monocrop and intercropped with maize for a total of 12 plots (3 m x 4 m) per site. RAB and HarvestPlus estimated the iron and zinc content of the beans prior to replication and dissemination of the improved varieties. Varieties B1, B3 and B5 had similar levels of iron (65) and zinc (30). Variety B2 had slightly higher levels of iron (75) and zinc (36) than the other varieties and B4 had very high levels of iron (95) but average zinc content. Based on iron and zinc biofortification standards in common bean, varieties B2 and B4 are biofortified.

Varieties B1 and B5 were established varieties in northern Rwanda while varieties B2, B3, and B4 were newly introduced. Some farmers reportedly were familiar with B1, which was a local landrace that was cultivated by a farmer and replicated by RAB. B5 was also somewhat familiar as it was introduced in the 1980s and was released in 1991 by RAB, and a variant of B5 appeared to be found in local mixtures. At the time of the auctions in 2012, variety B2 was not released and varieties B3 and B4 were pending release. Varieties B2 and B3 were much lighter in color than the other improved varieties (white and beige respectively) although some varieties

in the traditional mixture were similarly light in color. The other varieties ranged from purple (B1) to red (B4) and maroon (B5).

The on-farm trials described in this paper were part of a larger experimental design that involved on-farm trials at other locations and replications on research stations (Isaacs, 2013). The on-farm trials presented here were not designed to isolate the statistical differences in yield between the varieties since the yield data at each site were only used as information treatments for farmers at that site. Below we briefly discuss the differences in mean and standard deviation across the five sites to give the reader a general idea of how the varieties performed across locations on average.

Table 2. Mean yield between the 6 varieties in monocrop and intercrop system

	Monocrop			Intercrop		
Variety	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**
B1	3.28	1.82	0.36	1.55	0.93	0.19
B2	2.74	0.55	0.11	1.08	0.65	0.13
B3	3.65	0.73	0.15	1.27	0.61	0.12
B4	3.20	0.71	0.14	1.63	0.49	0.10
B5	2.67	0.98	0.20	1.59	0.64	0.13
B6	3.31	1.08	0.22	1.49	0.79	0.16

In each of the locations, the on-farm trials included a local variety mixture of common beans (B6) as a control and in the following section we compare the improved varieties with this control. The mean yield of variety B1 was almost identical to the local variety mixture on average in both mono crop (0.03 kg difference) and intercrop (0.06 kg difference). The higher standard deviation of B1 was due to poor performance in monocrop and intercrop in site D where excess water damaged or washed away many of the seeds. The mean yield of the unreleased and biofortified variety B2 was the lowest of any variety in intercrop and the second lowest yield in monocrop but it exhibited the lowest yield variance of all varieties in monocrop. The newly

released variety B3 yielded highest on average in monocrop (3.65 kg/plot) with relatively consistent yields but was the second lowest performing variety on average in intercrop, producing less than two kilograms/plot in two locations. The mean yield of unreleased and biofortified variety B4 (3.2) was slightly lower than the local variety mixture (3.31) in monocrop and was the highest in intercrop (1.63). B5 proved to be particularly susceptible to anthracnose and had the lowest average yield in monocrop (2.67 kg/plot) but performed well in intercrop with the second highest mean yield.

In summary, based on nutrient content alone varieties B2 and B4 are the most attractive. Based on yield performance there was wide variation between improved varieties on average and these new varieties do not seem to have a sufficient yield advantage over the traditional mixture to be competitive. From this small sample variety B3 appears to have the most advantage in monocrop and varieties B4 and to a lesser extent B1 have a chance of outcompeting the local mixture across both systems.

Modeling farmers' WTP for improved varieties

Linear regression models are easy to interpret and can tell us about average effects but they do not necessarily provide accurate estimates of partial effects at censored values. Experimental auction bids can be censored at zero when participants would require payment in order to accept the good in question. It can occur for a good that the bidder perceives to have a negative attribute, for example a genetically modified crop (Rousu et al., 2007). Given the poor performance of many of the varieties compared to the local traditional mixture we can assume that some farmers' bids for the bean seeds could have been censored.

Tobit type models (Tobin, 1958) are often used with experimental auction bids because of the possibility that vales are censored. We use a generic Tobit model assuming the error term

follows a normal distribution and the probability of observing a censored observation is $P(y_i = 0) = \Phi(-x_i\beta/\sigma)$ where Φ is the standard normal distribution. In this case β and σ indicate the probability of observing a non-zero value for y and also the mean of y for positive values of y. The generic Tobit model was amended to incorporate a random effects component to account for the panel nature of the data. In a random effects model the error term is split into the participant-specific part (u_{ij}), which captures the participant characteristics that influence value, and the idiosyncratic part (ε_{itjr}). The u_{ij} are allowed to be serially dependent, which is necessary in this case since the second round bids are dependent on the first round bids. The following model was estimated:

(1) $WTP_{itjr} = \alpha + \beta x_{itjr} + \gamma z_{itjr} + \delta v_{itjr} + (u_{ij} + \varepsilon_{itjr})$

(2) $WTP_{itjr} = max\ [0,\ WTP^*_{itjr}]$

The observed bid by participant *i* (*i=1,...n=25*) for bean variety *j* (*j=1,...n=5*) in session *t* (*t=1,...n=14*) during auction round *r* is expressed WTP_{ijtr}. WTP_{ijtr} is modeled as a function of three vectors of independent variables. The first is a vector of x_{ijtr} dummy variables for each variety. A vector z_{ijtr} is composed of experimental design variables including a dummy for the auction round, a dummy for whether or not the farmers participated in on-farm research, the auction session (i=1,…n=14), the order of presentation of bean varieties, and the time of day. A vector of socio-demographic variables v_{ijtr} contains information gathered in a pre-auction survey including gender, age, education, literacy, income category, land holding, bean harvest last season, net selling position, and familiarity with bean varieties (reported in table 1). The conformable vectors of coefficients to be estimated are α, ß, γ, and δ.

In order to analyze the ranked data we fit a rank-ordered logistic regression model by maximum likelihood estimation (Beggs et al., 1981). Three ranked alternatives form an

observation and all observations are related to the individual farmer. Given the estimates of the bean variety valuation by farmers, the rank order logistic form estimates the probability that each of the varieties is ranked first. Under the assumption that the π_i are independent and follow an extreme value type I distribution, the probability (π_i) that alternative i is valued higher than alternatives 2,…,k can be written in the multinomial logit form:

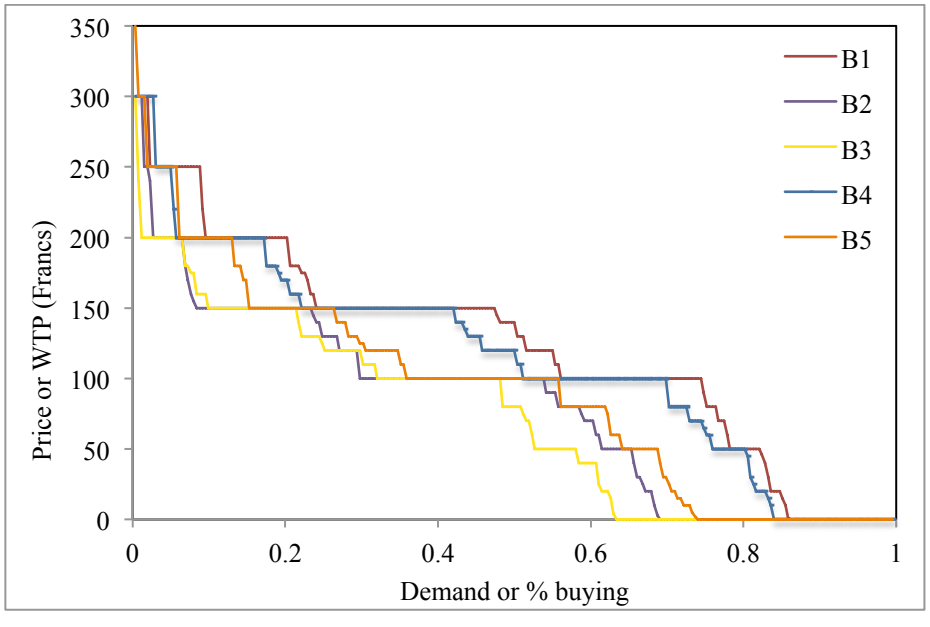
$$(3) \qquad \pi_i = \Pr\{value_1 > \max(value_2, \ldots, value_m)\} = \frac{\exp(value_i)}{\sum_{j=1}^{k} \exp(value_i)}$$

Results

Demand for improved and traditional bean varieties

The estimated demand curves for bean varieties appear to follow a step function. This is attributable to the common practice of using only 50 or 100 franc coins for informal exchanges. Five, 10, and 20 franc coins exist but are not commonly exchanged.

Figure 2. Demand curves for each bean variety based on nutrient content and yield



At the current market price for traditional beans (150RWF/500 grams), slightly less than half of the farmers were willing to buy any of the improved varieties after receiving information about the nutrient content and yield performance of the varieties. Only about 50% of farmers would pay at least 150 francs for varieties B1 and B4 (slightly less for B4 overall). For varieties B2 and B5 only 25% of farmers would pay 150 francs and even less than 25% for variety B3. These demand curves form an ordering of preferences for the improved varieties that does not appear to be consistent with the relative order of the nutrient values or yields of the varieties suggesting that neither of these attributes clearly explains farmer preferences. In the next section we explore the determinants of farmer WTP.

Determinants of WTP

In this section we pool the bids from both rounds and look at WTP derived from auction bids using a random effects Tobit model of all farmers with the individual farmer as the group variable to control for the separate but related bids in each round (table 3, column 1). The implied order of preferences for the bean varieties derived from these regression coefficients is consistent with the preferences implicit from the demand curves estimated above and each is significant at the 5% level. Variety B1 was dropped due to the overidentification problem with dummy variables and the negative coefficients on the other variety dummy variables indicate that B1 has the highest implicit WTP value.

Table 3. Tobit estimations of all farmers' WTP using random effects in reduced form

	(1) All farmers, both rounds		(2) All farmers, both rounds	
Variable	**coef.**	**sd**	**coef.**	**sd**
B2	-51.43*	5.19	-2.70	15.72
B3	-64.50*	5.22	-67.44*	5.89
B4	-13.32*	5.12	-13.32*	5.11
B5	-42.81*	5.17	-42.84*	5.17
Class	-15.29*	3.57	--	--
Household	3.17*	1.18	--	--
Beans bought	-0.35*	0.13	-0.31*	0.13
B2_class	--	--	-18.33*	5.59
Constant	149.10*	11.49	123.77*	4.44
Log likelihood	-12230	--	-12235	--
Observations	1980	--	1980	--
Censored	610	--	610	--
Sigma_u	30.27	2.39	32.03	2.43
Sigma_e	81.34	1.44	81.29	1.44
rho	0.12	0.02	0.13	0.02

Note: Both models were first estimated using all socioeconomic variables collected and then an F-test was performed to drop insignificant variables, which is presented here. *indicates statistical significance at the 5% level.

The socioeconomic variables that are significant at conventional levels include age, income class, and the quantity of beans bought in the previous season. An F-test was used to eliminate socioeconomic variables that do not contribute anything to the overall model. Age is positive but small in magnitude, indicating that older farmers were willing to pay slightly more across bean varieties. A negative coefficient on income class means that as farmers move up an income category, they are willing to pay on average 15 francs less per 500 g of beans. This might be because farmers in higher income groups are more food secure and able to save more seed allowing them to buy beans cheaper when prices are lower later in the year. Farmers who purchased beans last season were willing to pay 0.3 francs less on average for every 1 kg of

beans bought. In other words, a farmer who bought 50 kg of beans last season would offer approximately 15 francs less for 500 g of beans than a farmer who bought no beans last season. Farmers who are persistent net buyers of beans appear to be more price-conscious or possibly underbidding because they are only interested in the beans for consumption and are thus seeking a bargain.

Next we add interactions between the variety dummies and other relevant independent variables to explore whether there is an income, gender, or net selling effect associated with any of the varieties (table 3, column 2). The only interaction that was significant was for wealth class and variety B2. Wealth class was decreasing in WTP for variety B2 by 18 francs per wealth class. This relationship is possibly indicative of risk aversion behavior where poorer farmers are less willing to trade low yield for high nutrient content or they associate the unorthodox color (white) with market sales rather than home consumption. There is no significant relationship between net buyers of beans and individual bean varieties. The dummy variable for the biofortified variety B2 is no longer significant when we account for this interaction.

Location-specific effects

The point of doing on-farm agronomic research is that wide variation in climatic and soil conditions can lead to very different performance outcomes by a single variety. In this section we explore farmer WTP by location to see if location-specific preferences are different from the average preferences calculated above. Again we use Tobit estimations with the addition of a dummy variable for each location and bean variety combination (table 4). B1 is the dropped variety as in previous regressions and the effects are summarized in table 5 for comparison.

Table 4. Reduced form location specific Tobit estimations for both rounds by location

Location	A		B		C		D		E	
WTP_	**Coef.**	**Std.**	**Coef.**	**Std.**	**Coef.**	**Std.**	**Coef.**	**Std.**	**Coef.**	**Std.**
B2	-43.98*	10.18	-36.45*	10.77	-101.52*	13.84	-29.28*	13.28	-43.33*	9.75
B3	-62.23*	10.26	-46.02*	10.79	-151.44*	14.28	-26.97*	13.19	-51.74*	9.80
B4	33.75*	10.01	9.89	10.60	-109.21*	13.95	30.52*	12.91	-26.92*	9.72
B5	-42.11*	10.16	-63.73*	10.91	-50.19*	13.55	11.03	13.03	-74.52*	9.89
Class	-12.50*	5.29	-14.27	9.19	-14.47	9.21	-17.70	10.34	2.97	7.52
HH member	6.45	4.69	8.03*	3.54	6.75	5.16	1.39	3.94	5.79	4.14
Bean bought	-0.12	0.41	0.10	0.26	-1.06*	0.30	-0.07	0.24	0.21	0.26
Constant	139.66*	18.26	135.87*	27.81	198.11*	31.65	112.96*	30.47	109.27*	24.82
Likelihood	-2578	--	-2147	--	-2419	--	-1987	--	-1960	--
Uncensored	427	--	358	--	377	--	316	--	336	--
Censored	113	--	92	--	163	--	134	--	74	--
Sigma u	25.48	4.70	28.91	5.04	31.10	6.57	28.39	5.91	20.01	4.54
Sigma e	73.17	2.77	70.89	2.93	98.36	4.02	84.30	3.81	61.89	2.65
Rho	0.11	0.04	0.14	0.04	0.09	0.04	0.10	0.04	0.09	0.04

*indicates statistical significance at the 5% level

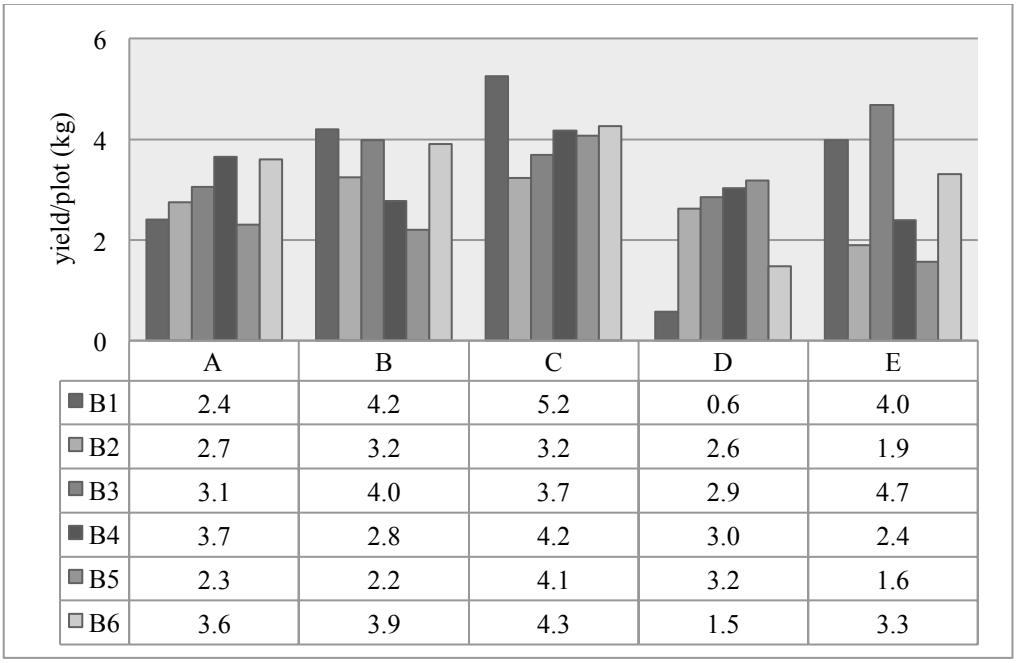
Table 5. Summary of location specific estimations from location specific Tobit estimates

WTP	A	B	C	D	E
B1	140	136	198	113	109
B2	96	99	97	84	66
B3	77	90	47	86	58
B4	173	146	89	143	82
B5	98	72	148	124	35

Note: These values are the sum of the constant (or the value of the dropped variety B1) and the individual variety coefficient.

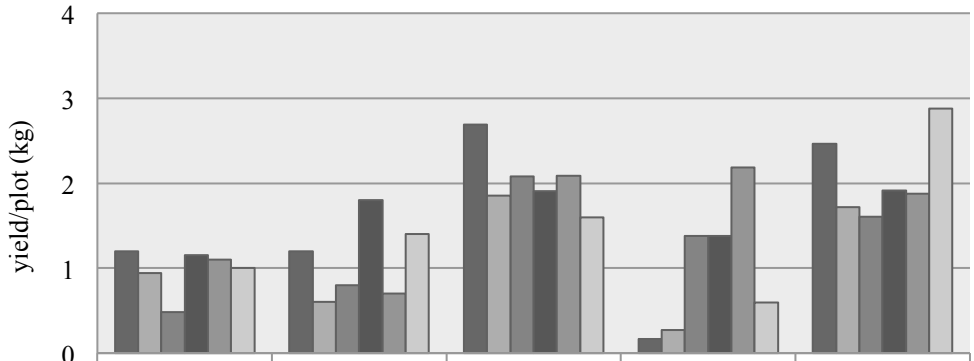
The coefficients on each variety represent the amount of each farmer's WTP that we can attribute to the individual variety after controlling for the significant experimental and socioeconomic variables (auction round, wealth class, number of members in the household, and the quantity of beans sold in the last season). When we compare these coefficients with the location-specific yields (from figures 3 & 4) we can see that in each location the variety with the highest average WTP was the variety with the highest average intercrop yield.

Figure 3. Monocrop yield across bean varieties (B1-B6) and locations (A-E).



	A	B	C	D	E
B1	2.4	4.2	5.2	0.6	4.0
B2	2.7	3.2	3.2	2.6	1.9
B3	3.1	4.0	3.7	2.9	4.7
B4	3.7	2.8	4.2	3.0	2.4
B5	2.3	2.2	4.1	3.2	1.6
B6	3.6	3.9	4.3	1.5	3.3

Figure 4. Intercrop yields across bean varieties (B1-B6) and locations (A-E).



	A	B	C	D	E
B1	1.2	1.2	2.7	0.2	2.5
B2	0.9	0.6	1.9	0.3	1.7
B3	0.5	0.8	2.1	1.4	1.6
B4	1.2	1.8	1.9	1.4	1.9
B5	1.1	0.7	2.1	2.2	1.9
B6	1.0	1.4	1.6	0.6	2.9

In location A, variety B4 was tied with B1 for the highest intercrop yield (and was the only variety to outperform B6 in monocrop). In location B, variety B4 had the highest intercrop yield and farmers offered the highest overall WTP. In location C, B1 was the highest yielding variety in intercrop and monocrop. In location D, B4 was the best performer in both intercrop and monocrop. And in location E, variety B1 was the highest yielding of the five improved varieties in intercrop although the farmer mixture (B6) was the highest yielding variety in intercrop, which explains the overall lack of strong preferences in this location.

This relationship between intercrop yield and WTP suggests that farmers still appear to conceptualize the success of a bean variety in terms of its intercrop performance in spite of the pressure farmers feel from the government to pursue monocropping. This result is also interesting since crop trials typically take place on-station in a monocrop system even though monocrop is not necessarily the system farmers use to evaluate the success of a new variety.

Comparing experimental auction outcomes with rankings

In this section we compare the order of preference reported in nonbinding rankings as opposed to binding auctions that are designed to be truth-revealing. A rank order logistic regression was estimated as described in the methods section, with the rank of each variety as the dependent variable. Logistic regression coefficients represent the change in the log odds of the outcome for a one-unit increase in the predictor variable and can be roughly interpreted as the odds that each of the varieties is ranked first. B1 is the dropped dummy variety again.

The likelihood ratio chi-square for the rank-ordered logistic model is 32.97 with a p-value of 0 which signifies that our model as a whole fits significantly better than an empty model. The coefficients in the consumption round are significant at the 1% level with the exception of B2,

which is not significant and B5 which is significant at about the 10% level (see table 6). For the production round, all coefficients on the varieties are positive and significant at the 1% level.

Table 6. Coefficients from a logistic rank regression of bean varieties

	Consumption		Consumption & Production	
Variety	**Coef.**	**Std. Err**	**Coef.**	**Std.**
B2	0.13	0.15	1.46*	0.20
B3	0.42*	0.19	0.93*	0.17
B4	-0.45*	0.14	0.83*	0.15
B5	0.25	0.16	1.14*	0.17

*indicates statistical significance at the 5% level.

Note: The coefficient represents the odds that variety was ranked first in the consumption round (when farmers tasted the bean varieties and received nutrient content information) and after both consumption information and production information (yield performance in monocrop and intercrop) was received.

Table 6 summarizes the implied rank order of the five varieties based on the coefficients from rank ordered logistic regressions in each round. In the round following the nutrient information treatment (labeled consumption) the coefficient on B4 is negative, which implies that B4 has greater odds of being ranked first than B1, the dropped variety.

When there is no financial incentive to articulate preferences there appears to be evidence of a tendency for farmers to tell the researcher what they perceive the correct answer is supposed to be, possibly a sort of 'reciprocity effect' for allowing them to participate in the research (Corrigan & Rousu, 2006). Another interpretation is that farmers are concerned with reporting what they think the authorities want to hear, in this case they may fear repercussions since they know government is promoting improved beans and monoculture cultivation.

In the round where farmers received the nutrient content information treatment we are interested in whether there is evidence that farmers overstate their preferences for biofortified varieties if they know their preferences are not binding. Indeed, the two varieties that changed order in the consumption round between the two methods are the biofortified varieties B4 and B2,

which were both ordered higher using the ranking method (see table 7).

Table 7. Implied ranking of bean varieties

	Consumption		Consumption & production	
	Rank	**WTP**	**Rank**	**WTP**
1st	B4	B1	B1	B1
2nd	B1	B4	B4	B4
3rd	B2	B5	B3	B5
4th	B5	B2	B5	B2
5th	B3	B3	B2	B3

Note: Order based on coefficients from rank ordered logistic regressions and Tobit estimations of WTP

In the round where farmers received additional production information, we expect farmers might exaggerate their preference for varieties with high monocrop yield and hide some other preferences they believed the researcher was not interested in. In this case the only variety that changed positions was variety B3, which was ranked lower than the implied rankings from the auction coefficients. Interestingly in the auction, variety B3 was revealed as the least preferred overall despite being the highest yielding variety in monocrop on average.

The change in the relative ordering of preferences between the nonbinding ranking and the binding auction bids from varieties with high monocrop yield to those with high intercrop yield supports the hypothesis that farmers were telling researchers what they thought they wanted to hear.

The effect of participating in on-farm research

Participants in the on-farm research clearly had more information than other auction participants about the various bean varieties. To examine the effect of participating in on-farm research we look at the mean value of WTP between the research farmers and non-research group. Table 8 summarizes estimates of research and non-research farmers' WTP across both auction rounds. These summary estimates are based on calculating the effect that is attributable

to each individual variety ($\alpha + ßx_{itjr}$) using the coefficients from the models for the groups.

Table 8. Summary table of WTP for each variety from a random effects Tobit model

	non-research	research	difference
B1	147.14	164.18	-17.04
B2	107.23	80.95	+26.28
B3	93.56	69.83	+23.73
B4	143.98	122.13	+21.85
B5	102.35	126.77	-24.42

Note: These values were calculated by summing the constant and the individual variety coefficient where the constant is the value of the dropped variety dummy variable (B1).

Variety B1 is strongly preferred by research farmers followed by roughly a tie between varieties B4 and B5, with B3 and B2 far behind. The non-research farmers strongly preferred B1 and B4 to the other varieties with variety B3 clearly the least preferred.

We might expect farmers who participated in the crop trials to offer higher bids in order to show appreciation to the researchers as a sort of 'reciprocal obligation.' On the contrary, these farmers offered slightly lower bids on average than the non-research farmers who only received information on the nutrient content and yield during the auction. After participating in the on-farm crop research, farmers offered WTP values approximately 20 RWF higher for the two established varieties B1 and B5. In contrast, the non-research farmers displayed greater openness to new varieties, submitting bids approximately 20 francs higher for the three newly introduced varieties (B2, B3, B4).

These results suggest that something in the research experience influenced the values research farmers were willing to pay for beans beyond the information that the non-research group received. Possible differences in information include production attributes such as the number of days to maturity, the plant leaf biomass relative to grain yield, or some other attribute

of importance to them that was not known to the other farmers. The explanation for the slightly higher preference for variety B2 among the non-research group may be that a positive effect of biofortification came through despite the low yields presented to them in the production round. Variety B3 was strongly disliked by the research farmers despite being the highest yielding variety in monocrop, which according to some farmers was because the vigorous plant growth led to competition with maize for light and requires stronger stakes. Qualitative findings also revealed that variety B4 was valued less by some research farmers because it was slower to reach maturation and required a longer time in the field making crop loss more likely (Isaacs, 2013). In any case, it appears that the research farmers' experience led them to the conclusion that the new varieties were inferior to the established varieties.

Conclusions

Farmer participatory crop improvement research offers the prospect of greater success in developing improved varieties in areas characterized by highly variable agroecological conditions and complex livelihood systems. A sometimes hidden concern remains that in some circumstances researchers will have difficulty in drawing the correct conclusions from such research due to difficulties in communicating with farmers. In this research we aimed to overcome this challenge by combining participatory on-farm agronomic trials and binding experimental auctions, which generated several results.

The main results are as follows: 1) incentive-compatible preference elicitation methods generate different outcomes than nonbinding methods in this setting; 2) intercrop performance of new varieties is more important to farmers than monocrop performance; and 3) farmer experimentation with new varieties is essential to accurately predicting farmer preferences and adoption behavior. Each of these conclusions is elaborated in more detail below.

Estimating demand for new crop varieties among subsistence farmers may benefit from the use of non-hypothetical designs such as experimental auctions. Binding preference elicitation methods appear to produce a more accurate measure of farmer valuation for new crops when a tradeoff between multiple attributes is involved. Under nonbinding preference elicitation farmers appear to overstate their preference for both newly introduced biofortified and high yielding varieties in monocrop. In our research, changes in the order of preference expressed between nonbinding ranking and binding auctions are perfectly consistent with the hypothesis that nonbinding rankings yield stated preference for the attributes of interest to researchers. The possible tendency of farmers to exaggerate these preferences to researchers has implications for how crop breeders, policy makers, and agricultural economists approach subsistence farmers about their preferences for new varieties.

There is evidence that farmers are more concerned with the performance of a new variety in intercrop than monocrop. Replication and dissemination of varieties with high on-station yield may not address farmers' needs as much as on-farm crop research using traditional intercropping systems. Policy that treats subsistence farmers like profit-maximizing producers does not acknowledge the suboptimal growing conditions and the desire for farmers to minimize exposure to specific agro-climatic and price risk through intercropping.

Subsistence farmers might be curious to try the new varieties presented in this research but the results from comparison of research and non-research farmers suggest that they probably will be disappointed. Participatory on-farm research is necessary to accurately identify varieties that perform well in specific agroecological niches and help identify attractive varieties to farmers prior to replication and dissemination, thus saving both farmer and development resources. While farmers may be eager to try new varieties they will quickly revert if they do not

find success.

The broader conclusion from this research is that there is no shortcut to determining which varieties of new crops farmers are likely to adopt. Further use of participatory methods and on-farm research with traditional cropping systems using binding elicitation methods appears to be the best way to predict adoption of new crop varieties.

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Chapter 3: Consumers' perceptions and tradeoffs between the safety and quality of artisan cheese

Introduction

There is little consensus on the safety or risk of various food products and production processes and how to achieve a safer food system through government action or inaction. One reason for the lack of consensus is that scientists often disagree about the safety and risk involved (Millstone, 2009), illustrated by recent studies illuminating the differences of opinion on the safety of conventional versus organic food (Brandt, 2011; Smith-Spangler, 2013). Another reason is that factors such as the underreporting of illness, difficulty in traceability of outbreaks, and the changing nature of pathogens complicate the measurement of foodborne illness (Mead et al. 1999). It is also increasingly understood that decisions about the acceptability of risk in the food system involve perceptions, opinions and values as well as science (Nestle, 2003; Paxson, 2008). The lack of scientific consensus about food safety and risk, the lack of documentation on food safety outbreaks, and the range of opinions and values towards food safety make designing food safety policy particularly challenging.

The debate over whether or not the milk used in cheese making should be pasteurized is contentious. Federal regulation currently requires that cheesemakers using unpasteurized milk (also called raw milk) age the cheese for a minimum of 60 days before sale (Cheese from Unpasteurized Milk, 2011). This is not the case in Europe where there is no aging requirement for unpasteurized cheese and some of the most expensive cheeses are made from unpasteurized milk and not intended to be aged. The US Food and Drug Administration (FDA) is considering tightening restrictions on raw milk cheese by lengthening the required aging period or banning unpasteurized milk cheese altogether (Neuman, 2011; Layton, 2010; Huffstutter, 2011). This

regulation would further limit artisan cheesemakers' ability to produce certain types of cheeses without pasteurizing the milk first. Pasteurization requires expensive equipment and eradicates the beneficial bacterial cultures that many artisan cheesemakers rely on for the flavor development that allows them to garner a premium in the marketplace.

The debate over the use of unpasteurized milk in cheese production has recently revived as artisan cheese consumption rises and the number of artisan cheesemakers in the US has doubled since 2000 to more than 400, seventy-five percent of whom use unpasteurized milk for at least some of their products (Roberts, 2007). The debate is part of a growing fissure between the burgeoning local food movement and the more traditional industrial food system that became apparent during the passing of the Food Safety Modernization Act of 2010 (H.R. 2751). Central to the discussion about the safety of products or processes is the role of risk assessment and the assumptions or 'framing' that is required in making assessments of risk (Millstone, 2009). Many assumptions in risk assessments reflect societal or personal values and preferences, not empirical evidence, and place weight on different dimensions of the assessment that can predetermine the outcome (Vaughan and Seifert, 1992). This is the main critique made by the artisan cheese trade group, the American Cheese Society (ACS, 2013), about a recent risk assessment of soft ripened cheese conducted by the FDA (FDA, 2012).

Given that values and preferences are so critical in defining risk and safety it is unfortunate that a rigorous treatment of them is often excluded from the policymaking process. The paper addresses two key research questions regarding the debate over the safety of cheese made from unpasteurized milk: how do artisan cheese consumers perceive tradeoffs between safety and quality? To what extent do they perceive pasteurization and aging to be food safety attributes? We explore these questions using experimental and non-experimental data. Non-

experimental data like retail prices are valuable because they reflect actual market transactions but they are of limited utility because it is impossible to infer anything from them about the consumers and the behavior underlying the transactions. Experimental data on the other hand allow us to both create context and isolate causality. We can elicit values for real goods in a field setting to understand how much consumers would pay as well as who the consumers are and what motivates them. By combining an experimental auction with sensory experiments and a survey measuring consumer attitudes about food safety and demographics we gain a lot more insight into why the transactions occurred than we do by just looking at retail prices. The combination of both retail and experimental auction data enhances both the depth of information received and the validity of the results.

In the second section we present some relevant literature on hedonic theory and its applications for goods similar to cheese, and briefly touch on the experimental literature dealing with food safety. Then in section three we discuss the estimation strategy and present the two different methodological approaches to the research questions. In the fourth section we describe the methods used and our data and in the fifth section we discuss the results of the estimations. Section six concludes.

Literature

Hedonic price theory is often credited to Lancaster (1966), who developed a framework in which utility is generated by the characteristics of goods, and Rosen et al. (1974), who described how consumers and producers interact in a framework of prices for product characteristics. Rosen et al. (1974) suggested a two-stage estimation approach where the prices of goods are regressed on the goods' attributes in the first stage and then the marginal prices of

each attribute in the "bundles" actually purchased by consumers are regressed onto the characteristics of the good along with consumer demographics and other demand variables in the second stage. In the first stage, differentiation of the hedonic price function with respect to a particular attribute yields the marginal implicit price of that attribute. The second stage allows for identification of willingness to pay (WTP) by relating the consumer demographic information back to the estimates of the marginal prices of the attributes. Follain and Jimenez (1985) and Witte et al. (1979) estimate the demand for housing characteristics from such multi-stage models.

Later research identified a simultaneity problem with the two-stage approach since consumers likely purchase goods that were higher in their preferred characteristic (Brown and Rosen, 1982). Numerous authors ignore the second stage since they are not interested in estimating consumer demand; they only estimate the marginal implicit prices of attributes from the first stage. Others have developed ways to avoid the simultaneity problem, such as Bajari et al. (2005) who take a semi-parametric approach to the second stage. Another alternative requires experimental data where purchases can be matched with actual consumers as per Melton et al. (1996). Melton used an experimental design to isolate the value of various attributes of a food product by varying the attributes present in each treatment across subjects. This approach does not require individually estimated price and quantity equations as in the two-stage approach but rather incorporates the demand shifters in the first stage estimation.

We take a traditional hedonic approach to estimate the marginal value of attributes that are related to the safety of artisan cheese (aging and pasteurization), as well as an experimental approach to estimating the WTP for these attributes. We estimate the first stage of a traditional hedonic price analysis using artisan cheese retail price data with a wide variety of attributes. Then we follow the example of Melton et al. (1996) in analyzing experimental auction bids in a

hedonic framework in order to isolate the value of the cheese attributes (pasteurization and age) as well as the underlying characteristics of the participants in the auctions that one typically gets from Rosen's second stage. We also explicitly look at consumers' choices of pasteurized and aged cheese and examine the relationship of these choices to their hedonic ratings (sensory scores of each cheese) and attitudes about risk to gainer a deeper understanding of the tradeoff between safety and quality.

Melton's work is situated within a broader literature that uses experimental auctions to estimate demand for food product attributes. Many of these studies use multiple methodological approaches for cross comparison of the value of the attribute estimated from experimental auction data. For example, there are studies that investigate the link between sensory evaluations and auction bids by comparing objective measurements of a product attribute with subjects' bids or evaluations and find that the bids and evaluations are increasing in that attribute (e.g. Lusk et al., 2001; Feuz et al., 2004; and Platter et al. 2005). Other studies compare auction bids with hedonic ratings for an attribute and find that subjects bid more for products they think have that attribute (e.g. Umberger and Feuz, 2004; Melton et al. 1996; Platter et al., 2005). Still other studies compare experimental auction bids with hedonic ratings for an attribute through post-auction surveys (Lusk, 2001; Lusk et al., 2006) or with risk tolerance by constructing an index based on answers to questions about risk (Brown et al., 2005).

In the next section we look at applications of hedonic price models and outline models for the retail price data and the experimental data.

Estimation Strategy

Applications of hedonic analysis can be relatively straightforward with durable goods

characterized by highly differentiated and easily defined attributes such as homes or cars (Court, 1939; Grilliches, 1961). Application of hedonic theory to non-durable food goods such as wine or coffee is increasingly common although measures of quality are more subjective in food products (Combris et al., 2003; Benfratelloa et al., 2009, Teuber et al., 2012). Hedonic analysis has also been extended to explore less orthodox attributes of food products such as the value of origin denomination (Teuber et al., 2012) and the value of the physical characteristics of vineyards (Cross et al., 2012). We construct a hedonic price model of artisan cheese by looking at how wine, a product with similar characteristics, has been modeled in the literature.

Benfratelloa et al. (2009) identify three categories of attributes that generally appear in the specification of hedonic functions of wine price. The first category includes *objective characteristics* such as the wine vintage, denomination, region, or grape variety, which usually appear on the label and are therefore easy for consumers to identify. The other two categories identified by Benfratelloa et al. (2009) involve quality, which is not easy to evaluate objectively with wine. *Sensorial quality* is measured through sensory evaluation such as the wine's aroma, finish and harmony of components, which experts say determine the wine's price. Wine buying guides sometimes publish sensory ratings but they do not represent a random sample of wines and are written and evaluated by a limited number of evaluators who may be biased in personal preferences (Castriota et al. 2012). Combris et al. (2003) compare predictions of quality ratings from a jury of evaluators and prices of wines from both sensory and objective characteristics and find that quality is mainly defined by the sensory characteristics of a wine whereas price is better predicted with objective characteristics. The other quality-related category identified by Benfratelloa et al. is the *reputation* of the wines, which conveys quality information to the consumer. Landon and Smith (1997) differentiate the individual reputation of a wine (specific

maker and vintage) from the collective reputation (membership in an appellation) and find that ignoring reputation can overstate the impact of quality on market price.

According to standard hedonic theory a basic model for artisan cheese prices would have the price of cheese P_c determined by the three categories of characteristics described by Benfratelloa et al. (2009):

$$(1) \qquad P_c = f(O_c, S_c, R_c)$$

where cheese attributes are classified as objective (O_c), sensory (S_c), or reputation (R_c). Objective characteristics are relatively straightforward to identify for artisan cheese since these attributes become a selling point for producers and are often readily available on labels. Basic objective characteristics of artisan cheese include the region or production location, milk type, style of cheese (including bacterial cultures and rind type), size of the cheese wheel, age of the cheese, and whether or not the cheese was pasteurized.

Sensory characteristics are more difficult to capture with cheese in the absence of a buying guide or a unique panel of expert jurist ratings as per Combris et al. (2003). The lack of this information on quality suggests that quality is not as well defined for cheese as it appears to be for wine. Defining cheese quality becomes a significant estimation challenge.

Public awards received at exhibitions or contests enhance reputation among artisan cheese producers. The most prominent awards for American cheese producers come from the American Cheese Society (ACS) in the US and the World Cheese Awards covering Europe and US. Another indicator of quality, limited to Europe, is participation in a protected designation of origin (PDO) such as AOC in France, DOC in Italy, which indicates not only the region it was produced in but also requires that a producer meets certain animal, production, and safety standards. This reputation information tends to be readily available to consumers who are

interested, often on the label.

Given the nature of the market for cheese and the information available, two distinct approaches emerge to estimate the value consumers place on age and pasteurization, each with different data requirements. One approach is to estimate a hedonic model based on retail price data to predict cheese price as a function of a wide variety of objective attributes (including pasteurization and aging time) and reputation (as defined by individual and collective public awards received) across a wide variety of cheeses. This approach does not capture any measure of sensory quality but has high validity in that it uses objective characteristics from a large volume of actual market transactions. A second approach relies on data generated in an experimental setting where consumers bid on and submit sensory ratings for a small number of cheeses that differ only in the objective attributes we are interested in. With the latter approach we can estimate consumer WTP for cheese as a function of the marginal prices of a limited number of attributes of interest (pasteurization and age), the consumer perception of the quality of the cheese, and the underlying demographic characteristics of the consumers.

Hedonic analysis of retail price data

First we apply the basic Rosen (1974) hedonic model to describe the price of artisan cheese, a heterogeneous good with multiple differentiated characteristics. Theory has little to say about the functional form of the hedonic model and various authors have explored the goodness of model fit with mixed results. The following basic model, attributes, and attribute levels is used:

$$(2) \qquad P_i = \alpha v_i + \beta w_i + \delta x_i + \varepsilon_i$$

where: P_i is the price of cheese *i*; v_i is a vector of dichotomous objective characteristics of cheese including a pasteurization dummy variable, a vector of milk type (4 levels including cow, goat, sheep, mixed), the origin of the cheese (grouped either by state or region), the style of cheese (blue, bloomy, washed rind, etc.) and the texture of cheese (soft, semi-soft, soft-ripened, and semi-hard); w_i is a vector of continuous objective characteristics including the age of the cheese in days and the average weight of the wheel of cheese in pounds; x_i is a vector of dichotomous variables that indicate the reputation of the cheese; α, β, and δ are parameter vectors to be estimated; and ε_i is a random error term. With a quality-differentiated product, price is derived as the sum of the marginal utilities of its contributed attributes. We can obtain the marginal utility of each attribute by taking the partial derivative of equation (2) with respect to each attribute.

There are two potential problems in the above model specification. The first is that we are most interested in the marginal value of pasteurization and age but since it is currently illegal in the US to produce unpasteurized cheese that is less than 60 days old, we only observe pasteurized cheese in this category. We have included interaction terms to capture the effect of cheeses that fall into this category. A second problem is the strong correlation between independent variables in the model that are related to age. Typically aged or 'mature' cheese tends to be more expensive since flavors develop over time and the cheese maker accrues storage and maintenance costs while the cheese is aging (common with cheddar). However, there are several expensive young or fresh cheeses (less than 60 days old) that are considered artisan, in the sense that they have very small (about 4 ounces), unique forms and are aged and handled very carefully to promote vigorous bacterial growth in a short period of time. Other cheeses have very specific windows of aging and cannot withstand aging beyond about 60 days for white

mold or 90 days for blue mold cheeses. The aging time is also correlated with the size of the cheese and the texture. A larger cheese takes longer to ripen and tends to be harder because it loses more moisture during the longer aging time. These interactions are discussed in more detail in the analysis section.

Hedonic price analysis of experimental auction data

A hedonic price model of experimental auction bids is set up as per Melton et al. (1996). The objective characteristics used in the experimental auction model are derived from specific comparisons of two characteristics isolated in the experiment: whether the milk was pasteurized and how long it was aged. Due to the small number of cheeses used we cannot determine the marginal value of the other objective attributes of the cheese as in the hedonic model of retail prices; instead we rely on consumers' sensory ratings and demographic characteristics to predict consumer WTP.

This model has two parts. First we want to predict whether or not a consumer would choose the cheese based on the attribute of interest versus a cheese that does not have that attribute. The probability of the participant choosing to bid on a cheese with a specific attribute (either pasteurized or aged) as opposed to taking the cheese they were endowed with that does not have that attribute is modeled using a logistic specification. Second, we model participants' willingness to pay for cheese as a function of the attributes of interest and the same factors used in the logistic model. Intuition led us to reject a model of WTP as conditional on the decision to select the endowed cheese or bid (as in Cragg's (1971) double hurdle model). The logistic estimation of consumer choice follows the description of the hedonic model of WTP below.

The hedonic model of auction bids includes a vector of preferences for sensory

characteristics continuously measured on a Likert scale ranging from 0 to 10. Unlike Combris et al. (2000; 2003), the sensory data come from consumers who participated in auctions and not from expert panels. Thus, the sensory data reflects personal preferences. Equation (3) is a hedonic price equation that explains the auction bids as follows:

$$(3) \qquad WTP_{ij} = \alpha v_{ij} + + \gamma z_{ij} + \beta w_{ij} + \partial x_{ij} + \varepsilon_i$$

where WTP_{ij} is the willingness to pay for cheese *i* by person *j*; v_i is a vector of objective attributes (including pasteurization and age); z_{ji} is a vector of sensory attributes (taste, visual, texture); and w_{ij} is a vector of socio-demographic characteristics; x is a vector of attitudinal characteristics (about risk and food safety); and α, β, and γ are parameter vectors to be estimated; and ε_i is a random error term.

We obtain three results from this portion of the analysis. First, we can examine the relationship of the two objective attributes of interest to individual bid prices. While the two models presented draw on different types of information we would still expect to see the same signs and relative importance assigned to the attributes of interest. Second, we can explore whether consumers' behavior in the auctions matches their sensory scores as per Noussair et al. (2004). Including sensory scores in the estimation allows us to explore the relative importance of sensory qualities in explaining artisan cheese prices. Third, we can examine the effects that characteristics of consumers and their households have on individual bid prices.

Methods

Data sources

As described above the analysis relies on two data sources. The data used in the hedonic analysis of retail prices comes from two online artisan cheese retailers. Along with the prices of cheeses we record the basic objective characteristics (pasteurization status, age, milk type, style, etc.) and whether the cheese or cheesemaker has won any awards. If we cannot ascertain the requisite information directly from the distributor's website we go to the retailer's website. All cheeses sold by the retailers are included in the sample with the exception of processed cheese products (such as spreadable cheeses, butter, etc.).

The hedonic model of experimental auction bids relies on sensory experiments, experimental auctions, and a short demographic survey with consumers at farmers' markets in multiple locations in Michigan, New York and Vermont. A description of the participants included in the sample and details of the experimental auction procedure follow.

Sample

Since we are only interested in consumers affected by regulation of artisan cheese our target population included only artisan cheese consumers. We conducted the experiments "in the field" to reduce sample selection bias since participants are intercepted rather than self-selected (Harrison and List, 2004). We chose three states that represent different cultures of cheese making in a nascent, intermediate and more developed context (Michigan, New York and Vermont respectively). Within each state we conducted experiments at farmers markets in multiple cities that ranged in size and median income. We chose to sample at farmers markets to capture the widest demographic of artisan cheese consumers and to have a consistent sample

across and within states.

We identified three locations in each state where there was at least one farmers market. We then contacted the market managers, discussed the research and scheduled a day to conduct research at the market if the market manager was amenable. In Michigan we conducted auctions in Ann Arbor (2 day markets and 2 evening markets), Lansing (2 day markets), Grand Rapids (1 day), and Bath (1 day). In New York we conducted auctions in Ithaca (1 day and 1 evening market), Troy (1 day and 1 evening), Albany (1 day), Schenectady (1 day). In Vermont we conducted auctions at Burlington (2 days), Brattleboro (2 days), and Manchester (1 day). The auctions varied in hours of operation from 3 to 6 hours in length and in the density of pedestrian traffic. The total number of participants in the research across all locations was 347.

Auction procedure

A table was set up at each location during market hours with two monitors conducting experiments simultaneously using computer tablets. At the beginning of the day or after a participant completed an auction a new participant was recruited. We randomized participation by inviting every passerby to participate if someone was not already participating at that station. The protocol for the auction consisted of the exact same ten steps with every participant and is illustrated in appendix 1.

In step 1, participants learned about the nature of the research and the benefits and risks to them and were asked if they consented to participate. They were informed that they would be engaged in the research for approximately 15-20 minutes and would be compensated $5 and a ½ lb of cheese (approximately a $7 value) for participating in the auction.

In step 2, participants answered a series of questions concerning their basic demographic

data, cheese consumption habits, and the frequency of purchasing cheese made from unpasteurized milk.

Step 3 was a non-binding practice round to introduce participants to the Becker-DeGroot-Marschak (BDM) auction mechanism (Becker et al., 1964). In the BDM auction, a "market" price is randomly generated from a pre-specified distribution chosen by the experimenter and compared to the sealed bid the participant submits. If the individual's bid is greater than the market price, the individual wins the good being auctioned and pays the market price. If the individual's bid is lower than the market price no transaction occurs. Lusk et al. (2004) demonstrated that BDM auctions and English auctions generate statistically equivalent bids regardless of whether participants receive an endowment, offer bids to upgrade, or offer full bids. A BDM mechanism is advantageous in this context because it allows us to conduct the auction in the field with a single participant thus incorporating the participant's heuristics and the effect of the market experience (Lusk and Shogren, 2007).

In the practice round participants tasted two different samples of cheese (approximately 3/4" cube) acquired from two different vendors at each market and labeled with random 3-digit numbers (eg. 324). Instructions on the tablet informed the participants that they were endowed with ½ pound of one cheese but they could offer a bid to switch to the other cheese if they preferred. This is referred to as an "endow and upgrade approach" following Shogren et al. (1994) and Lusk et al. (2005). If a participant accepted the endowed cheese, we refer to them as having chosen that cheese, and if they bid on the alternative cheese then that is the one they chose. Participants' bids were then compared with a random number between $0 and $5 generated by the computer tablet (participants were not informed of the distribution). The tablet then displayed a message informing participants that they won the auction if their bid to switch

was higher than the random market price or lost if their bid was lower. Participants were informed that they would receive the cheese they bid on and be expected to pay the randomly generated price if they won or keep the endowed cheese and pay nothing if they lost. The researcher then reiterated that the practice round was non-binding but there would be multiple rounds of bidding and a single randomly selected binding round at the end.

The endow-and-upgrade approach is advantageous in this context for multiple reasons despite an ongoing debate about the presence of an endowment effect, i.e. that people become attached to a good if they perceive that they own it (Hanemann et al., 1991; Shogren et al., 1999; Corrigan and Rousu, 2006; Plott and Zeiler, 2011). Upgrading directs participant attention away from field substitutes (in this case a field substitute would be a similar cheese available by a vendor at the market) and focuses attention on the marginal difference between the attributes of interest. Endowing participants also minimizes uncertainty and information effects such as the option value problem, where people expect to gather more information in the future about the value of the goods (Corrigan, 2005). We split the participation fee into cash and a cheese endowment; the cheese endowment generates interest in the auction since the subject will leave with the good either way (Lusk and Shogren, 2007) and the relatively small amount of cash allows us to avoid a house money effect, i.e. that people bid more because they are not using their own money (List and Rondeau, 2003).

In step 4, each participant was given a sample of the three cheeses used in the auction (60-day unpasteurized, 60-day pasteurized, and 90-day unpasteurized). From here on we refer to the three cheeses as 60R, 60P, and 90R respectively. These cheeses were all organic Vermont cheddar cheese made by the same cheesemaker and only differed in the date they were processed (60 or 90 days old) and whether or not they were pasteurized. Participants were asked to blindly

evaluate the sensory attributes of the three cheeses using a marked scale. They were instructed to rate the visual, olfactory, and taste attributes of each cheese on a 0-10 scale.

In step 5, participants were presented with two cheese samples aged approximately 60 days and identical except that one was pasteurized and one was not. The cheeses were identified as aged for 60 days and pasteurized or unpasteurized and the participant was "endowed" with the cheese that did not fit their stated preference during the pre-auction survey. Participants who answered "never" or "I don't know" in response to whether they purchase cheese made from unpasteurized milk were endowed with unpasteurized cheese (step 5a), and participants that answered "sometimes" or "often" were endowed with pasteurized cheese (step 5b). Participants were then given the opportunity to "upgrade" to the cheese they were not endowed with.

In step 6, all participants were endowed with a 60-day unpasteurized cheese and given the opportunity to bid to switch to the unpasteurized version aged for 90 days.

Results and Discussion

Hedonic analysis of retail price data

The mean retail price of 227 cheeses sold by two of the largest online retailers is $24.29/lb (table 9, column 1). The mean price of the unpasteurized cheese is approximately $2 more per pound than pasteurized cheese and the difference is statistically significant. For comparison we also present the same estimation after removing cheeses that are aged less than 60 days since most of these are expensive specialty cheeses that in the US can only be produced with pasteurized cheese according to the current federal law. When we compare all cheeses that are aged more than 60 days we are left with a similar number of cheeses in each group and the premium for unpasteurized cheese widens to almost $6 per pound (table 9, column 2).

Table 9. Descriptive statistics of retail prices (per pound) by pasteurization status.

	All observations			Aged > 60 days only		
	Mean	**St.dev**	**N**	**Mean**	**St.dev**	**N**
Unpasteurized	$25.54	6.43	82	$25.54	6.43	82
Pasteurized	$23.59	10.95	145	$19.45	7.43	86
Total	**$24.29**	**9.60**	**227**	**$22.42**	**7.58**	**168**
Mann-Whitney[†]	*Prob > |z| = 0.0141*			*Prob > |z| = 0.0000*		

[†]Note: P-value for a two-sample Wilcoxon rank-sum (Mann-Whitney) test of equivalency between the price of pasteurized and unpasteurized cheese

Next we turn to hedonic price estimation to look at the marginal values of all the attributes simultaneously. When we control for the objective characteristics described above using hedonic price analysis we are able to disaggregate the values more clearly. We identified the main attributes of the cheeses and included them as predictors of price using ordinary least squares (OLS) regression.

In a linear hedonic regression, the coefficients represent the marginal value (in dollars) estimated for each attribute. The attributes include: texture (fresh, soft, semi-soft, semi-hard, hard), milk type (cow, sheep, goat, mixed milk), rind type (bloomy rind, washed rind, washed rind, natural rind, waxed, and clothbound) processing style (cheddar), bacterial cultures (blue), added flavoring (herbs or smoked), and rennet type (animal or microbial). Other independent variables include the length of time the cheese was aged (in months), weight (in pounds), and whether it was pasteurized (dummy variable). A dummy variable is used to indicate whether the cheese ever received an award from the American Cheese Society (ACS) annual competition. Experimental variables include the source of the online data and a random effects component to account for multiple cheeses from a single manufacturer.

When we include each attribute in the regression individually, the cheese style variables are marginally significant with relatively large coefficients. Using a correlation matrix of all the individual attributes and intuition about which attributes tend to occur together we created

interaction terms in order to reduce the number of insignificant variables in the regression, reduce collinearity between texture and style, and better characterize the price of artisan cheese. For example, a bloomy rind cheese is generally a soft cheese that is aged for less than 60 days and is required by law to be pasteurized so we interacted bloomy, soft, and pasteurized. Blue cheese wheels are typically semisoft cheeses so an interaction between blue and semisoft is included. Cheddar is almost always considered a semi-hard cheese and clothbound cheeses are always cheddar. Washed rind cheeses can be any texture. The results of this estimation are presented in Table 10.

Table 10. Marginal values of cheese attributes from hedonic estimate of retail prices

variable	Coef.	Std.	t
Past/bloomy/soft	6.07***	(1.70)	3.56
Blue/semi-soft	4.93***	(2.04)	2.42
Cheddar/semi-hard	-0.02	(1.81)	-0.01
Cloth/cheddar	7.52	(4.57)	1.65
Washed rind	4.38***	(1.86)	2.35
Natural rind	3.33**	(1.75)	1.90
Waxed rind	-0.36	(2.26)	-0.16
Flavors added	3.43***	(1.49)	2.31
Goat milk	8.71	(1.50)	5.80
Mixed milk	-2.25	(2.64)	-0.85
Sheep milk	9.86***	(2.19)	4.51
Pasteurized	-4.19***	(1.40)	-2.98
Age (in months)	0.15***	(0.05)	2.98
Microbial rennet	2.14	(1.39)	1.53
Weight (in pounds)	-0.14***	(0.06)	-2.23
Awards (dummy)	0.67	(1.25)	0.54
Murrays	6.75***	(1.67)	4.03
Constant	18.67***	(2.01)	9.29
R-squared	0.45		
Observations	215		

Notes: The same model with a random effects component for the cheese maker (89 cheese makers in the sample) yields almost identical results (not shown). ** indicates significance at the 5% level, and *** indicates significance at the 1% level. The dependent variable is price per pound. Estimates using OLS with interaction effects.

Most of the interactions are significant compared to cheeses that do not have these attributes. In other words, we have attempted to capture as much of the heterogeneity of the cheeses as possible but attributes that were not easily characterized fall into the constant. Pasteurized bloomy rind soft cheeses and clothbound cheddars are two of the most lucrative combinations at about $6 and $7/pound more than a cheese without these attributes. Blue cheese (which is usually semi-soft) and washed rind cheese both sell for about $4 more than an average cheese. Cheese flavored with herbs or smoked sells for about $3 more than a similar non-flavored counterpart. Milk type variables are significant and large with goat and sheep milk cheeses selling for more than cow milk by about $4/lb. This result is reasonably expected because the milk from the smaller ruminants tends to be higher in fat and is more expensive per gallon. After controlling for other variables, pasteurized cheese sells for $4.19/pound less than unpasteurized cheese on average. The age of cheese (in months) is positive and equal to about $0.15/pound/month or about $1.80/pound/per year. Cheese weight is negative implying that smaller cheeses tend to be more expensive on a per pound basis. The retailer dummy is significant and large since one retailer tends to sell cheeses at approximately $6/pound more than the other.

The hedonic analysis of artisan cheese retail prices shows that in the current market there is no evidence that consumers pay more for pasteurization as a food safety attribute. On the contrary the marginal value is negative and significant for pasteurized cheese (about $4- 5 less per pound), suggesting that consumers place a higher value on unpasteurized cheese. Either consumers do not believe pasteurization is safer, are unaware that the FDA considers pasteurization to be safer, or believe it may be safer but value another attribute (such as the taste) more than pasteurization. Consumers do pay more for aged cheese, but since age is a signal of

quality in terms of both taste and safety, from retail prices we cannot determine whether consumers who pay more for aged cheese do so because it is safer or because it tastes better. We explore this question in the experimental portion of the research.

Hedonic analysis of experimental auction bids

Descriptive statistics of participants

Table 11 summarizes the descriptive statistics for selected demographic variables. One hundred fifty-three, 98, and 96 consumers from farmers markets in Michigan, New York, and Vermont, respectively participated in experimental auctions for a total of n=347 participants. The sample was approximately 36% female with an average age of 43. The highest level of education attained by 10% of the sample was high school, the highest level of education attained by 52% of the sample was a college degree, and 38% attained postgraduate education. This sample was more educated than the average American where high school was the highest level of education for 47.07% of the population and 30.9% attained a college degree or higher (United States Census Bureau, 2012a). The distribution of reported household income in our sample was relatively similar to the overall US population albeit with fewer participants from the highest income households. Across the US approximately 32% of households have income less than $30,000, 40% have income between $30,000 and $80,000 and 28% have income more than $80,000 (United States Census Bureau, 2012b). There were two slight differences between New York and Vermont which balanced each other out overall: in New York fewer participants than average were in the $30,000 to $80,000/year category and in Vermont slightly more than average fell into the less than $30,000/year category. Approximately 25% of the sample had children and 80% of participants considered themselves the primary shopper in the household.

Table 11. Descriptive statistics and definitions of demographic variables

Variable	Definition	All	MI	NY	VT
Gender	1 if individual is male; 0 if individual is female	0.36	0.37	0.37	0.34
		(0.48)	(0.48)	(0.48)	(0.48)
Age	Age in years	42.94	43.77	43.56	41.01
		(16.55)	(17.89)	(15.1)	(15.78)
Education	High school	10%	11%	9%	10%
	College	52%	53%	54%	47%
	Post graduate	38%	35%	37%	43%
Income	<$30,000	26%	27%	14%	33%
	$30,000 to 80,000	34%	33%	43%	23%
	>$80,000	29%	25%	31%	28%
	Prefer not to answer	11%	15%	7%	9%
Children	1 if children under 16 are living at home; 0 otherwise	0.25	0.26	0.26	0.23
		(0.43)	(0.44)	(0.44)	(0.42)
Primary shopper	1 if individual is primary shopper in household; 0 otherwise	0.8	0.83	0.75	0.8
		(0.4)	(0.4)	(0.44)	(0.41)
Pounds	Cheese consumption in pounds in the last 2 weeks	1.96	1.92	2.12	1.85
		(1.72)	(1.47)	(2.45)	(1.02)
Artisan	1 if individual consumes artisan cheese; 0 otherwise	0.86	0.84	0.97	0.78
		(0.35)	(0.37)	(0.17)	(0.42)
% Artisan	% of cheese consumption that is artisan	26.86	26.22	28.78	25.92
		(25.63)	(26.63)	(22.37)	(27.28)
Unpasteurized cheese	Never purchase	9%	9%	9%	10%
	Sometimes purchase	43%	39%	43%	50%
	Often purchase	14%	13%	13%	17%
	Don't know	34%	40%	35%	23%
Food poisoning	1 if individual has had food poisoning; 0 don't know or no	0.57	0.63	0.52	0.54
		(0.50)	(0.49)	(0.50)	(0.50)
Observations		347	153	98	96

Notes: Mean value is reported except when there is a percentage. Standard deviations are in parentheses.

Participants reported consuming an average of about two pounds of cheese in their household in the last two weeks and 86% of consumers reported consuming artisan cheese in the last two weeks overall. Approximately 27% of all the cheese reportedly consumed by participants in the last week was artisan cheese. The majority of participants consume cheese made from unpasteurized milk: 43% “sometimes” purchase it and 14% “often” purchase it. Thirty-four percent of participants answered “I don’t know” and 9% never purchase it.

We also calculated the percentage of participants in each state who were local residents based on the zip codes provided. In Michigan, 97% of those surveyed were Michigan residents, in New York 82% of participants were New York residents, and in Vermont only 65% of participants were Vermont residents. The demographics in Vermont appear to be influenced by a transient tourist or student population while the participants at farmers markets in Michigan were almost all local residents. The average participant in Vermont was younger, more educated, had lower income, consumed less cheese and less artisan cheese in particular but was more likely to consume cheese made from unpasteurized milk. In the analysis that follows we control for any differences in demographics but in general find that they have little influence on WTP.

Sensory evaluations

Participants were instructed to rate the sensory characteristics: visual, olfactory, and taste, on a scale from 0 (labeled dislike) to 10 (labeled like). The default on each scale was set to 5, which was labeled as neutral to participants.

First we look at means comparisons between the three states (Michigan, New York, and Vermont) and then within the three cheeses (60R, 60P, 90R). One-way ANOVA comparison of multiple means determined that there was no statistical difference in the visual or olfactory ratings across the states. With respect to taste there was a difference in ratings between consumers in Michigan and the other two states. Between Michigan and New York there was a difference of -0.39 at the 3% confidence level and between Michigan and Vermont there was a difference of -0.50 at less than 1% confidence. There was no statistical difference between New York and Vermont however.

Table 12. Summary of sensory ratings

All States	Visual	Olfactory	Taste
Unpasteurized 60-day	6.96	6.09[a]	6.18[a]
	(1.95)	(1.99)	(2.23)
Pasteurized 60-day	6.72	6.10[a]	6.41[a]
	(1.84)	(1.75)	(2.06)
Unpasteurized 90-day	6.94	6.54[b]	7.08[b]
	(1.93)	(1.85)	(1.94)
Michigan	**Visual**	**Olfactory**	**Taste**
Unpasteurized 60-day	7.01	6.09	6.58[a]
	(1.96)	(2.08)	(2.26)
Pasteurized 60-day	6.75	6.14	6.59[a]
	(1.85)	(1.82)	(2.21)
Unpasteurized 90-day	6.94	6.53	7.25[b]
	(1.96)	(1.89)	(2.05)
New York	**Visual**	**Olfactory**	**Taste**
Unpasteurized 60-day	6.89	6.06	5.95[a]
	(1.96)	(2.08)	(2.19)
Pasteurized 60-day	6.76	6.12	6.28
	(1.85)	(1.71)	(2.01)
Unpasteurized 90-day	6.78	6.54	7.02[b]
	(1.99)	(1.88)	(1.98)
Vermont	**Visual**	**Olfactory**	**Taste**
Unpasteurized 60-day	6.95	6.10	5.80[a]
	(1.95)	(1.74)	(2.13)
Pasteurized 60-day	6.65	6.03	6.26
	(1.82)	(1.71)	(1.84)
Unpasteurized 90-day	7.09	6.57	6.85[b]
	(1.82)	(1.80)	(1.70)

Note: Ratings are based on a scale of one to ten with ten being the highest and five neutral. Standard deviations are in parenthesis. If two mean ratings within a state for a given cheese treatment have the same letter they are not statistically different. If they have different letters then the Bonferroni-adjusted significance of the difference between the three cheese varieties is 5% or better in that state. If there are no letters there is no statistical difference.

The difference in the visual ratings between the three cheeses for participants in all states was not significant at a conventional level but the two unpasteurized cheeses had somewhat higher visual ratings, possibly because of the more natural knitted curd appearance that is lost with pasteurization (via homogenization). There was no significant difference between the olfactory ratings of the unpasteurized 60-day cheese and the pasteurized 60-day cheese but there was between each of those two cheeses and the unpasteurized 90-day aged cheese (indicated by the superscripted letters in table 12). The higher ratings on the olfactory and taste characteristics

of the aged cheese make sense since these qualities tend to improve as a cheese ages. In Michigan there were differences in the taste ratings between the two younger cheeses and the 90-day aged cheese as in the aggregated data. In New York and Vermont the only statistical difference was that the taste of the unpasteurized 60-day cheese was rated statistically lower than the unpasteurized 90-day cheese.

From these ratings we conclude that the average artisan cheese consumer cannot detect a taste difference between a pasteurized and an unpasteurized cheese but can detect a difference related to aging the cheese. These findings differ from Colonna et al. (2011) who conducted sensory tests with pasteurized and unpasteurized versions of numerous cheeses and found that more people preferred cheese made from unpasteurized milk cheese on average (in blind taste tests and particularly when they were labeled). The experiment used in this paper was designed to look at how consumers make tradeoffs between cheese safety and quality attributes, not specifically to look at the differences in the sensory attributes between the cheeses. A more appropriate experimental design for that research question would involve multiple varieties of cheese as per Colonna et al. (2011). We chose a cheddar cheese in this experiment for broad consumer appeal but the flavor differences would be expected to be a little less dramatic with a variety like cheddar, which is typically sold as an aged cheese. A professional sensory analyst suggested that the pasteurized cheese used in this research had superior mouthfeel likely caused by the homogenization of the milk that occurs during pasteurization which gives it a more uniform texture that is now more mainstream due to the prevalence of pasteurization.

Attitudes about food safety

We asked a series of questions to gauge consumers' perceptions of safety and risk as it relates to food and the responses are reported in table 13. Other authors have found that attitudes towards technology, nature and food affect individuals' perceptions of the benefits and risks of production technologies like genetic modification (Bredahl, 2001).

Table 13. Summary statistics and definitions of attitudinal variables

Variable	Description (1=disagree; 10=agree)	Mean (SD)
worry	I worry about the safety of the food I buy	6.79 (2.99)
trust_gov	I trust that government food safety regulations protect me adequately.	4.35 (2.82)
standards	I would like to see stronger food safety standards imposed in the US.	6.22 (2.75)
pay more	I would pay more for a product with a higher than average level of food safety.	6.60 (2.75)
expiration	I check the expiry or "best before" date on food before purchasing it.	8.12 (2.48)
floor	I throw out any food that falls on the floor while being prepared.	4.91 (4.73)
raw milk	I think it is safe to drink unpasteurized milk if I know the source.	6.71 (2.80)
natural	I usually aim to eat natural foods.	7.87 (2.07)

On average the artisan cheese consumers who participated in the study worry about food safety. They don't particularly trust that government food safety regulations protect them but they would like to see stronger food safety regulations imposed. This suggests there may be some debate about exactly what stronger regulations would entail and what food safety means to participants. Subjects say they would pay more for a product with higher food safety. Participants appear to be very concerned about expiration dates despite the inconsistency and lack of regulation governing the use of expiry dates. Overall, subjects were neutral about food that falls on the floor while being prepared but notably there was wide variation in these

responses, suggesting that some participants do and some do not. On average participants think it is safe to drink unpasteurized milk if they know the source and presumably those that chose the unpasteurized cheese were more likely to agree with this statement. On average participants in the study indicated that they aim to eat natural foods. Presumably the differences in the attitudes of participants about food safety can help explain their choice between pasteurized and unpasteurized cheese. We explore the responses to these attitudinal questions and other determinants of choosing a pasteurized or aged cheese in the next section.

Determinants of choosing unpasteurized cheese and aged cheese

In this section we look at the determinants of a) the probability that a consumer chose the unpasteurized cheese over the pasteurized cheese in the first round and b) the probability that a consumer chose the unpasteurized aged cheese over the unpasteurized unaged cheese in round 2. To do this we estimate logistic regressions with the dependent variable as the cheese that was chosen in each round, even in cases where the endowed cheese was chosen and the bid was zero.

In round 1, the odds of whether a participant chooses unpasteurized over pasteurized are largely based on sensory ratings of the cheese and consumer attitudes about food safety. The higher participants rated the smell and taste of the unpasteurized cheese (and the lower they rated the smell and taste of the pasteurized cheese), the more likely they were to choose the pasteurized cheese. Responses to a number of the questions designed to gauge consumers' attitudes about food safety had statistically significant coefficients. Participants who want stronger food safety standards imposed in the US were more likely to choose the pasteurized cheese. Participants that check expiry dates before purchasing food are less likely to purchase unpasteurized cheese. Participants that would consume raw milk if they knew the source are less

likely to choose the pasteurized cheese.

Table 14. Logistic regression of the odds of choosing a pasteurized or aged cheese

	Pasteurized		Aged		
variables	Coef.	Std. Err	Coef.	Std. Err	variables
Demographic variables					
Gender	0.22	(0.31)	0.41	(0.35)	Gender
Age (in years)	0.00	(0.01)	-0.01	(0.01)	Age (in years)
Income (>80,000)	0.21	(0.43)	0.53	(0.48)	Income (>80,000)
Income (30-80,000)	-0.09	(0.41)	0.37	(0.45)	Income (30-80,000)
Income (not reported)	0.87	(0.55)	0.31	(0.60)	Income (not reported)
College graduate	0.60	(0.50)	1.20**	(0.54)	College graduate
Post graduate	0.98	(0.55)	1.88***	(0.62)	Post graduate
Children (dummy)	0.00	(0.17)	0.11	(0.19)	Children (dummy)
Primary shopper	0.12	(0.40)	-0.48	(0.43)	Primary shopper
Cheese consumed (lbs)	-0.02	(0.09)	0.14	(0.08)	Cheese consumed (lbs)
Artisan (percent)	0.00	(0.01)	0.00	(0.01)	Artisan (percent)
Sensory variables					
R60_visual	-0.10	(0.12)	-0.05	(0.14)	R60_visual
R60_smell	-0.26***	(0.10)	-0.38***	(0.12)	R60_smell
R60_taste	-0.60***	(0.11)	-0.82***	(0.12)	R60_taste
P60_visual	0.10	(0.14)	-0.12	(0.15)	R90_visual
P60_smell	0.22	(0.12)	0.33***	(0.14)	R90_smell
P60_taste	0.60***	(0.11)	1.08***	(0.15)	R90_taste
Attitudinal variables					
worry	-0.01	(0.06)	0.13**	(0.06)	worry
trust_gov	-0.03	(0.05)	0.07	(0.06)	trust_gov
stronger_standards	0.15***	(0.07)	-0.01	(0.07)	stronger_standards
pay_more	-0.07	(0.08)	-0.11	(0.08)	pay_more
expirydate	0.15***	(0.06)	-0.08	(0.07)	expirydate
floor	-0.07	(0.05)	-0.04	(0.06)	floor
raw_milk	-0.11**	(0.05)	-0.01	(0.06)	raw_milk
natural	-0.10	(0.07)	0.10	(0.09)	natural
Other variables					
Food poisoning	0.30	(0.29)	0.28	(0.33)	Food poisoning
Endowment (dummy)	0.92***	(0.32)	0.37	(0.34)	Endowment (dummy)
Inconsistent choice	-1.49***	(0.43)	--	--	
Consistent choice	0.18	(0.33)	--	--	
Vermont	0.74**	(0.34)	-0.11	(0.37)	Vermont
New York	0.76**	(0.34)	-0.06	(0.39)	New York
Constant	-1.97	(1.17)	-2.66**	(1.29)	Constant
Pseudo R-squared	0.2978			0.3823	Pseudo R-squared

Notes: ** indicated significance at the 5% level, and *** indicates significance at the 1% level. Pasteurized is the choice between U60 (unpasteurized aged for 60 days) and P60 (pasteurized aged for 60 days) and aged is the choice between U60 and U90 (unpasteurized aged for 90 days). Inconsistent choice and consistent choice were omitted from the "Aged" regression because the unaged cheese was the endowed cheese every time so "inconsistent" was determined by choice.

Participants endowed with pasteurized cheese were more likely to choose pasteurized

cheese, supporting the notion that many consumers took the endowed cheese because it was free. We also included a dummy variable for whether participants' taste preferences were consistent with their choices in the pasteurization round. We found that those whose choice was inconsistent with their taste preference were less likely to choose the pasteurized cheese, implying that advocates of raw milk cheese chose it simply because the cheese was identified as unpasteurized. Finally, participants who participated in the study in Vermont and New York were more likely to choose pasteurized cheese than those in Michigan.

The odds of choosing a cheese that is aged, on the other hand, is a function of education and taste and a slight concern about food safety. More educated participants (with a college or post graduate education) are more likely to choose an aged cheese than someone with less education. The smell and taste of the cheeses was also important in the odds of a participant choosing the aged cheese. Finally there is weak evidence that participants chose the aged cheese because of a safety concern—those that worry about the safety of the food they buy were more likely to choose the aged cheese but the magnitude of this difference is quite small.

Weighing sensory preferences versus safety attributes

In this section and the next we explore the tradeoff consumers make between sensory preferences and safety by checking if participants' choices are consistent with the order of their taste preferences. First we look at whether participants' notions of quality conveyed through sensory ratings are consistent with their choice between the pasteurized and unpasteurized cheese.

First we look at the tradeoffs between sensory preferences and pasteurization status. In step 5 of the auction, 347 subjects had to make a choice between P60 and U60; 186 participants (54%) chose the unpasteurized cheese and 161 participants (46%) chose the pasteurized cheese

in the first round, regardless of which cheese they were endowed with. Of the 347 subjects who participated in the experimental auctions, 108 participants (31%) ranked the taste of the unpasteurized cheese higher than the pasteurized cheese (R>P), 138 (40%) ranked the tastes the same (R=P), and 101 (29%) subjects ranked the taste of the unpasteurized cheese higher (R<P).

Fifty-three percent of participants' choices in the first round of the auction were consistent with their taste preferences (see table 15) with slightly more of those choosing pasteurized over unpasteurized cheese. Presumably these participants have a preference for either pasteurized or unpasteurized cheese on principle and prefer the taste of the cheese they selected.

Table 15. Consistency between auction participants' choice and sensory ratings

Total sample	Choice[1]	Endowment	taste preference[2]	n for each choice x endowment x taste preference combination	Consistency of choice & taste preference[3]
N= 347	60R (raw) 186	P 99	R>P	47	consistent
			R=P	30	inconsistent
			R<P	22	
		R 87	R>P	40	consistent
			R=P	31	indifferent
			R<P	16	
	60P (past.) 161	P 99	R>P	16	
			R=P	27	
			R<P	56	consistent
		R 62	R>P	5	inconsistent
			R=P	13	
			R<P	44	consistent

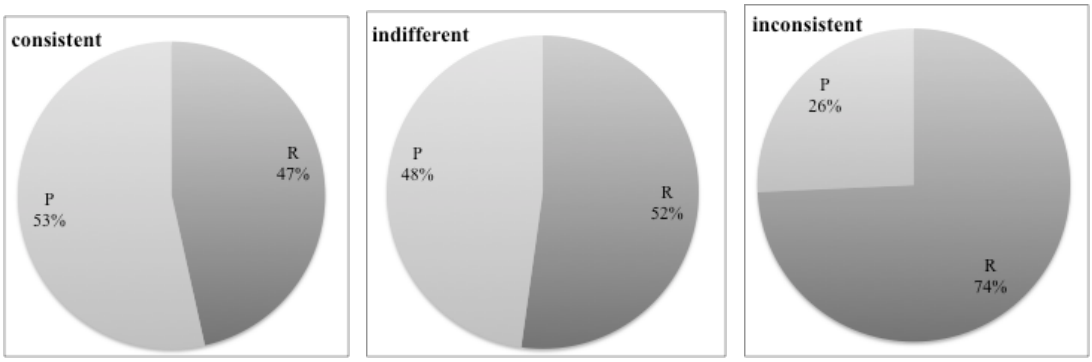
[1] The participant's choice is either the endowed cheese (if they did not bid) or the alternative cheese (if they did bid).
[2] R>P indicates the participant has a sensory preference for raw (unpasteurized) over pasteurized cheese, R<P indicates a sensory preference for pasteurized cheese, and R=P indicates indifference between the two.
[3] "Consistent" represents consumers whose choice was consistent with their taste preferences, "indifferent" represents that they rated the two cheeses equal or took the endowed free cheese, "inconsistent" indicates that their choice was inconsistent with their taste preference (including participants who rated them equal but did not take the free cheese).

Approximately 26% of the sample was indifferent between the two cheeses or had preferences that were not strong enough to justify bidding so they took the endowed cheese (presumably because it was free). The majority of these consumers rated the tastes equally and

would have been happy with either cheese so it makes sense that they took the free one. Presumably the preferences of the remaining participants in this group were not strong enough to warrant paying more.

The third group, approximately 20% of the sample, made a choice that was either inconsistent with their taste preferences or they rated the taste of the two cheeses equally but still chose to bid to switch rather than take the free cheese.

Figure 5. Portion of participants whose choices were consistent, indifferent, and inconsistent with the taste ratings they gave to the pasteurized (P) and unpasteurized cheese (R).



Notes: consistent implies that participants rated cheese P higher and chose P, indifferent implies that the participant rated them equally or rated the opposite cheese (R) higher but took the free endowed cheese (P), and inconsistent implies that they rated the opposite cheese (R) higher or equal (to P) but chose the cheese that required them to bid.

Figure 5 illustrates the categorizations outlined above broken down by participants' choices. Fifty four percent of participants made choices that were consistent with their taste preference, 26% were indifferent (rated them equally or took the free one despite rating the other one higher), and 20% were inconsistent (their highest taste rating differed from their choice). A slight majority of participants whose choices were consistent with their sensory ratings preferred the pasteurized cheese. Among participants who took the free or endowed cheese they were almost equally divided as well with slightly more taking the unpasteurized cheese. Among participants whose sensory ratings were inconsistent with their choice we see a large difference.

Approximately ¾ of these participants chose the unpasteurized cheese, suggesting that they would choose an unpasteurized cheese over a pasteurized cheese on principle.

Table 16 reports the attitudinal responses of participants by each of the consistency groups described above. Statistically the consistent group, who voted with their taste buds, is the same regardless of what choice they made (between raw and pasteurized). An attitudinal divide however, emerges with the inconsistent group.

Table 16. Attitudinal responses by consistency group

Description (1=disagree; 10=agree)	consistent		p-value	inconsistent		p-value	indifferent		p-value
	Raw	Past		Raw	Past		Raw	Past	
I worry about the safety of the food I buy	7.05 (2.91)	6.28 (2.99)	0.08	6.77 (3.03)	7.61 (2.28)	0.29	6.66 (3.34)	7.28 (3.01)	0.36
I trust that government food safety regulations protect me adequately.	4.69 (3.10)	3.95 (2.99)	0.08	3.92 (2.74)	5.61 (2.52)	0.02	5.04 (2.62)	3.86 (2.78)	0.04
I would like to see stronger food safety standards imposed in the US.	6.62 (2.67)	6.28 (2.70)	0.40	5.35 (2.95)	6.89 (2.05)	0.04	5.94 (2.93)	6.40 (2.77)	0.45
I would pay more for a product with a higher than average level of food safety.	6.81 (2.41)	6.38 (2.39)	0.23	6.17 (2.65)	6.61 (2.48)	0.55	6.62 (2.95)	7.19 (2.28)	0.31
I check the expiry or "best before" date on food before purchasing it.	7.98 (2.56)	7.99 (2.46)	0.97	7.21 (2.98)	9.06 (1.30)	0.01	8.74 (2.01)	8.74 (2.11)	1.00
I throw out any food that falls on the floor while being prepared.	4.81 (3.32)	5.00 (3.23)	0.70	4.12 (3.32)	5.17 (2.98)	0.24	5.47 (3.44)	3.70 (3.12)	0.01
I think it is safe to drink unpasteurized milk if I know the source.	6.83 (2.60)	6.30 (2.94)	0.20	7.81 (2.48)	5.44 (3.15)	0.00	6.72 (2.70)	6.60 (2.90)	0.84
I usually aim to eat natural foods.	7.80 (2.27)	7.69 (1.95)	0.71	8.69 (1.83)	7.11 (2.49)	0.01	7.53 (2.24)	8.09 (1.64)	0.18
number of observations	86	99		52	18		47	43	

*Notes: "Consistent" represents consumers whose choice was consistent with their taste preferences, "indifferent" represents that they rated the two cheeses equal or took the endowed free cheese,, "inconsistent" indicates that their choice was inconsistent with their taste preference (including participants who rated them equal but did not take the free cheese). P-values report ANOVA test of difference between ratings (0-10).

Within the inconsistent group, participants choosing the pasteurized cheese over the raw cheese trust government regulations and would like to see stronger food safety standards imposed. They also prefer to take food safety into their own hands, reportedly checking

expiration dates more, but they are less likely to entrust their safety to someone else—knowing the source of a food with controversial safety is not enough for them. The participants that chose the pasteurized cheese are also less fervent about eating natural foods than the group who chose the unpasteurized cheese.

The indifferent group was statistically quite similar except that respondents who chose pasteurized milk were less likely to trust government food safety regulations and less likely to throw out food that falls on the ground. This suggests that the indifferent group is generally more carefree about food safety than the other groups.

Next we look at the tradeoffs between sensory preferences and age. All participants were endowed with the 60R cheese and asked to choose between 60R and 90R in step 6 of the auction. Of the 347 participants, 139 chose the 60-day unpasteurized cheese (60R) and 208 chose the 90-day unpasteurized cheese (90R). The unpasteurized 60-day cheese was the default cheese for all consumers in this round.

Sixty-eight percent of participants had sensory preferences for either the 90-day aged cheese or the 60-day aged cheese that were consistent with their choice of cheese. The vast majority of these participants (70%) had higher sensory ratings for the 90-day aged version. Twenty-one percent of participants were either indifferent to the sensory attributes of the two cheeses or preferred the 90-day aged cheese but took the unpasteurized 60-day cheese because it was the endowed cheese. Some of these participants were indifferent based on their sensory ratings (rated them equally) so it makes perfect sense to take the endowed cheese since it is free. The rest of the participants in the indifferent group rated the aged cheese higher so their preferences were not strong enough to justify switching or they did not like the idea of more aged cheese.

Table 17. Consistency between participants' choices and sensory ratings of aged cheese

Total sample	Choice[1]	taste preference[2]	n for each choice x endowment x taste preference combination	Consistency of choice & taste preference[3]
N= 347	60R (raw) 139	60>90	67	consistent
		60=90	41	indifferent
		60<90	31	
	90R (aged) 208	60>90	10	inconsistent
		60=90	28	
		60<90	170	consistent

[1] The participant's choice is either the endowed cheese (60-day aged cheese if they did not bid) or the 90-day aged cheese (if they did bid).
[2] 60>90 indicates the participant has a sensory preference for the 60-day cheese over the 90-day, 60<90 indicates a sensory preference for the 90-day cheese, and 60=90 indicates indifference between the two.
[3] "Consistent" represents consumers whose choice was consistent with their taste preferences, "indifferent" represents that they rated the two cheeses equal or took the endowed free cheese, "inconsistent" indicates that their choice was inconsistent with their taste preference (including participants who rated them equal but did not take the endowed/free cheese).

The remaining 11 percent of participants chose a cheese inconsistent with their taste preferences. Some of these participants rated the taste equally but bid on the aged cheese after seeing that it was aged longer, while the others preferred the 60-day cheese but chose the 90-day cheese aged cheese, either because they think aged cheese is supposed to be higher quality or because they think it is safer.

WTP and effect of cheese type and location on WTP

Next we look at the experimental auction bids for each of the three cheeses (unpasteurized, pasteurized and aged). Summary statistics of the mean auction bids and mean auction bids with the non-zero bids excluded are reported in table 18. Of the 347 people sampled, in step 5 of the auction 198 (57%) were endowed with pasteurized cheese and invited to bid to switch to an unpasteurized version and 149 (43%) were endowed with unpasteurized cheese and invited to bid to switch to a pasteurized version. The mean price difference that the 198 participants endowed with pasteurized cheese were willing to pay for half a pound of the

unpasteurized cheese was $1.20 and when zero bids were removed (99) consumers were willing to pay on average $2.40 to upgrade. The mean price difference that the 149 participants endowed with unpasteurized cheese were willing to pay for half a pound of the pasteurized cheese was $0.94 and $2.26 when we removed the zero bids.

Table 18. Summary statistics of WTP by cheese type and location

Round	N	Mean WTP	Std. Dev	Min WTP	Max WTP	Non-zero Obs	% Non-zero	Non-zero Mean WTP	Non zero Std Dev.
All States									
Unpasteurized	198	$1.20	$1.55	0	5	99	50%	$2.40	$1.38
Pasteurized	149	$0.94	$1.44	0	5	62	42%	$2.26	$1.41
Aged	347	$1.54	$1.66	0	6	208	60%	$2.57	$1.40
Michigan									
Unpasteurized	79	1.59_a$	$1.74	0	5	46	58%	$2.73	$1.44
Pasteurized	74	0.62_a$	$1.09	0	4	25	34%	$1.82	$1.15
Aged	153	1.52_a$	$1.73	0	6	88	58%	$2.64	$1.50
New York									
Unpasteurized	55	0.91_b$	$1.35	0	5	20	36%	$2.51	$0.98
Pasteurized	43	0.94_a$	$1.50	0	5	16	37%	$2.53	$1.42
Aged	98	1.63_a$	$1.66	0	5	61	62%	$2.62	$1.35
Vermont									
Unpasteurized	64	0.97_b$	$1.37	0	5	33	52%	$1.89	$1.38
Pasteurized	32	1.69_a$	$1.78	0	5	21	66%	$2.58	$1.59
Aged	96	1.50_a$	$1.56	0	5	59	61%	$2.43	$1.29

Notes: Participants either bid to switch to a pasteurized or an unpasteurized cheese and then all participants bid to switch from an unaged to an aged version. All cheese samples were approximately 0.5 pounds. The subscripts report differences between the states within each cheese type. For unpasteurized cheese, the mean WTP was statistically different between Michigan (a) and New York (b) and Vermont (b).

As described above, in step 6 of the auction all 347 participants were given a choice between an unpasteurized cheese aged 60 days and an unpasteurized cheese aged 90 days. Overall they were willing to pay $1.54 for the cheese aged an additional 30 days and $2.57 when non-zero bids are excluded.

Table 19 reports the results of tests of equivalence of the WTP between the three cheese types (unpasteurized 60-day, pasteurized 60-day, and unpasteurized 90-day) for all states. We

report the results of a Bonferroni multiple-comparison test, a parametric two-sample t-test and a non-parametric Mann-Whitney U test. In cases where the significance level differs across tests we place more emphasis on the non-parametric test given the non-normality of the data since it is censored. The test results indicate that when we look at the aggregate data across the three states there is a significant difference among the WTP between all pairs of cheeses.

Table 19. Test of equivalence of WTP across cheese by pasteurization and age

Test	P60	U60	
Bonferroni	0.39*	N/A	
Two-sided t	(0.08)**		U60
Two-sample Wilcoxon	[0.05] †		
Bonferroni	0.00	0.04	
Two-sided t	(0.00)	(0.00)	U90
Two-sample Wilcoxon	[0.00]	[0.00]	

Notes: U60= unpasteurized 60-day aged, U90=Unpasteurized 90-day, and P60= Pasteurized 60-day. P-values for a Bonferroni multiple comparison test*, two sided t-test** and two-sample Wilcoxon rank-sum (Mann-Whitney) test of equivalence† of WTP across cheese by pasteurization and age (60-versus 90-day aged, N=347).

In Michigan, the split between participants endowed with the pasteurized cheese versus those endowed with the unpasteurized cheese was much closer than other states, indicating that a greater portion of people in Michigan were either opposed to raw milk or unaware of the raw milk debate. Michigan consumers were willing to pay the most for the unpasteurized cheese. New Yorkers were indifferent between the pasteurized and unpasteurized cheese and had the highest WTP for the aged cheese. In Vermont twice as many consumers were endowed with pasteurized cheese than unpasteurized cheese, indicating that participants in Vermont were more likely to knowingly consume cheese made from unpasteurized milk. The portion of the Vermont consumers who bid on unpasteurized cheese was willing to pay the least out of all three states and the portion of participants in Vermont that bid on pasteurized cheese bid the most for it. When interpreting these results it should be taken into consideration that many participants in Vermont were from out of state and likely tourists.

We also compare the mean difference in WTP between states using one-way analysis-of-variance (ANOVA) reported in table 10 using subscripts. The value of the test statistic is compared with a corresponding significance level (Chi squared with k-1 degrees of freedom). Comparison of the unpasteurized cheese and pasteurized bids across states are significant at about the 1% level (p=0.02 and p=0.00 respectively) indicating that the means are not all equal. There is higher WTP in Michigan for the unpasteurized cheese and higher WTP for the pasteurized cheese in Vermont. This is likely due to the fact that many participants in Vermont were from out of state but we cannot test this since participants' zip codes are not linked to the responses for confidentiality reasons. There is no statistical difference across the states for the aged cheese, indicating roughly equivalent willingness to pay (WTP=1.54 and P=0.82).

Hedonic analysis of auction bids

We perform hedonic analysis of experimental auction bids as per Melton et al. (1996). We use a tobit type model to accommodate the large number of censored bids from consumers who bid zero because they preferred the cheese they were endowed with. We use a random effects specification since each participant bid in each of the rounds and their bids are related in this way.

Table 20. Hedonic analysis of experimental auction bids

WTP	Coef.	Std.	z
Pasteurized	-0.20	(0.44)	-0.47
Aged	0.73***	(0.28)	2.62
Age (years)	-0.02**	(0.01)	-2.09
Income (>80,000)	0.75**	(0.33)	2.30
Income (30-80,000)	0.18	(0.30)	0.60
Income (not reported)	1.12***	(0.42)	2.69
College graduate	-0.10	(0.37)	-0.27
Post graduate	0.00	(0.40)	-0.01
Pounds	0.13**	(0.06)	2.04
Taste 60R (0-10)	-0.31***	(0.07)	-4.48
Taste 60P (0-10)	-0.14**	(0.07)	-1.92
Taste 90R (0-10)	0.53***	(0.07)	7.14
worry	0.07	(0.04)	1.57
trust_gov	0.04	(0.04)	0.90
stronger_standards	-0.05	(0.05)	-0.93
pay_more	-0.01	(0.06)	-0.20
expirydate	-0.05	(0.05)	-1.05
floor	-0.03	(0.04)	-0.78
raw_milk	0.04	(0.04)	0.80
natural	0.07	(0.06)	1.08
Endowment (dummy)	0.36	(0.32)	1.13
Constant	-1.54	(0.90)	-1.71
Sigma u	0.11	(1.88)	0.06
Sigma e	2.53	(0.14)	18.12
Rho	0.00	(0.07)	0.00
Observations	690		
Censored	337		

Notes: ** indicated significance at the 5% level, and *** indicates significance at the 1% level.

Artisan cheese consumers who participated in the study are not willing to pay more for pasteurization status but they are willing to pay more for aged cheese. The most important determinant of how much a consumer is willing to pay for artisan cheese is their income level, followed by their taste preferences. As we would expect, consumers in the highest income bracket were willing to pay more than those in the lowest income group to get the cheese they wanted. Taste matters very much to consumers; the higher they rated a given cheese the more they were willing to pay for it. Other determinants of artisan cheese consumer WTP are their age (older consumers pay less for cheese on average) and how much cheese they consume. None of the questions about attitudes towards food safety played a role in determining consumer WTP.

Conclusions

Hedonic analysis of both the retail data and the experimental auction data demonstrates that consumers of artisan cheese are not willing to pay more for pasteurization. On the contrary, artisan cheese consumers pay more for unpasteurized cheese both in the current market and in an experimental setting. All else equal, artisan cheese consumers are also willing to pay more for an aged cheese in both analyses but it appears that this decision is mostly related to an improvement in the quality of taste rather than an improvement in the safety.

One important feature of artisan products is heterogeneity. We are able to partially capture this heterogeneity through various independent variables used in the hedonic analysis of retail prices (about 50% of it). There is however, a large amount of variation in price that cannot be accounted for and this appears to be related to the elasticity of artisan cheese demand. Producers reportedly set prices based on what they think the cheese is worth and what it takes to cover their lifestyle and keep them milking cows and making craft cheese (Paxson, 2013). The heterogeneity of cheese and the emphasis on creativity and originality also means that styles of cheese are difficult to characterize and frequently changing as are US consumers' preferences.

Consumer preferences are also heterogeneous. In blind tasting there was no significant difference in the ratings between pasteurized and unpasteurized cheese. More than half of consumers in the study chose the cheese they gave the highest taste ratings to, one quarter took the free cheese, and only one fifth of consumers seem to have based their decision on whether or not the cheese was pasteurized and most of those participants chose the unpasteurized cheese. This heterogeneity in preferences could provide justification for policy that allows two distinct markets to exist. The science is ambivalent on the safety of artisan cheese and this research shows that consumer opinions and values do not indicate that consumers are concerned about the

safety of unpasteurized cheese. While there are many consumers who are indifferent there are also consumers with strong preferences for both pasteurized and unpasteurized cheese, particularly in favor unpasteurized artisan cheese.

Consumers' attitudes about food safety were an important determinant of their decision to choose one cheese or the other and this difference is seemingly ideological. Consumers who chose pasteurized cheese on principle (i.e. they chose the pasteurized cheese even though they rated the taste of the unpasteurized cheese higher) were more likely to trust government regulation of food safety and more interested in seeing stronger regulations. On the other hand, consumers who chose the unpasteurized cheese on principle were more likely to trust a product that was not regulated by the government but rather sold directly by the producer.

Lusk (2012) found that people think about food policy and regulation differently than other types of issues and concluded "food ideology represents a unique construct in its own right". In this sample it appears that there are a range of attitudes about what constitutes a risk as well as a difference in opinions of how involved the government should be in food safety. While the safety of raw milk cheese appears to be an ideological decision to some artisan cheese consumers, the majority makes purchasing decisions consistent with their taste preferences. Other consumers do not view pasteurization of milk used in cheesemaking as a safety concern and make their decisions based on price when they consider the two products of equal taste. The majority of the sample who made the decision seemingly on ideological grounds chose the unpasteurized cheese.

Many studies assume that attitudes about controversial production practices or food technologies can be explained by a lack of consumer education or negative media attention. Numerous studies in the economics literature make this assumption and frame their research in

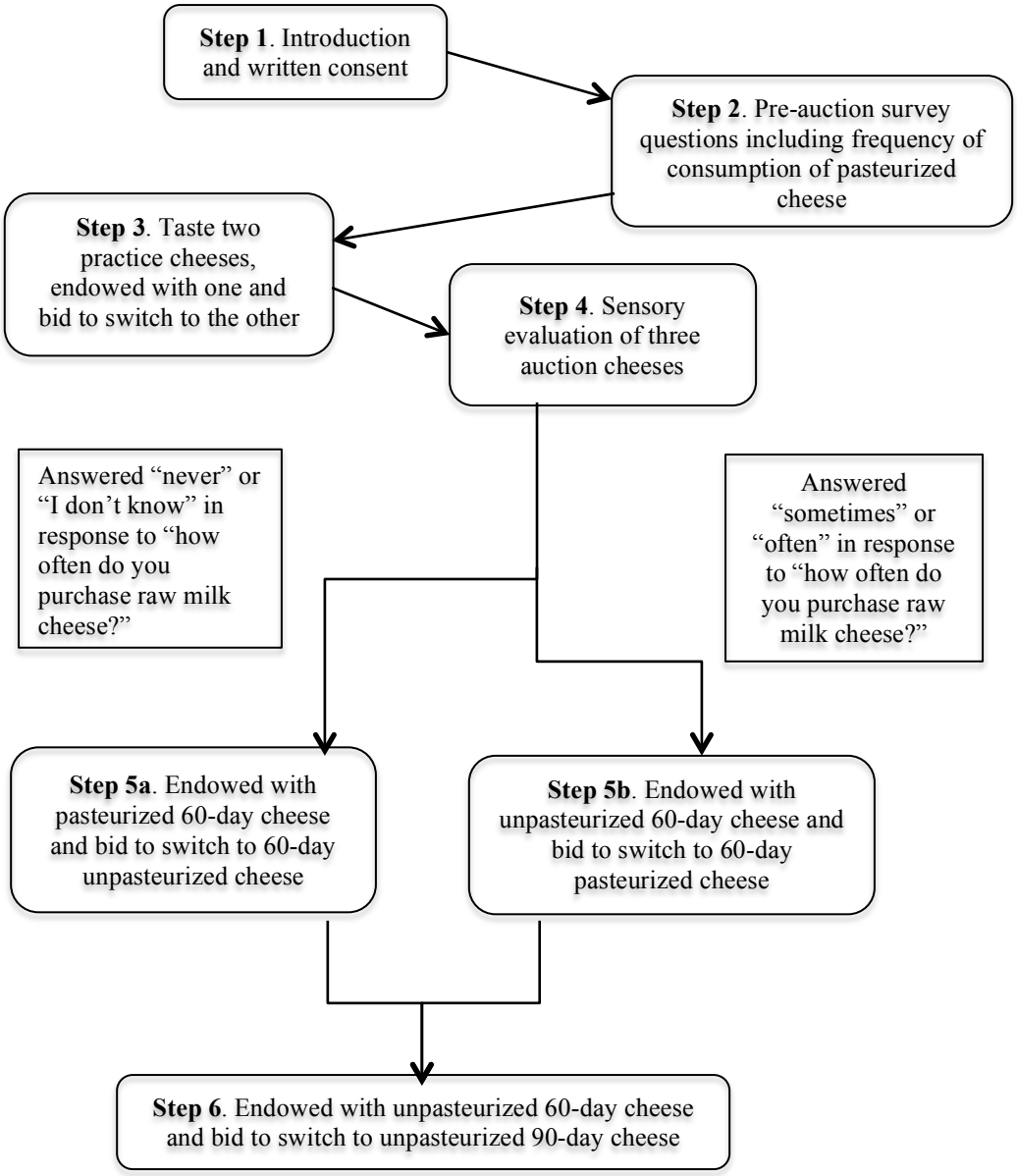
terms of acceptance of a new technology following new information, for example with the use of irradiation to increase the safety of meat products (Fox et al., 2001; DeRuiter and Dwyer, 2002; Nayga, 2003). There is evidence here that decisions about food safety may be based more on attitudes that are related to the changing food system, particularly the greater interest in artisan, local, and natural foods. These findings are consistent with research in psychology and sociology that finds that consumer risk assessment is a more complex context specific expression of personal values (Hansen et al., 2003; Finucane and Holup, 2005; Korthals, 2001; Sapp et al., 1995). These results suggest that a divide may be forming between FDA policy and consumer demand on matters such as the safety of artisan foods.

Current FDA regulation governing the production of cheese made from unpasteurized milk infringes on consumer choice and decreases profits for many artisan producers who prefer to produce cheese made from unpasteurized milk. Impending FDA regulation based on a simulated risk assessment suggests more stringent regulation is planned in the future (FDA, 2012), which threatens consumers and producers in the artisan cheese market. In the absence of empirical evidence that unpasteurized cheese is less safe than pasteurized cheese the results of this study support the use of mandatory labeling for unpasteurized cheese products but offer no justification for other restrictions on cheese made from unpasteurized milk.

APPENDIX

APPENDIX

Figure 6. Schematic of auction procedure



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Chapter 4: The impact of information about the safety of pasteurization on demand for artisan cheese

Introduction

An asymmetric information problem exists between producers and consumers of food and there are high costs associated with reducing the asymmetry. Producers generally know how safe their food is and have an incentive to supply safe food in order to build a reputation and avoid harming consumers. Consumers may be able to use their senses to detect if food has spoiled but without specialized knowledge and equipment they cannot detect if it contains harmful bacteria or pathogens. There are several ways to reduce the information costs of food safety including statutory regulation, certification and labeling, and consumer education (Antle, 1996). The most common way of reducing information costs is through government regulation of production practices, which minimizes harm to consumers and moves food safety towards an efficient level. Defining an efficient level of food safety can be subjective however, given differences in preferences about the extent to which safety should be pursued at the expense of other aspects of quality.

There is an ongoing debate about the role of bacteria and the acceptability of risk in the food system (Nestle, 2010). The proliferation of small-scale "artisan" food producers is emblematic of this debate and presents new concerns for policymakers. Artisan food products are often handmade, minimally processed, and highly diversified products in which the uniqueness of the product is of paramount importance to its demand. The uniqueness of these products is the antithesis of standardization, which is the basis for ensuring the safety of food products in the broader industrial scale food system. The emphasis on standardization has created tension about how to regulate artisan products. In some cases, empirical evidence demonstrates that

standardization of processes can improve food safety outcomes, although the standardization of these processes often comes at the expense of other aspects of quality. Quality can take a range of meanings in this context, from sensory characteristics, to diversity of consumer choice, to health benefits such as the presence of beneficial bacteria. In some cases however there is no scientific consensus about the food safety outcomes of particular processes and there are even opposing opinions about which processes are safest. Genetic modification and irradiation are two examples of controversial food technologies where consumer preferences are divided over the safety outcomes. Genetic modification in particular has generated a lot of attention yet no scientific consensus exists over the safety of genetically modified food (European Network of Scientists for Social and Environmental Responsibility, 2014).

Previous studies (e.g. Shogren, 1993; Nayga et al., 2006) have tended to focus on consumer acceptance of controversial food technologies in mainstream products and markets, thus omitting a unique subset of the changing food system. Consumers of artisan foods are an increasingly important part of the market and understanding their attitudes towards risk, their preferences, and their decision-making should be part of the broader food safety debate. New producers of artisan products are entering the marketplace every day and understanding the impacts of policies on them is essential. Artisan food products are produced under very different conditions than mainstream products and often use traditional methods of production that do not meet regulatory standards designed for industrial operations. In this sense, the nature of artisan food production is incongruous with mainstream or industrial approaches to food safety and leaves policymakers in a challenging position. Understanding consumers' perceptions of the safety of artisan products and how much information consumers have about the safety of artisan food production is critical for designing policy that represents changing consumers' demand for food safety.

In this paper, we look at the value of scientific information in the debate over pasteurization of milk used in artisan cheesemaking. On one side of the debate is the perspective that pasteurization has led to huge improvements in food safety and is thus an obvious safety-enhancing procedure that should be required wherever possible. On the other side, pasteurization is seen as an unnecessary procedure that kills beneficial bacteria, which are the foundation of flavor development and actually make the cheese safer by competing with harmful bacteria while the cheese is aging. Pasteurization thus represents a tradeoff between safety and quality for some consumers and this is what we explore in light of the information asymmetry that exists in this market. We look at the effect of pro-pasteurization and pro-raw milk (unpasteurized milk) information on consumers' willingness to pay (WTP) for pasteurized and aged cheese. We are particularly interested in whether consumers place greater weight on negative information than positive information as other researchers have found with other products (Rousu, 2007; Nayga, 2006), and what factors influence whether the information results in a change in consumers' WTP. We assess the expected value of the information in this market and discuss the welfare implications.

Background

The practice of pasteurizing milk used in the production of cheese in the United States dates back to World War II when the United States Department of Agriculture (USDA) encouraged producers to pasteurize the milk used to produce the millions of pounds of cheese being supplied to US and allied troops abroad (Johnson et al. 1990). Following two outbreaks of typhoid fever in 1944, the Surgeon General indicated that cheese must be made from pasteurized milk or be aged before sale to allow the beneficial bacteria time to proliferate. After two years of

discussion, the Food and Drug Administration (FDA) passed 21 CFR 133 requiring that cheese be made from pasteurized milk or aged no less than 60 days (at a temperature greater than 35°F). D'Amico et al. (2010) outline a series of early studies that may have laid the groundwork for the 60-day minimum aging period, namely a study by Gilman et al. (1946), which found that undulant and typhoid fever epidemics have not been associated with cheese cured for more than 63 days.

This regulation has remained unchanged despite the changing nature of risk from dairy products and recent scientific findings that contradict the premise of the regulation. According to the CDC database, safety of dairy products is now among the highest of all foods (CDC, 2014). There have been no major outbreaks of milk or cheese-related illnesses in recent years as there have been with fruits and vegetables (such as spinach and cantaloupes) despite the increase in production of cheese made from unpasteurized milk. In addition to the decreased risk, new research has questioned the need for the 60-day aging requirement. There is evidence that the 60-day aging period is arbitrary as recent research has shown that pathogens can survive past 60 days (D'Amico et al., 2008a) and that aging cheese supports the growth of the pathogen *Listeria monocytogenes* regardless of pasteurization (D'Amico et al., 2008b). Recent research has also shown that raw milk is not necessarily less safe than pasteurized milk, indicated by a low incidence of pathogens in raw milk intended for cheesemaking (D'Amico and Donnelly, 2010).

The FDA appears to be poised to extend the minimum aging period for cheese made from unpasteurized milk based on a recent risk assessment (FDA, 2012). The FDA risk assessment finds that soft cheeses made from unpasteurized milk are 160 times riskier than those made from pasteurized milk. Vaughan and Seifert (1992) argue that many of the assumptions used in risk assessments reflect societal or personal values and preferences, not empirical evidence, and place

weight on different dimensions of the assessment that can predetermine the outcome. The American Cheese Society documents many of the assumptions implicit in the FDA risk assessment and finds that it may overstate any additional risk a consumer takes when consuming cheese made from unpasteurized milk (American Cheese Society, 2013). Among the most obvious ways in which risk assessments can be subjective are that the parameters are often estimated from single studies, or they fail to account for conflicting empirical evidence. To a large extent the conclusion of increased risk is based on the assumption that raw milk is inherently more risky, which is not consistent with D'Amico (2008a) as mentioned previously.

Regulations such as mandating pasteurization of milk used in cheesemaking and setting a minimum aging period for cheese made from raw milk are designed to reduce the information asymmetry between the consumer and producer. However, consumer preferences for food safety are not homogenous, varying based on factors such as how much information they have about the food or the safety of the production process, their level of risk tolerance, their previous experiences with foodborne illness, and their attitudes towards the role of bacteria in the food system. In light of the contested science and divergent opinions on this issue, it seems appropriate to explore the role of information on consumer WTP for pasteurized and unpasteurized cheese.

Much of the research testing the effect of information on controversial technology acceptance takes an experimental approach since it is possible to introduce information treatments and observe the change in consumers' responses to the new information. Studies have found that consumer preferences and acceptance of a specific food safety-enhancing process can be influenced by knowledge and information about the risks (Fox et al., 2002; Nayga, 2006). Lusk et al. (2004) compared consumer acceptance of information on a controversial product with

food safety implications in the US and EU and found that information on the product's benefits decreased the amount of compensation that subjects demanded to consume the food. Hayes et al. (1995) investigated how subjects process information and found that they generally underestimated the probability of food-borne pathogens and placed more weight on their own prior perceptions of the odds of illness than on the new information presented to them during the study. Rousu et al. (2007) developed a method for testing and calculating the economic value of the effects of objective information for a food product in a market with conflicting information.

There has been comparatively little work linking WTP measures to welfare changes resulting from policy initiatives. Lusk (2005) valued the welfare effect of biotechnology policies by looking at consumer willingness to accept genetically modified ingredients, and he estimated the impact of liberalizing trade of genetically modified food into the EU. Another method for estimating changes in consumer welfare is to use observed bids from experimental auctions with consumption data extracted in a post-auction survey. For example, Lusk et al. (2004) obtained bids for five different varieties of a good to investigate two scenarios: where the price of one product changes and where a new product changes the prices of other products on the market. Lusk and Marette (2010) outline and compare three methods for using WTP estimates to calculate the welfare effects of food policies for two empirical examples: a ban and a label. They conclude that estimates of consumer surplus changes can vary markedly across value elicitation approaches.

Methods

In this paper participants in an experimental auction are provided with information regarding the safety of pasteurization of milk used in artisan cheese production. We observe how

this information changes their WTP for the cheese and we explore the relationship between these changes and the underlying demographic characteristics and risk attitudes. We build on the method of valuing information outlined by Rousu et al. (2007) by sorting consumers into two endowment groups (pasteurized and unpasteurized cheese) to mitigate any signal of quality sent by the endowment and using an endow-and-upgrade approach to focus participants' attention on bidding the marginal difference between the two goods. Following the initial bidding round to upgrade, participants are provided with pro-pasteurization information, pro-raw milk information or both information treatments together. We calculate the expected value of this information and estimate the change in consumer surplus from a ban on unpasteurized cheese.

Sample

Since we are only interested in consumers affected by regulation of artisan cheese our target population included only artisan cheese consumers. We conducted the experiments "in the field" to reduce sample selection bias since participants are intercepted rather than self-selected (Harrison and List, 2004). We chose three states that represent different cultures of artisan cheese consumption and production in a nascent, intermediate and more developed context (Michigan, New York and Vermont respectively). Within each state we conducted experiments at farmers markets in multiple cities that ranged in size and median income. We chose to sample at farmers markets to capture the widest demographic of artisan cheese consumers and to have a consistent sample across and within states.

We identified three locations in each state where there was at least one farmers market. We then contacted the market managers, discussed the research and scheduled a day to conduct research at the market if the market manager was amenable. In Michigan, we conducted auctions at markets in Ann Arbor (2 day markets and 2 evening markets), Lansing (2 day markets), Grand

Rapids (1 day), and Bath (1 day). In New York we conducted auctions at markets in Ithaca (1 day and 1 evening market), Troy (1 day and 1 evening), Albany (1 day), Schenectady (1 day). In Vermont we conducted auctions in Burlington (2 days), Brattleboro (2 days), and Manchester (1 day). The markets varied in hours of operation ranging from 3 to 6 hours in length and in the density of pedestrian traffic. The total number of participants in the research across all locations was 347.

Auction procedure

A table was set up at each location during market hours with two monitors conducting experiments simultaneously using computer tablets. At the beginning of the day or after a participant completed an auction a new participant was recruited. We randomized participation by inviting every passerby to participate if someone was not already participating at that station. The protocol for the auction consisted of the exact same ten steps with every participant and a schematic of the auction procedure can be found in the appendix.

In step 1, participants learned about the nature of the research and the benefits and risks to them and were asked if they consented to participate. They were informed that they would be engaged in the research for approximately 15-20 minutes and would be compensated $5 and a ½ lb of cheese (approximately a $7 value) for participating in the auction.

In step 2, participants answered a series of questions concerning their basic demographic data, cheese consumption habits, and frequency of purchasing cheese made from unpasteurized milk (choices included: sometimes, often, never, I don't know).

Step 3 was a non-binding practice round to introduce participants to the Becker-DeGroot-Marschak (BDM) auction mechanism (Becker et al., 1964). In the BDM auction, a "market" price is randomly generated from a pre-specified distribution chosen by the experimenter and

compared to the sealed bid the participant submits. If the individual's bid is greater than the market price, the individual wins the good being auctioned and pays the market price. If the individual's bid is lower than the market price no transaction occurs. Lusk et al. (2004) demonstrated that BDM auctions and English auctions generate statistically equivalent bids regardless of whether participants receive an endowment, offer bids to upgrade, or offer full bids. A BDM mechanism is advantageous in this context because it allows us to conduct the auction in the field with a single participant thus incorporating the participant's heuristics and the effect of the market experience (Lusk and Shogren, 2007).

In the practice round participants tasted two different samples of cheese (approximately 3/4" cube) acquired from two different vendors at each market and labeled with random 3-digit numbers (eg. 324). Instructions on the tablet informed the participants that they were endowed with ½ pound of one cheese but they could offer a bid to switch to the other cheese if they preferred. This is referred to as an "endow and upgrade approach" following Shogren et al. (1994) and Lusk et al. (2005). If a participant accepted the endowed cheese, we refer to them as having chosen that cheese, and if they bid on the alternative cheese then that is the one they chose. Participants' bids were then compared with a random number between $0 and $5 generated by the computer tablet (participants were not informed of the distribution). The tablet then displayed a message informing participants that they won the auction if their bid to switch was higher than the random market price or lost if their bid was lower. Participants were informed that they would receive the cheese they bid on and be expected to pay the randomly generated price if they won or keep the endowed cheese and pay nothing if they lost. The researcher then reiterated that the practice round was non-binding but there would be multiple rounds of bidding and a single randomly selected binding round at the end.

The endow-and-upgrade approach is advantageous in this context for multiple reasons despite an ongoing debate about the presence of an endowment effect, i.e. that people become attached to a good if they perceive that they own it (Hanemann et al., 1991; Shogren et al., 1999; Corrigan and Rousu, 2006; Plott and Zeiler, 2011). Upgrading directs participant attention away from field substitutes (a similar cheese available from another vendor at the market) and focuses their attention on the marginal difference between the attributes of interest. Endowing participants also minimizes uncertainty and information effects such as the option value problem, where people expect to gather more information in the future about the value of the goods (Corrigan, 2005). We split the participation fee into cash and a cheese endowment; the cheese endowment generates interest in the auction since the subject will leave with one kind of cheese or another either way (Lusk and Shogren, 2007) and the relatively small amount of cash allows us to avoid a house money effect, i.e. that people bid more because they are not using their own money (List and Rondeau, 2003).

In step 4, each participant was given a sample of the three cheeses used in the auction (60-day unpasteurized, 60-day pasteurized, and 90-day unpasteurized). From here on we refer to the three cheeses as 60R, 60P, and 90R respectively. These cheeses were all organic Vermont cheddar cheese made by the same cheesemaker and only differed in the date they were processed (60 or 90 days old) and whether or not they were pasteurized.

In step 5, participants were presented with two cheese samples aged approximately 60 days and identical except that one was pasteurized and one was not. The cheeses were identified as aged for 60 days and pasteurized or unpasteurized and the participant was "endowed" with the cheese that did not fit their stated preference during the pre-auction survey. Participants who answered "never" or "I don't know" in response to whether they purchase cheese made from

unpasteurized milk were endowed with unpasteurized cheese (step 5a), and participants that answered "sometimes" or "often" were endowed with pasteurized cheese (step 5b). Participants were then given the opportunity to "upgrade" to the cheese they were not endowed with.

In step 6, all participants were endowed with a 60-day unpasteurized cheese and given the opportunity to bid to switch to the unpasteurized version aged for 90 days.

In step 7, participants were provided with an information treatment and repeated either the step 5 or step 6 bidding comparison. If they repeated step 5 they were given the same endowment as in step 5 and followed the same procedure except they randomly received one of two information treatments. One information treatment was a collection of information from consumer advocacy groups and scientific research articles supporting the unpasteurized cheese. The other information treatment was a collection of information from industry, government and scientific research articles advocating pasteurization of milk. The information treatments are described in more detail in the next section and can be found in the appendix.

In step 8, participants repeated step 5 or 6, whichever they were not reassigned in step 7. If they repeated step 5 they were given the same endowment as in step 5 and followed the same procedure except they randomly received one of the information treatments.

In step 9, participants completed a series of survey questions designed to characterize their attitudes towards risk and food safety.

Description of information treatments

Table 21 illustrates the details of the six possible combinations of bidding comparisons and information treatments labeled combinations A-F. Participants were asked to make two product comparisons—between a pasteurized and unpasteurized cheese of the same age (60R/60P) and between two unpasteurized cheeses, one of which was aged for 60 days and the other 90 days

(60R/90R). In steps 5 and 6 participants evaluated these comparisons and bid on products without receiving any information about the debate. In step 7, they were assigned one of the six combinations in table 1, so the order of which comparison they received first varied, as did the order of which information treatment they received.

There were two information treatments, pro-pasteurization and pro-raw milk. The probability with which each participant was assigned a given combination of cheese comparison and information treatment was adjusted so that roughly the same number of bids is recorded in each of the three information treatments: pro-pasteurization, pro-raw milk information, and both information treatments. In step 8, one-third of participants received no information so they only have the information from the previous step (combinations E and F). The other two-thirds of participants received the opposite information treatment than step 7, giving them both types of information (combinations A-D). If a participant received a different information treatment in step 8 than step 7 then we consider them to have received "both" information treatments for this bidding round. This accounts for the fact that both types of information cannot occur before receiving only one type of information. We test for an order effect of the treatments in the results section.

Table 21. Combinations of bidding comparisons and information treatments

	comparison 1	**Information Treatment 1**	**comparison 2**	**Information Treatment 2**	**N = 347**
A	60R/60P	pro-pasteurized	60R/90R	pro-raw milk	69
B	60R/60P	pro-raw milk	60R/90R	pro-pasteurized	67
C	60R/90R	pro-pasteurized	60R/60P	pro-raw milk	65
D	60R/90R	pro-raw milk	60R/60P	pro-pasteurized	67
E	60R/60P	pro-raw milk	60R/90R	N/A	41
F	60R/60P	pro-pasteurized	60R/90R	N/A	38

Notes: 60-day unpasteurized cheese=60R, 60-day pasteurized cheese=60P, and 90-day unpasteurized cheese=90R).

The exact scripts of the information treatments can be found in the appendix. These scripts are based on a collection of information from consumer advocacy groups, government and scientific research articles advocating either raw milk cheese or pasteurization of cheese. Since much of the science is disputed we characterized these perspectives with careful attention not to give any information that is scientifically inaccurate. Citations are provided with the text in the appendix but were not provided in the scripts that participants received.

Analysis of censored bids

In the analysis, we isolated the effect of the underlying demographic and attitudinal variables on WTP. To do this we estimated the change in WTP from participants' bids before and after they received information as a function of relevant independent variables. The equation we estimated is the difference between the information round and the no information round as follows:

$$(1) \qquad \mathrm{WTP}_j^{info} - \mathrm{WTP}_j^{no} = \beta_1^* + \beta_2^* \mathrm{X}_2^* + \varepsilon_j^*$$

Where β_1^* is an intercept term, β_2^* is a vector of difference coefficients multiplied by X_2^* a vector of exogenous variables, ε_j^* is a random error term, and * indicates the difference between the coefficients in each round (eg. $\beta_1^{*=} \ \beta_1^{info} - \beta_1^{no}$).

Experimental auction bids are often considered censored because a participant who dislikes a product might have a negative willingness to pay yet is restricted from bidding a negative value. When the dependent variable is the difference between two rounds of bidding, additional censoring occurs because a participant's bid could be censored in one round while in the other round it is positive. This generates multiple censoring scenarios, which need to be treated differently since the true difference in WTP with the censored regression will be different

than the mean difference between the two observed bid prices calculated above. Table 22 illustrates the direction and interpretation of the censoring scenarios that arise.

Table 22. Description of the four possible censoring scenarios for change in WTP

Censoring	No information round	Information treatment round	Change in WTP (info- no info)
Right censored	0	+	+
Left censored	+	0	-
No information	0	0	0
Uncensored	+	+	+/-

*Notes: Change in WTP is the difference in bids between the information round and the no information round. + indicates a positive bid and – indicates a negative bid. If the participant bids zero in the no information round and positive in the information treatment round then the change in WTP = (+)-0=+.

Uncensored bids were estimated normally while censored bids were evaluated by defining a left and right-censored dependent variable. In cases where a bidder bid zero in the first round and a positive value following the information treatment we considered the bid to be right censored since it could have been more positive if negative bids were allowed. If the bid is positive in the first round and zero in the second then the bid is left censored since it is a negative value but could have been more negative if negative bids were allowed. In other words, a zero bid in the first round with no information potentially overestimates the true difference in WTP from the information and a zero bid following the information treatments potentially underestimates the true difference in WTP from the information. Bidding zero in both rounds indicates that the bid for the cheese is censored but not necessarily because of the difference attributed to the information so we learn nothing from these observations. Positive bids in both rounds represent uncensored bids and are evaluated as the positive or negative difference between the two rounds. In summary, we are able to treat zero bids correctly and minimize bias with a censored regression model of the differences in bid prices. The tradeoff is that the model is non-linear in its unknown parameters, which complicates the error term.

We account for the censored observations by estimating a generalized Tobit model (Greene, 2003) using maximum likelihood estimation with the *Proc Lifereg* procedure in SAS as per Rousu et al. (2007). With this procedure we are able to simultaneously treat some observations as uncensored and others as either left or right censored as needed. Since this a non-parametric procedure we had to specify the distribution, which was normal.

Results

Summary statistics

The sample of artisan cheese consumers was approximately 36% female with an average age of 43. The highest level of education attained by 10% of the sample was high school, the highest level of education attained by 52% of the sample was a college degree, and 38% attained postgraduate education. This sample was more educated than the average American where high school is the highest level of education for 47.07% of the population and 30.9% attained a college degree or higher (United States Census Bureau, 2012). The distribution of reported household income in our sample was relatively similar to the overall US population albeit with fewer participants from the highest income households. Across the US approximately 32% of households have income less than $30,000, 40% have income between $30,000 and $80,000 and 28% have income more than $80,000 (United States Census Bureau, 2012). Approximately 25% of the sample had children and 80% of participants considered themselves the primary shopper in the household. The summary statistics of demographic and attitudinal variables are reported in table 23.

Table 23. Descriptive statistics and definitions of demographic and attitudinal variables

Variable	Definition	Mean	(SD)
Gender	1 if individual is male; 0 if individual is female	0.36	(0.48)
Age	Age in years	42.94	(16.55)
Education	High school	10%	
	College	52%	
	Post graduate	38%	
Income	<$30,000	26%	
	$30,000 to 80,000	34%	
	>$80,000	29%	
	Prefer not to answer	11%	
Children	1 if children under 16 are living at home; 0 otherwise	0.25	(0.43)
Primary shopper	1 if individual is primary shopper in household; 0 otherwise	0.8	(0.4)
Pounds	Cheese consumption in pounds in the last 2 weeks	1.96	(1.72)
Artisan	1 if individual consumes artisan cheese; 0 otherwise	0.86	(0.35)
% Artisan	% of cheese consumption that is artisan	26.86	(25.63)
Unpasteurized cheese	Never purchase	9%	
	Sometimes purchase	43%	
	Often purchase	14%	
	Don't know	34%	
Food poisoning	1 if individual has had food poisoning; 0 don't know or no	0.57	(0.50)
Attitudinal variables			
Worry	I worry about the safety of the food I buy	6.79	(2.99)
Trust_gov	I trust that government food safety regulations protect me adequately.	4.35	(2.82)
Standards	I would like to see stronger food safety standards imposed in the US.	6.22	(2.75)
Pay_more	I would pay more for a product with a higher than average level of food safety.	6.60	(2.75)
Expiration	I check the expiry or “best before” date on food before purchasing it.	8.12	(2.48)
Floor	I throw out any food that falls on the floor while being prepared.	4.91	(4.73)
Raw_milk	I think it is safe to drink unpasteurized milk if I know the source.	6.71	(2.80)
Natural	I usually aim to eat natural foods.	7.87	(7.78)
Observations		347	

Notes: A percentage in the mean column indicates the percentage of the sample that falls into that category. Attitudinal variables are on a 10-point hedonic scale with 0 is disagreement and 10 is agreement so responses greater than 5 represent more agreement on average and less than 5 represent more disagreement on average.

Participants reported consuming an average of about two pounds of cheese in their household in the last two weeks and 86% of participants reported consuming artisan cheese in the last two weeks. Approximately 27% of all the cheese reportedly consumed by participants in the last week was artisan cheese. The majority of participants consume cheese made from unpasteurized milk: 43% “sometimes” purchase it and 14% “often” purchase it. Thirty-four percent of participants answered “I don’t know” and 9% never purchase it.

Following the survey, participants were asked a series of questions designed to gauge their attitudes about food safety risk and the average responses are reported in the bottom half of table 23. On average the artisan cheese consumers who participated in the study worry about food safety. They don't particularly trust that government food safety regulations protect them but they would like to see stronger food safety regulations imposed. This suggests there may be some debate about exactly what stronger regulations would entail and what food safety means to participants. Subjects say they would pay more for a product with higher food safety. Participants appear to be very concerned about expiration dates despite the inconsistency and lack of regulation governing the use of expiry dates. Overall, subjects were neutral about food that falls on the floor while being prepared but notably there was wide variation in these responses, suggesting that some participants do and some do not. On average participants think it is safe to drink unpasteurized milk if they know the source and presumably those that chose the unpasteurized cheese were more likely to agree with this statement. On average participants in the study indicated that they aim to eat natural foods.

Table 24 reports the summary statistics of the experimental auction bids for each of the three cheeses (unpasteurized, pasteurized and aged) including the mean WTP and mean WTP with the non-zero bids excluded. Of the 347 participants, in step 5 of the auction 198 (57%) were

endowed with pasteurized cheese and invited to bid to switch to an unpasteurized version and 149 (43%) were endowed with unpasteurized cheese and invited to bid to switch to a pasteurized version. The mean price difference that the 198 participants endowed with pasteurized cheese were willing to pay for half a pound of the unpasteurized cheese was $1.20 and when zero bids were excluded, the remaining 99 participants were willing to pay $2.40 on average to upgrade. The mean price difference that the 149 participants endowed with unpasteurized cheese were willing to pay for half a pound of the pasteurized cheese was $0.94 and when zero bids were excluded the remaining 62 participants were willing to pay $2.26 to upgrade.

Table 24. Summary statistics of WTP to switch to the following cheese types

Round	N	Mean WTP	Std. Dev	Min WTP	Max WTP	Non-zero Obs	% Non-zero	Non-zero Mean WTP	Non zero Std Dev.
Unpasteurized	198	$1.20	$1.55	0	5	99	50%	$2.40	$1.38
Pasteurized	149	$0.94	$1.44	0	5	62	42%	$2.26	$1.41
Aged	347	$1.54	$1.66	0	6	208	60%	$2.57	$1.40

*Note: Participants either bid to switch to a pasteurized or an unpasteurized cheese and then all participants bid to switch from an unaged to an aged cheese. All cheese samples were approximately 0.5 pounds.

In step 6 of the auction all 347 participants were given a choice between an unpasteurized cheese aged 60 days and an unpasteurized cheese aged 90 days. Overall they were willing to pay $1.54 for the cheese aged an additional 30 days and $2.57 when zero bids are excluded. Mann-Whitney tests of equivalence were performed between each of the three cheeses and all were significantly different at the 5% level or better.

Effect of information treatments on WTP

Table 25 reports the change in WTP for each cheese type following the information treatment. One hundred forty nine participants were endowed with the unpasteurized cheese and were asked if they would like to bid to switch to a pasteurized cheese. Of these 149 participants, 50 received pro-pasteurization information, 45 received pro-raw milk information and 54 received both information treatments together. The pro-pasteurization information treatment increased participant WTP for pasteurized cheese by an average of $0.51 and the pro-raw milk information decreased WTP for pasteurized cheese by $0.25. The effect of receiving both pro-pasteurization and pro-raw milk information treatments together was an increase in WTP for pasteurized cheese of $0.24.

Table 25. Change in WTP for each bidding scenario from the information treatment

Bidding scenario	information treatment	N	change in WTP	st. dev	Min	Max	% zero	Prob >|z|
pasteurized	pro-pasteurization	50	$0.51**	(1.05)	0	5	70%	0.04
(N=149)	pro-raw milk	45	$-0.25	(0.88)	-3.5	2	71%	0.29
	both together	54	$0.24	(1.09)	-2.9	4	72%	0.60
unpasteurized	pro-pasteurization	57	$0.00	(1.01)	-2.5	5	77%	0.70
(N=198)	pro-raw milk	63	$0.30	(1.26)	-5	4	60%	0.18
	both together	78	$0.49**	(1.43)	-3.5	5	63%	0.05
aged	pro-pasteurization	103	$-0.02	(1.11)	-4	5	82%	0.92
(N=347)	pro-raw milk	108	$0.03	(0.91)	-2	5	68%	0.25
	both together	136	$-0.03	(0.93)	-4	3	78%	0.99

Notes: Bidding scenario indicates which cheese participants were bidding on (eg. pasteurized = WTP for pasteurized cheese compared to unpasteurized cheese). Prob > |z| is the probability a of the null hypothesis of no significant difference in WTP from the information treatment using a Wilcoxon rank sum test. **indicates significant differences at the 5% level.

One hundred ninety-eight consumers were endowed with pasteurized cheese and asked if they would like to bid to switch to unpasteurized cheese. Of the 198 participants, 57 received the pro-pasteurization information treatment, 63 received pro raw milk information and 78 received

both information treatments together. The pro-pasteurization information had no effect on participant WTP for unpasteurized cheese, and the pro-raw milk information increased WTP for unpasteurized cheese by $0.30, although this was not significant. Receiving both information treatments increased WTP for unpasteurized cheese by $0.49.

Participants also received either or both information treatments before bidding on the aged cheese. All 347 participants received a choice between a 60-day unpasteurized cheese and a 90-day unpasteurized cheese. One hundred three of these participants received pro-pasteurization information, 108 received pro-raw milk information, and 136 received both information treatments before bidding. There was no significant effect of any of the information treatments on WTP for aged cheese. The pro-raw milk information treatment does mention that there are benefits in safety from aging, which appears to have a slightly positive effect on consumer WTP for aged cheese compared to the other two information treatments but the difference is not significant. One limitation of this study is that the information treatments were relatively brief and may not have been as influential on participants' opinions as a video or more in depth treatment would have (Tonsor and Wolf, 2011).

Minimum and maximum change in WTP ranged from negative to positive in all of the bidding scenarios except for participants bidding on pasteurized cheese who received pro-pasteurization information where there were no negative WTP changes. There was a high percentage of zero bids across the pasteurized, unpasteurized and aged bidding scenarios ranging from 60% to 82% indicating that many consumers were not affected by the information treatments. Based on Wilcoxon rank sum tests the only two scenarios where the information treatments had a significant effect on WTP were the effect of pro-pasteurization information on WTP for pasteurized cheese and the effect of receiving both types of information together on

WTP for unpasteurized cheese. Pro-pasteurization information appears to have bolstered the conviction of participants who bid on the pasteurized cheese while receiving both types of information caused participants who were bidding on the unpasteurized cheese to bid higher. These results suggest that participants exhibited a confirmation bias, or the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand (Nickerson, 1998).

We conducted a two-sample t test of the effect of the order of the information treatment on the change in WTP in the second round of bidding. We found there was no statistical difference between the bids of participants who received the pro-pasteurization information first and those that received the pro-raw milk information first. The mean difference was $0.06 with a t value of 0.45 indicating that the order participants received the information did not influence their WTP.

Table 26 reports maximum likelihood estimates and standard errors of the determinants of change in WTP following the information treatments. We pooled the changes in WTP across all bidders and included interaction effects between the type of cheese participants were bidding on (pasteurized, unpasteurized, or aged) and the information treatments (pro-pasteurization, pro-raw milk, and both treatments). Similar to the results of the Wilcoxon rank sum tests in table 4 we see that the pro-pasteurization information treatment increased the WTP of participants who were bidding on pasteurized cheese and the combination of both information treatments increased the WTP of participants bidding on unpasteurized cheese. Additionally, when we control for censoring, the pro-raw milk information treatment is now significant and positive at the 10% level for those bidding on unpasteurized cheese.

Table 26. Determinants of change in WTP from information treatments

Parameter	Estimate	Standard Error
Endowment x information treatments		
Pasteurized x info past	1.77***	0.71
Pasteurized x info raw	-0.47	0.74
Pasteurized x info both	0.91	0.70
Unpasteurized x info past	0.56	0.75
Unpasteurized x info raw	1.32*	0.70
Unpasteurized x info both	1.59**	0.73
Aged x info past	0.53	0.68
Aged x info raw	0.93	0.68
Aged x info both	0.55	0.67
Other variables		
Gender	0.02	0.19
Age	0.01**	0.01
Income > $80,000	-0.47*	0.26
$30,000-80,000	0.14	0.24
Income not reported	-0.12	0.32
College Graduate	0.02	0.30
Post-graduate	0.09	0.31
Children	-0.09	0.10
Shopper	-0.02	0.23
Pounds	-0.04	0.05
Artisan	0.00	0.00
Worry	-0.05	0.03
Trust government	-0.10***	0.03
Stronger standards	-0.11***	0.04
Pay more	0.07	0.05
Expiry date	0.02	0.04
Floor	0.02	0.03
Raw milk	-0.02	0.04
Natural	0.02	0.05
Poison	-0.05	0.18
Endowment (past=1)	-0.36	0.24
Vermont	-0.15	0.20
New York	0.20	0.22
Scale	1.61	0.07
Observations	415	
Right Censored	62	
Left Censored	32	

Notes: The intercept term is suppressed. *,**,*** represent 10%, 5%, and 1% significance respectively.

Participants who are older are more responsive to information increasing their WTP following the information treatments by $0.01 for every year of age. Participants in the highest income category decreased their WTP after seeing the information treatments compared to participants in the other income categories. Participants that are less likely to agree that government food safety standards protect them adequately and are less likely to want stronger standards imposed in the US were less responsive to the information treatments than participants who agreed with those statements.

When we look at the participants bidding on pasteurized cheese and unpasteurized cheese separately as reported in Table 27, some differences emerge. The pasteurization information treatment dummy variable is dropped in the regression of the group bidding for pasteurized cheese. The change in WTP for pasteurized cheese is significantly decreased from the raw milk information treatment compared to the dropped information treatment. Among participants bidding for pasteurized cheese those with children increased their WTP for pasteurized cheese in the round following the information treatments (regardless of information treatment). More educated consumers on the other hand, decreased their WTP for pasteurized cheese following the information treatments. Similar to the overall results reported in table 26, participants who are more likely to trust that government food safety regulations protect them decreased their WTP for pasteurized cheese following the information treatment.

In the regression estimates of participants who bid on unpasteurized cheese, the dummy variable for the raw milk information treatment was dropped. The pasteurization information treatment was associated with a significantly lower WTP than the dropped raw milk information treatment, which is consistent with the mean change in WTP reported in table 25. Age and income are significant determinants of change in WTP and have the same signs as we saw in the

pooled regression. The fact that these coefficients are the same in the pooled regression suggests that older participants increase their WTP for unpasteurized cheese in response to favorable information about raw milk and high-income consumers decrease their WTP for raw milk in response to pro-pasteurization information.

Table 27. Determinants of change in WTP from information treatments by endowment

	WTP Pasteurized		WTP Unpasteurized	
Parameter	Estimate	Standard Error	Estimate	Standard Error
Information treatments				
Pasteurization	--	--	-0.86*	0.48
Raw milk	-2.11***	0.55	--	--
Both treatments	-0.80	0.51	0.36	0.45
Other variables				
Gender	-0.83	0.58	-0.08	0.43
Age	0.00	0.02	0.02*	0.01
Income > $80,000	-0.38	0.75	-1.03*	0.58
$30,000-80,000	1.16	0.78	0.07	0.49
Income not reported	-1.18	0.83	0.54	0.81
College Graduate	-1.43**	0.71	0.94	0.62
Post-graduate	-1.43*	0.81	1.06	0.68
Children	0.67**	0.32	0.05	0.21
Shopper	0.21	0.63	0.15	0.53
Pounds	-0.18	0.13	0.02	0.08
Artisan	0.01	0.01	0.00	0.01
Worry	0.06	0.09	-0.12*	0.07
Trust government	-0.24**	0.11	-0.16**	0.07
Stronger standards	-0.18	0.13	-0.18**	0.09
Pay more	0.04	0.17	0.15	0.11
Expiry date	0.08	0.12	0.01	0.07
Floor	0.01	0.08	-0.02	0.07
Raw milk	-0.11	0.10	-0.14	0.09
Natural	-0.04	0.11	0.10	0.12
Poison	-0.41	0.43	0.89**	0.40
Vermont	-0.62	0.50	0.41	0.46
New York	0.21	0.57	1.19**	0.49
Scale	1.48	0.16	1.81	0.15
Intercept	4.90***	1.60	-0.24	1.49
Observations	72		123	
Noncensored	49		84	
Right Censored	14		29	
Left Censored	9		10	

Notes: One information treatment variable is dropped in each regression. *,**,*** represent 10%, 5%, and 1% significance respectively.

A number of attitudinal variables were significant and all were associated with a decrease in

WTP following the information treatment. If someone had food poisoning in the past they also decreased their WTP for unpasteurized cheese in response to the information. And participants from NY increased their WTP for unpasteurized cheese more than participants in other states in response to the information treatments. Comparing the results of the estimations of the entire sample with the separate estimations for pasteurized and unpasteurized cheese illustrates important differences between consumers. These differences are canceled out when we look at the population as a whole.

Expected value of information about pasteurization of cheese

In the previous two sections we showed that information about pasteurization affects how much participants were willing to pay for pasteurized or unpasteurized cheese. An important economic question is what is the public good value of this information? We loosely follow the methodology for valuing information outlined by Rousu et al. (2007) to calculate the net welfare change or expected value of information for bidders who change their observed behavior after receiving information about the pasteurization of milk used in cheese making. Information has a public good value if a participant changes his or her behavior as a result of receiving the information, or in this case increases or decreases their WTP following an information treatment.

Consumer surplus is normally expressed as the difference between consumer WTP for a good and the market price of that good. In this case consumer surplus is simply the change in WTP from the information treatment or formally:

$$(2) \qquad CS_{ij} = (WTP_{ij}\text{-}p) = \Delta WTP_{ij}$$

Consumer surplus (CS) is defined as the difference between participant *j*'s willingness-to-pay following information treatment *i* and the market price (p) of the product in a store. The amount

consumers would pay on the cheesemaker's website for 0.5 lbs of any of the auctioned cheese (regardless of whether it was pasteurized) is approximately $6.56, or $13.11/lb (assuming they purchase 2 lbs). However, the market price is irrelevant since the bids we solicited were for the participant's marginal WTP to upgrade from an endowed product to a potentially superior product. In this case the marginal WTP is equivalent to the consumer surplus since the market price is the value of the good the participants were endowed with but since the cheese was free we directly estimated the marginal value.

Although all participants enjoy the surplus gained by consuming one product instead of the other, the surplus represents the value of information only for participants whose WTP changes following the information treatment. We designed the experiment such that participants can only bid on either pasteurized or unpasteurized cheese but not both and so we assume the surplus they get from the product they did not choose is zero. We can calculate how many participants changed their behavior in response to the information by counting the total number of positive bids in each category (WTP for pasteurized or unpasteurized) and the total number of people whose WTP changed following the information treatment.

We first calculate the percentage of participants who paid a positive amount for the product they were bidding on (either pasteurized or unpasteurized cheese), which is reported in Table 28 in the column labeled "% buy total". This is simply the number of bidders who purchased the pasteurized or unpasteurized cheese divided by the total number of participants presented with the option to do so. To calculate the expected value of information we also need to know the percentage of participants whose WTP changed as a result of the information. This is reported in the column labeled "% who change" in table 28.

Table 28. Expected value (EV) of information about pasteurization[1]

Information treatment	N	Mean change in WTP /lb	% buy total[2]	% who change[3]	Probabi -lity of change[4]	EV per treat- ment[5]	EV per person ($/lb)	EV per changer /lb
Pro-pasteurization information (N=107)								
WTP pasteurized	50	$1.02	58.0%	20.0%	0.34	$0.35	$0.35	$2.90
WTP unpasteurized	57	$0.00	40.4%	5.3%	0.13	$0.00		
Pro raw milk information (N=108)								
WTP pasteurized	45	$-0.50	26.7%	13.3%	0.50	-$0.25	$-0.12	$-0.87
WTP unpasteurized	63	$0.60	66.7%	14.3%	0.21	$0.13		
Both information treatments (N=132)								
WTP pasteurized	54	$0.48	40.7%	1.9%	0.05	$0.02	$0.28	$2.66
WTP unpasteurized	78	$0.98	62.8%	16.7%	0.27	$0.26		

[1] We assume that a participant consumes either pasteurized or unpasteurized cheese, so only one of the two premium coefficients will be positive, while the other is zero. The premium coefficients will also differ across participants.
[2] Percentage of participants who made a positive bid for this cheese
[3] Percentage of participants who changed their bid following the information treatment
[4] Proportion of initial positive bidders who changed their bid following the information treatment
[5] Expected value per treatment is the product of the probability of changing and the mean change in WTP

With these two columns we can compute the probability that a participant is influenced by information by taking the percentage of participants whose WTP changed after receiving the information treatment and dividing it by the percentage of participants who purchased the cheese. The probability of being influenced by the information labeled "probability of change" in table 28 is expressed as follows:

$$(3) \qquad \text{Prob}\{\text{bidder j changes bid as a result of treatment i}\} = \frac{\%\text{change}_{ij}}{\%\text{buy}_{ij}}$$

Participants who bid on the pasteurized cheese were the most likely to change their bids as a result of the information regardless of which information treatment they received although they were unresponsive to both information treatments together. The probability of changing one's bid for pasteurized cheese after the pro-pasteurization information treatment given that the

participant bid a positive amount initially was 34 percent and the mean amount paid was $1.02/lb including participants who bid zero. The probability of changing one's bid for the pasteurized cheese after receiving the raw milk information treatment was approximately zero. The probability of changing one's bid in response to raw milk information given that the participant bid a positive amount for that cheese initially was 50% for pasteurized cheese and 21% for unpasteurized cheese. After receiving both information treatments the probability of changing one's bid for pasteurized cheese was 5% and for unpasteurized cheese it was 27%.

Once we know the probability that a consumer would change their bid from the information in each category we can calculate the expected value of information. The expected value for each treatment is the product of the mean change in WTP from the information and the probability of changing one's bid in response to the information for pasteurized cheese and unpasteurized cheese. The expected value of the information is the sum of the expected value per treatment of the participants bidding on pasteurized cheese and the participants bidding on unpasteurized cheese. If we assume that the participants who change their bids have relative preferences for pasteurized and unpasteurized cheese that are uniformly distributed across the population of artisan cheese consumers we can calculate expected value (EV) as follows:

$$(4) \qquad EV_{ij} = \Delta WTP_{ij}^{past} \text{ x } Prob\{change_{ij}\} + \Delta WTP_{ij}^{unpast} \text{ x } Prob\{change_{ij}\}$$

The last three columns in Table 7 report the expected value per information treatment, the expected value per person on a per pound of cheese basis, and the expected value of the information per "changer," or those whose WTP changes in response to the information treatment. The "expected value per changer" is the amount of expected value accrued to the person who is receptive to the information and this is calculated by multiplying the expected

value per treatment times the average percentage of participants who changed bids in either direction. Expected value is thus a measure of value across all participants regardless of whether they were bidding on the pasteurized or unpasteurized cheese.

The expected value for the pro-pasteurization information treatment is $0.35/lb per person but this value is entirely based on the effect of pro-pasteurization information bolstering the conviction of participants who chose pasteurized cheese. The expected value for a person that receives pasteurization information and changes their WTP is $2.90/lb. The expected value of pro-raw milk information is negative overall but this is largely due to the negative reaction of participants in the pasteurized group. The overall expected value for a bidder who changes as a result of raw milk information is a decrease of $0.87. This does not imply that "negative" information applies downward pressure on prices but rather that consumers are divided and participants who are more likely to buy pasteurized cheese are more responsive to information about it. The impact of both information treatments together is an overall positive expected value of $0.28/lb per person and an expected value of $2.66/lb for the average consumer that responds to information. This expected value was almost entirely attributable to consumers who were more likely to buy unpasteurized cheese.

Conclusions

The experimental design of this research was based on the assumption that some consumers perceive pasteurization of milk used in cheesemaking to be safety-enhancing while others perceive it as unnecessary for safety and detrimental to other aspects of quality. Results from the paper suggest that there is not necessarily an issue of information asymmetry in this controversial market as the vast majority of participants were indifferent between the pasteurized

and unpasteurized cheeses and/or were not willing to pay more once they received an information treatment. It appears that consumers who are more likely to purchase pasteurized cheese are informed about the benefits and risks of pasteurization and consumers who are more willing to purchase unpasteurized cheese are informed about the benefits and risks of not pasteurizing. In general participants prefer aged cheese but they were not responsive to information about the safety aspects of aging cheese nor did knowing that the aged cheese was unpasteurized deter them from buying it.

In contrast to previous studies, we did not find that negative information in a controversial situation decreases WTP (Fox et al., 2002). In part this is because once the sample is divided into two groups, bidding on pasteurized and unpasteurized cheese it is not clear how to define negative. We found that consumers weight positive information more when it supports their choice and discount negative information when it runs contrary to their choice. More specifically, someone who is likely to purchase pasteurized cheese is also likely to increase their WTP for pasteurized cheese after hearing of its benefits. Additionally, consumers who are likely to choose unpasteurized cheese because they feel it is of higher quality despite the potential increased safety risk, are more interested to have both information about pasteurization and raw milk together. This suggests that these consumers are aware of the tradeoff but still choose the "riskier" product. These findings suggest that if we just take a random sample of the population and ask them about their preferences for a controversial technology we are likely to find that on average their preferences cancel each other out. If we pre-sort them into groups we are likely to learn a lot more about their preferences.

Consumers' perspectives towards new food technologies, particularly controversial technologies like irradiation and genetic modification, may be a lot more closely related to

consumers' attitudes about safety than portrayed in the economics literature. While there may be some degree of information asymmetry with a technology like pasteurization of milk used in cheesemaking, many consumers have opinions that are not likely to be swayed by new scientific information or a consumer education campaign. It appears that consumers select information that confirms their preconceptions on issues such as food safety or controversial technology adoption. This confirmation bias is also likely present with many policymakers and risk analysts in federal agencies. The important question thus becomes not whether there is a need for information dissemination but rather what are the different consumer beliefs about government involvement in food safety regulation and regulation of new technologies and how does this effect their preferences. Acceptance of new technologies is often conceived of purely as an economic question but low adoption may simply be about strong opinions and risk preferences as has been found in the psychology and sociology literature (Hansen et al., 2003; Finucane and Holup, 2005; Korthals, 2001; Sapp et al., 1995). Product labeling of controversial technologies is appropriate so consumers can decide whether to consumer the technology rather than unknowingly consumer the controversial product or be prohibited from consuming the product at all.

Clearly there are two distinct markets for artisan cheese in terms of consumer preferences for pasteurized and unpasteurized cheese. These findings support the current practice of labeling cheese as pasteurized or unpasteurized and do not show evidence of preferences for extending the mandatory aging requirement for unpasteurized cheese as a safety measure.

APPENDICES

APPENDIX A

Raw milk information treatment

The following is a collection of information from consumer advocacy groups, government and scientific research articles advocating raw milk cheese. (221 words)

Cheese is routinely produced safely from unpasteurized or raw milk and when sold under federal guidelines can be consumed without unnecessary risk (ACS, 2012).

Pasteurization of milk kills the naturally occurring bacteria found in raw milk. These naturally occurring bacteria make cheese safer by outcompeting pathogens or negative bacteria that may be introduced during cheese making which is why the FDA requires a minimum aging time of 60 days for cheese made for unpasteurized milk (Johnson et al. 1990). Natural bacteria in unpasteurized cheese also contribute to a superior flavor profile.

There is no statistical difference in the pathogen occurrence between unpasteurized and pasteurized milk that is intended for cheese making (D'Amico et al., 2010). Pasteurized milk can host the same germs and pathogens that raw milk food can harbor and post-pasteurization contamination is as much a risk to consumers as contamination prior to pasteurization (D'Amico et al., 2010). People get sick from pasteurized milk cheese all the time and as recently as 2007 three people died from pasteurized milk (CDC, 2014).

With mandatory labeling for raw milk cheese consumers know what they are consuming and are free to make their own choices. Requiring cheese makers to pasteurize milk before making cheese decreases the choices available to consumers and makes it more difficult for small cheese makers to compete with the industry giants like Kraft Foods, who lobby the government to limit the production of unpasteurized cheese (Watson, 2004).

*Note: Citations were not included in the information treatments that participants received.

APPENDIX B

Pasteurization of milk information treatment

The following is a collection of information from industry, government and scientific research articles advocating pasteurization of milk used in cheese making. (225 words)

Pasteurization is a process that kills harmful bacteria by heating milk to a specific temperature for a set period of time. Pasteurization has made consumption of milk and milk products safer and reduced the number of foodborne illnesses in the US dramatically over the past century (DeWaal and Bhuiya, 2007).

Milk is especially susceptible to negative bacteria or pathogen contamination because these bacteria are usually present on the grounds and in the facilities of a dairy. Aging cheese does not make unpasteurized milk cheese safe at higher doses of contamination (Schlesser et al., 2006). Pasteurizing is the only way to ensure that all negative bacteria are removed from the milk (CDC, 1999). Most nutrients remain after milk is pasteurized (CDC, 2014).

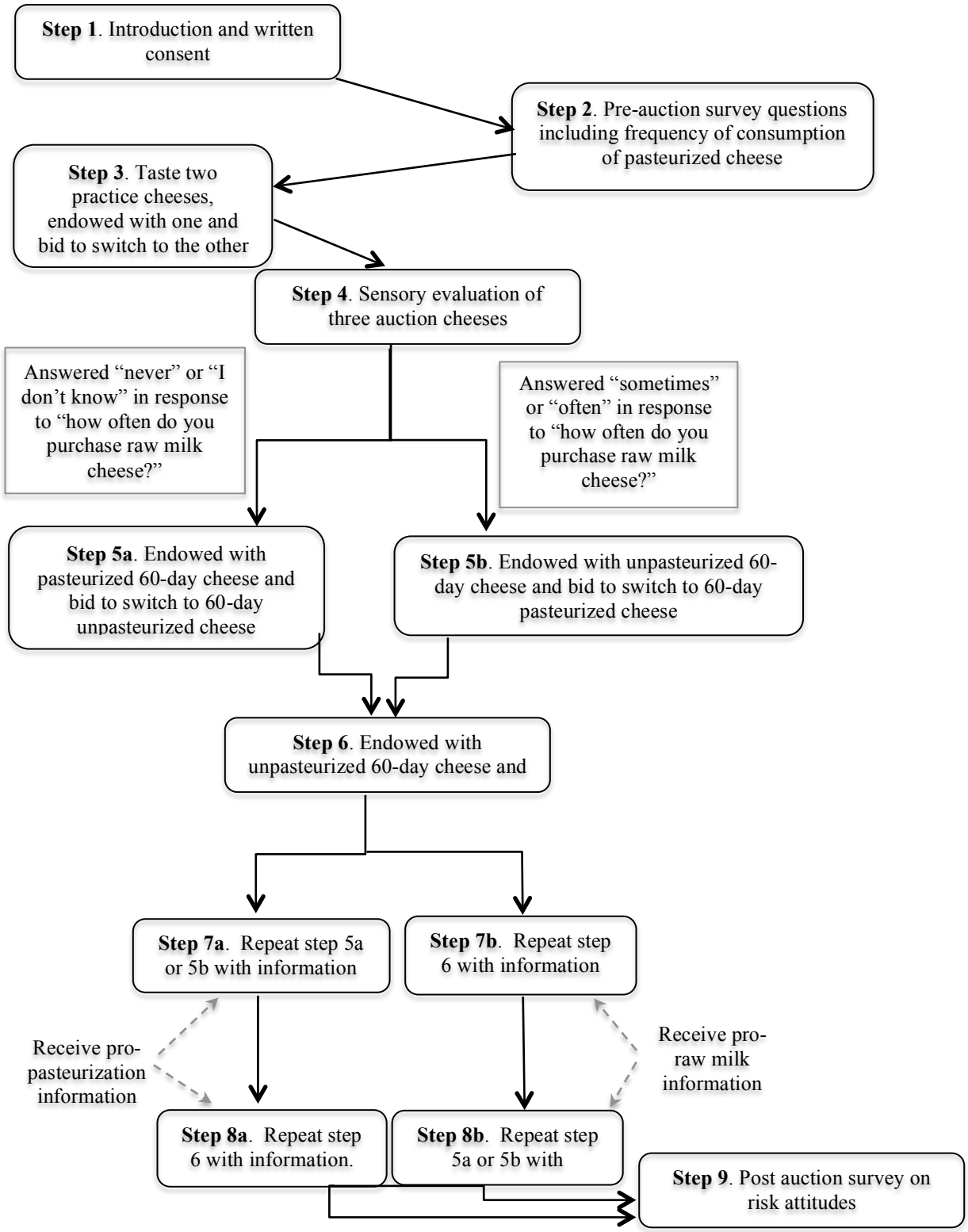
The beneficial properties of raw milk are not documented scientifically and are outweighed by the risks of getting sick (FDA, 2014a). Both the Center for Disease Control and the Food and Drug Administration believe that unpasteurized milk products are riskier than pasteurized ones (CDC, 2014, FDA, 2014b). Infection from pathogens can range from diarrhea to life-threatening complications like hemolytic-uremic syndrome (HUS) or meningitis.

It is the role of the government to protect consumers from food products that may carry a health risk. Outbreaks, illnesses, and recalls resulting from raw milk consumption incur costs for individuals and society.

*Note: Citations were not included in the information treatments that participants received.

APPENDIX C

Figure 7. Schematic of auction procedure with information treatments



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