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Chinese aquaculture farmers' value system and on-farm decision making

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ABSTRACT

The Chinese aquaculture industry, which employs millions of farmers and provides low cost protein for consumers worldwide, is critically important to domestic economic growth and global food security. Central to the safety of aquaculture products are farmers, who are ultimately responsible for following good production practices. We assess how farmers' value system is related to on-farm decision-making, with particular attention given to the overuse of antibiotics, a major problem in this industry. Primary data was gathered through farmer interviews in three aquaculture-producing provinces in Southern China. Using a best-worst scaling framework, we find that producers care most about attributes and practices that are directly related to their operation and are impartial to consumer preferences. Our results show that producers who value food safety the most are more likely to stop using antibiotics in their operations.

KEYWORDS: farmer preferences; food safety; aquaculture; antibiotics; China

1. Introduction and background

Food safety issues are undermining developments in emerging agrifood supply chains. While the majority of the food security debate in developing countries has centred on the availability (or lack thereof) of a sufficient, nutritious, food supply, food safety has not received adequate research attention. Yet, communities in developing and emerging countries face an increased risk of serious health problems due to the consumption of unsafe food. Food products that do not meet the safety and quality standards of high-value markets, not only cause significant economic losses to producers, but also to the country of origin and neighbouring countries where the products are sold (Emmott, 2013). Central to the safety of any food supply are farmers, who are ultimately responsible for following good production practices. In China, food safety has received increased global attention due to a series of incidents that caused serious health problems, and significant economic consequences. Specifically, there are rising concerns over the safety of aquaculture products from China, which produces the majority of the world's farmed fish, and is the largest exporter to the international market (FAO, 2008; Gale and Buzby, 2009). Though Chinese food safety issues have gained the attention of researchers in recent years, most of the focus has been on consumer behaviour and issues regarding China's agricultural marketing system (e.g. Wang *et al.*, 2008; Waldron *et al.*, 2010; Ortega *et al.* 2011, 2012, 2014a). Moreover, China's top-down approach to food safety places more emphasis on the end product than on production practices. Given the lack of upstream supply chain knowledge with regards to food safety, this study draws from the economics, marketing, and psychology literature to study Chinese aquaculture producer preferences and explores how their value system informs on-farm decision-making with regards to food safety.

The study of preferences has been reserved mostly to applications of consumer issues. However, many of the decisions made along the food supply chain involve various agents, of which, arguably, producers have the most influence regarding the safety and quality of our food. Individual's value systems, defined by Rokeach (1973), as an organization of beliefs concerning preferable modes of conduct or end-states of existence along a continuum of relative importance, have been linked to preferences for various product attributes. Methods traditionally employed in consumer-oriented research have been adapted to better understand producer preferences, namely producer willingness to change. Schulz and Tonsor (2010) utilized a choice experiment to assess U.S. cow-calf producer preferences for voluntary traceability systems and Olynk, Wolf and Tonsor (2012) estimated changes in dairy producers' welfare when various production technologies were removed from their option sets. In a development context, several

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studies have modelled farmers' preferences for biodiversity (Birol *et al.* 2009), environmental management (Richardson *et al.* 2013), livestock traits (Ruto *et al.* 2008) and drought tolerant characteristics in staple crops (Ward *et al.* 2014).

The use of best-worst scaling has been gaining recent attention from applied economic researchers. Lusk and Briggeman (2009) identified a set of food values and found a significant relationship between consumers' value system and their stated and revealed preferences. Wolf and Tonsor (2013) explored Michigan dairy farmers' policy preferences using seven policy options related to the 2012 U.S. Farm Bill and found differences between large and small dairy operators. Pruitt *et al.* (2014) analysed various users' preferences for agricultural market information and outlined implications for the maintenance of public investments given a tightening of U.S. federal budgets. Erdem *et al.* (2012) investigated stakeholders' perception regarding responsibility for food safety via best-worst scaling and find that consumers tend to think farmers are more responsible for ensuring meat safety than farmers do. This study builds upon this approach by (i) identifying a set of important producer-based value attributes regarding aquaculture production in China, (ii) assessing how aquaculture farmers value these attributes, and (iii) determining how farmers' value system relates to on-farm food safety decision-making.

China's aquaculture industry is mostly concentrated in the central, eastern and southern provinces where the Yangtze and Pearl rivers provide water for these operations. An in-depth study of the aquaculture sector by Broughton and Walker (2010) points out that the system operates as two entities: a low-standard sub industry that supplies for the domestic market and a separate one for products bound for the export market, that is governed mostly by higher international safety and quality standards. Though mostly separate, the researchers of the present study found that some farmers supply to both channels and have fishponds that operate under varying standards. The majority of domestic production is focused on carp and other local species while tilapia and shrimp dominate the export market. The majority of products raised for domestic consumption are sold in the live market, where there are over 340 wholesalers who buy products from individual farmers or distributors and sell to supermarket retail, wholesale or restaurant buyers; the average time to consumption post farm gate is less than a week (Broughton and Walker, 2010). In contrast, the export supply chain is dominated by an increasing number of processors. Given processing and shipment of these products to foreign markets, time to consumption is anywhere from several weeks to months. While inspection of Chinese aquaculture products in some importing countries is based on risk assessment, the researchers found that some Western buyers have their own quality inspectors or rely on third-party auditors to test the product. Even so, various critics have raised concerns over imported fish and Chinese production standards in Western markets (see Ortega *et al.*, 2014c).

Issues ranging from environmental sustainability, to ethics and food-product safety have caught the attention of Western consumer watch groups such as Monterey Bay Aquarium's Seafood Watch which have placed Chinese aquaculture products under their 'avoid' recommendation list. Moreover, a series of production guidelines have been developed by third party organizations to promote responsible aquaculture practices across the industry. Given the lack of information available regarding Chinese aquaculture producers, this study is one of the first to document farmers' preferences for select value attributes governing the global aquaculture industry.

Table 1: Aquaculture producers' value attributes

Attribute	Description
Food Safety	Extent to which consumption of product will not cause illness
Traceability	Ability to identify the origin, and movement of the product through the supply chain
Animal Welfare	Ethical and responsible treatment of live product
Water Quality	Using quality water in operation
Environmental Impact	Sustainable environmental practices
Food Safety Certification	Willingness to undergo food safety inspection
Scape Control	Protecting native species
Regulatory Compliance	Abiding by laws and regulation
Drug Management	Responsible use of veterinary drugs including antibiotics
Community Relation	Developing good standing with the local community
Consumer Knowledge	Producer awareness and knowledge of final end consumer

2. Methods

Given that Chinese producer data on these value attributes does not exist and related data on farmer behaviour is not widely available, fieldwork to gather primary data was necessary. A producer survey was developed to obtain information from Chinese aquaculture producers regarding their production practices (including their use of antibiotics), socio-demographic characteristics, as well as their knowledge of the various stages of production in their operation. A choice experiment (CE) using best-worst scaling was utilized to assess farmer preferences. Through consultation with experts on the Chinese aquaculture industry, academics, trade officials and a thorough review of the literature that included an assessment of various standards developed by voluntary certification programs, eleven aquaculture value attributes were identified for evaluation[4]. These range from ethical standards such as community relation, animal welfare and environmental sustainability to product quality standards, including food safety, drug management as well as regulatory issues such as food safety certification and regulatory compliance. A complete list of the value attributes and their corresponding description is presented in Table 1.

Best–worst scaling is based on random utility theory, a well-tested theory of human decision-making

[4] Literature reviewed includes reports by FAO (2010), Washington and Ababouch (2011), and Guidelines for Best Aquaculture Practice Standards for Tilapia and Shrimp Farms provided by the Global Aquaculture Alliance.

Which of the following value attributes is most important and which is least important to you in your operation? (Select only one value as most important and one as least important)

Most important	Value Attribute	Least Important
	Food Safety	
	Traceability	
	Environmental Impact	
	Regulatory Compliance	
	Drug Management	
	Consumer Knowledge	

Figure 1: Example of Best-Worst choice task

hypothesized by Thurstone and generalized by McFadden (McFadden, 1974, 2001; Thurstone, 1927). Several advantages of using best-worst scaling over other revealed preference methods, including their reliance on the use of relative trade-offs, have been documented in recent years (see Flynn *et al*., 2007; Lusk and Briggeman, 2009). In this study, farmers were shown a series of choice sets (Figure 1) containing the various value attributes identified and asked to select which was the most (best) and least (worst) important to them[5].

When answering each question, producers are assumed to be choosing the two attributes that maximize the difference between the two items on an underlying scale of importance (Lusk and Briggeman, 2009). Allowing λ_j to formally represent the location of value attribute j on the underlying scale of importance, the latent unobservable level of importance for famer i is given by

$$I_{ij} = \lambda_j + \epsilon_{ij} \qquad (1)$$

where ϵ_{ij} is a random error term. Therefore, the probability that farmer i chooses attribute j as most important and attribute k as least important is equal to the probability that the differences between I_{ij} and I_{ik} is greater than all other J*(J-1)-1 possible difference in the choice set. If the error term is independently and identically distributed type I extreme value, then this probability takes the multinomial logit (MNL) form:

$$Prob(j = best \cap k = worst) = \frac{e^{\lambda_j - \lambda_k}}{\sum_{l=1}^{J} \sum_{m=1}^{J} e^{\lambda_l - \lambda_m} - J} \qquad (2)$$

The parameter λ_j can be estimated through maximum likelihood estimation using equation (2). The dependent variable takes a value of 1 for the attributes chosen by a farmer, and 0 for the remaining J*(J – 1) – 1 pairs of attributes that are not selected. λ_j represents the importance of value attribute j relative to the attribute ranked least important (identified ex-post), normalized to zero, to avoid the dummy variable trap. To explore preference heterogeneity, a random parameters model (RPL) was estimated. The importance parameter for farmer i and issue j is denoted by

$$\tilde{\lambda}_{ij} = \bar{\lambda}_j + \sigma_j \mu_{ij} \qquad (3)$$

where $\bar{\lambda}_j$ is the mean and σ_j is the standard deviation of λ_j, and μ_{ij} is a random variable which follows a standard normal distribution. This specification implies the assumption that the importance ranking location of attribute j is normally distributed with mean $\bar{\lambda}_j$ and standard deviation σ_j. Following Train (2003) and Huber and Train (2001), individual–specific estimates can be obtained by using the estimated parameters as a prior and using each farmer's actual choices to form an individual-specific posterior estimate.

In order to obtain results consistent with standardized ratio scaling techniques, the share of importance (S) for each value attribute, equal to the forecasted probability of being chosen as most important, can be calculated as

$$S_j = \frac{e^{\lambda_j}}{\sum_{k=1}^{J} e^{\lambda_k}} \qquad (4)$$

The 'share of preference' for all value attributes must sum to one. Moreover, each share of preference reflects both the true importance of the attribute in producers' value system (measured on a ratio scale) as well as the relative uncertainty in the importance famers place on the attribute (Lusk and Briggeman, 2009). In other words, if the share of preference for one attribute is twice that of another attribute, the result can be interpreted as the former attribute being twice as preferred as the latter (Wolf and Tonsor, 2013).

The producer survey was conducted in the summer of 2011 in three major leading aquaculture-producing provinces of China: Fujian, Guangdong and Guangxi (Figure 2). Agricultural economists from China and the U.S. reviewed the surveys, and ten enumerators were trained to conduct the producer interview and administer the questionnaire that included twelve best-worst choice tasks. Expert advice was sought from applied economists as well as local county officials to obtain a sample of farmers from the region. Three to five counties with fishing villages were randomly selected in each of the

Figure 2: Study location

[5] The experimental design for the best-worst choice experiment was borrowed from Finn and Louviere (1992).

Table 2: Sample summary statistics

Variable	Mean or %	SD
Male	90.0%	
Age	46.47	9.52
Education (years)	8.37	2.60
Years in Aquaculture	11.36	7.77
Farm Size (mu)	123.81	339.94
Net Income (CNY/year)	86,788.57	118,957.31
Net Income from Aquaculture (CNY/year)	61,760.38	101,279.73
Number of Workers	3.44	4.89
Contract Farming	13.8%	
Cooperative Member	5.5%	
Export Oriented	18.2%	
Sample Size (n)	110	

Source: Authors' survey data.

provinces. A total of 150 questionnaires were administered, of which 110 were complete and included in the data set used throughout this analysis.

The majority of aquaculture farmers in our sample were men (90%), 46.5 years of age with 8.4 years of education (Table 2). On average, they had over ten years of experience in aquaculture, farmed about 123 *mu* (approximately 20 acres) and had a net income of approximately 86,788 CNY[6] per year (approximately $13,438) of which 71% was derived from their farming operation. The top aquaculture products raised were carp, tilapia, catfish and shrimp. Approximately 18% of operations in our sample were export oriented and 14% of farms operated under contracts.

Information regarding farmers' level of knowledge and perceived food safety risks at various stages of the supply chain was gathered through a series of 5-point Likert-scale questions, where 1 represented no knowledge/concern and 5 highly knowledgeable/concerned. On average, farmers were found to be more knowledgeable (scores of 4 or 5) of their input suppliers (fingerling, feed and pharmaceutical providers) for whom they also showed heightened concern regarding food safety risks (Table 3). Farmers were least knowledgeable of exporters as well as various regulatory agencies. On average, producers expressed the most concern (scores of 4 or 5) for food safety risks for upstream production related stages of the supply chain including input suppliers and on-farm water and disease management. Farmers attributed the lowest level of food safety risk to processors and downstream stages of the supply chain including retail management practices and the ultimate consumer.

4. Results

Relative importance of value system attributes

Results from the RPL model, presented in Table 4 indicate the relative importance of each of the value attributes. Estimates are shown relative to 'consumer knowledge', which was determined to be the least important value and indicates how little producers care about the importance of consumers' effect on their business. This result is particularly important as it further contributes to the knowledge

Table 3: Farmers' level of knowledge and food safety concern over supply chain stages

Supply Chain Stage	Percent (%) knowledgeable	Percent (%) concerned
Suppliers of fingerlings	73.15	86.24
Suppliers of feed	51.00	84.40
Suppliers of pharmaceuticals	47.22	69.72
Production- water quality	N/A	83.33
Production- disease management	N/A	84.26
Production- technical knowledge	N/A	64.81
Processors	17.16	10.28
Exporters	5.56	N/A
Wholesale/retail	54.20	30.79
End consumer	42.45	31.48
Local regulatory agency	34.86	N/A
National regulatory agency	11.92	N/A
Foreign regulatory agency	1.83	N/A

Source: Authors' survey data.

asymmetry that exists between both ends of the Chinese food supply chain (Ortega *et al.*, 2011).

RPL model results reveal that water quality, on average, is the most important attribute for aquaculture farmers. Farmers in this region attribute most fish diseases resulting in production losses to poor water quality. Water quality is by and large determined by exogenous conditions, as fish are raised in outdoor ponds with water supplied from nearby rivers, lakes, or other water bodies. The overall low water quality in China has created significant concerns for aquaculture farmers. However, farmers can contribute to their own on-farm water quality by controlling fish density, feed and drug use, and adopting new technology. Farmer awareness of this important issue is a good start for the promotion of environmental protection in China.

Food safety, animal welfare, regulatory compliance, and traceability are the next most important issues to farmers. Interestingly, these are either monitored by the government (latter two) or easily picked up by the public or media. Violating any of these may lead to legal and financial consequences. Drug management, scape control, and environmental impact are less important factors concerning farmers. Veterinary drug use is loosely controlled in China and environmental regulations are more geared towards targeting industrial rather than agricultural pollution. Additionally, the negative impact to the environment of dumping polluted water into rivers or lakes or fish escape, will not directly impact own farm production.

Food safety certification, community relations, and consumer knowledge (chosen as the base because of its least important status) were the least important for farmers. Farmers haven't noticed the potential market premium for food safety certification because their output is not produced as branded product for processors, rather sold to wholesalers as bulk commodities. Their neighbours tend to be in the same business, a wide existing phenomenon in China that farmers in the same

[6] At the time of the study (summer 2011) 1CNY was equal to approximately £0.096, $US0.155 USD and €0.107.

Table 4: Random parameter logit results and derived shares of preference

Variable		Coefficient		Shares of Preference
Water Quality	Mean	3.871	(0.171)*	0.407
	SD	1.265	(0.128)*	
Food Safety		3.281	(0.159)*	0.226
		0.863	(0.111)*	
Animal Welfare		2.290	(0.186)*	0.084
		2.866	(0.246)*	
Regulatory Compliance		1.820	(0.168)*	0.052
		1.597	(0.164)*	
Traceability		1.793	(0.180)*	0.051
		2.370	(0.166)*	
Drug Management		1.700	(0.158)*	0.046
		1.889	(0.172)*	
Scape Control		1.682	(0.169)*	0.046
		2.231	(0.150)*	
Environmental Impact		1.580	(0.131)*	0.041
		0.405	(0.191)*	
Food Safety Certification		1.009	(0.147)*	0.023
		1.329	(0.116)*	
Community Relation		0.496	(0.166)*	0.014
		1.915	(0.159)*	
Consumer Knowledge		0.000		0.010
Log likelihood		−2991.53		

Note: Standard Errors are presented in parentheses. Asterisk, '*', denotes statistical significance at the 0.05 level.

village tend to produce the same commodity using similar practices. Additionally, many supply chain layers separate farmers from the end consumers, thus they do not obtain direct signals indicating that many of these consumer demands and values are important.

Because the utility parameters have no natural interpretation other than their relative ranks, derived shares of preferences from equation (4) for each of the values were calculated and are presented on the right side of Table 4. Our results show that producers have the highest mean preference share for water quality (40.7%), which is almost twice as preferred as food safety (22.6%), the next most important value attribute. Animal welfare received a share of 8.4%, indicating that farmers understand the effects of good fish handling practices on product quality. While food safety contributed almost a fifth to overall preferences, regulatory compliance, traceability, drug management and food safety certification, in aggregate, had a 17.2% share of preference. Concerns regarding environmental impact or scape control made up 8.7% of the mean preference share and less than a 4% share was attributed to community relation or consumer knowledge. In other words, community relation and consumer knowledge are ten times less important to farmers than the most important value attribute, water quality.

Correlations between producers' values were calculated using farmer-specific RPL model estimates (Table 5). Given that all of the correlation coefficients are below 0.5, this indicates that each of the values identified represent a unique concept within farmers' value system (Lusk and Briggeman, 2009). Values exhibiting a correlation coefficient greater than 0.2 are highlighted in light grey in Table 5. Water quality is positively associated with both drug management as well as environmental impact, meaning that farmers who believe water quality is important are also likely to believe that drug management or the environmental impact of their operations is important. On the contrary, farmers who believe water quality to be important are less likely to believe that traceability or food certification is important. While traceability was found to be positively associated with scape control and food safety certification, farmers who valued it were less likely to find environmental impact and drug management important. It is worth noting that traceability and food safety certification do not make products safer, rather, they are just indicators to consumers. On the other hand,

Table 5: Pearson correlations between producer values from individual-specific RPL estimates

Value		1	2	3	4	5	6	7	8	9	10
Water Quality	1	1.00									
Food Safety	2	0.16	1.00								
Animal Welfare	3	0.07	−0.10	1.00							
Drug Management	4	0.37	−0.02	0.14	1.00						
Scape Control	5	−0.17	−0.10	−0.06	−0.04	1.00					
Environmental Impact	6	0.28	−0.16	0.10	0.18	−0.21	1.00				
Regulatory Compliance	7	−0.17	0.17	−0.10	−0.07	0.04	−0.21	1.00			
Traceability	8	−0.32	−0.02	0.14	−0.32	0.47	−0.36	−0.04	1.00		
Food Safety Cert.	9	−0.22	−0.05	−0.17	−0.14	0.12	−0.23	0.06	0.22	1.00	
Community Relation	10	−0.01	0.04	−0.06	−0.04	−0.04	−0.01	0.08	−0.04	0.07	1.00

drug management and water quality contribute directly to product quality and safety. It is reasonable that farmers rank items in the same category closely and those in different categories remotely resulting in the positive and negative correlations.

Value attributes and on-farm decision-making

To explore how farmers' value system is related to on-farm decision-making, we gathered data on each farmer's willingness-to-stop using antibiotics through a separate discrete choice experiment. Individual parameter estimates from the best-worst RPL model were obtained and used to calculate correlation coefficients between each farmer's share of preference and the premium (or discount) needed to stop using antibiotics (Ortega *et al.*, 2014b). The use of antibiotics was selected to assess how farmers' value system affects on-farm decision-making due to the food safety implications of this practice in the Chinese aquaculture industry. Table 6 shows Pearson correlation coefficients between each farmer's value attribute share of preference and their willingness-to-stop using antibiotics. Our empirical results show that producers who value food safety the most, are more likely to stop using antibiotics in their operations. This finding highlights the association present between food safety and the use of antibiotics and links farmers value system and preferences to their on-farm behaviour.

5. Discussion and conclusion

While research on preference structures has focused mostly on consumer studies, we demonstrate how farmers' value system plays a role in on-farm decision-making. In this study we adapt a best-worst research framework to better understand producer preferences and how they relate to decisions that affect product safety and quality. Our results reveal that producers were found to have the least concern and knowledge regarding the end users of their products, and they also indicated that knowledge of consumers and safety certification were not important to them (although they find safety itself important). The latter is at odds with findings that consumer value food safety certification (Wang *et al.* 2008). We find that attributes which farmers value most are those directly related to their operation, such as water quality, safety, and animal welfare which they can link directly to product quality and output. Farmers also have the strongest concerns about their input suppliers, which is also directly connected to their product. While farmers' focus on their operation may ensure product safety, efforts should be made to convey this message to consumers to enhance their confidence and unveil unsafe products in the marketplace. Such bridging of information asymmetry can be accomplished through certifications of food safety, eco-friendly practices, and other attributes consumers value (Ortega *et al.* 2011).

Table 6: Correlations between shares of preferences for producer Values and Willingness to Stop Using Antibiotics

Value	Pearson Correlations
Water Quality	– 0.144
Food Safety	0.201*
Animal Welfare	0.070
Drug Management	0.029
Scape Control	– 0.198*
Environmental Impact	– 0.032
Regulatory Compliance	0.063
Traceability	– 0.015
Food Safety Certification	– 0.052
Community Relation	0.158
Consumer Knowledge	– 0.014

Note: One asterisk (*) denotes the correlation between the producer value and the willingness to stop using antibiotics is significantly different from zero at the p = 0.05 significance level.

Our results also suggest that some safety issues in the Chinese aquaculture sector go beyond on-farm production practices. Factor inputs including feed, veterinary drugs, and water management can all contribute to food safety incidents. Furthermore, although processors, wholesalers and retailers can also contribute to safety problems, farmers do not seem concerned, likely because they would not be held responsible if a safety event occurred. However, in the event of a food safety incident, a significant demand shock for the product will impact the commodity at the farm gate. Results from both sides of the supply chain suggest that farmers should be cautious in choosing whom to work with. Contracting with suppliers and buyers (wholesalers or processors) is recommended as it fits with the Chinese government policy of encouraging contract farming (Wang *et al.* 2014) and is likely to decrease food safety incidents by increasing transparency among links in the supply chain. We also find that foreign regulatory agencies, either government or third party certifiers, are not well understood by Chinese aquaculture producers. More outreach from these parties is needed so that trust and good relations can be established to enhance the safety and quality of products that are imported by the home countries of these foreign agencies.

While this study explores Chinese aquaculture famers' value system, additional work is needed to fully understand how farmer preferences and production level decisions affect product safety. A limitation of the present study is that it only addresses aquaculture farmers in a specific region of China and does not take into account the behaviour of other agents in the supply chain. Further, additional insight can be obtained by comparing how farmers' value systems vary across various types of agricultural producers. A study of preferences for these and other individuals along the supply chain and across various commodities will better inform food policy regarding product safety and is left as an area of future research.

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