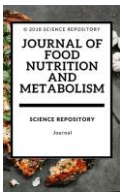

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Research Article

Consumers' Acceptability of Using Prominent New Technologies in Atlantic Salmon Farming

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ABSTRACT

This study examines and compares consumers' willingness-to-accept and willingness-to-pay a premium price for purchasing certified farm-raised Atlantic salmon using a multinomial logit model. Consumers lost their trust in the seafood industry after the food incidence of polychlorinated biphenyls in farmed Atlantic salmon which caused a significant change in the demand for the product. The implementation of traceability systems is recommended to provide food safety for consumers. The result showed gender, age, annual household income, salmon type consumption, reading labels prior to purchase salmon, were commonly and statistically significant for both target groups of respondents; however, respondents' knowledge about the adverse effects of polychlorinated biphenyls on human health status placed great values on their decisions to purchase certified farm-raised Atlantic salmon by paying a 15 per cent premium price.

Introduction

There is no doubt that the economies of the Canadian coastal regions are affected by the role of fisheries and aquaculture industry in a way of its substantial contribution to the gross domestic product and year-round employment especially in rural areas and fishing communities. The dependency rate of the vibrant economies of the Atlantic Canada provinces to the fisheries and aquaculture industry clearly shows how important it is in these regions. For instance, the total national sales of commercial sea and freshwater fisheries landings (e.g., groundfish, pelagic, shellfish, etc.) and aquaculture production (e.g., salmon, trout, steelhead, clams, oysters, mussels, scallops, etc.) in 2013 were about CAD 3.27 billion, of which 29 per cent (i.e., CAD 0.963 billion) was contributed by the aquaculture production [1]. The industry also benefited from the ongoing global increase in demand for different types of seafood products which led to a substantial increase in their exports to more than 40 countries including the United States (mostly to the New England region) and China as the major importers of these types of products in the same year [2]. In particular, the fisheries and aquaculture industry had a positive traded balance of CAD 1.56 billion in 2013. With its four provinces (i.e., Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and New Brunswick) representing over 40,000 kilometres of coastline, Atlantic Canada accounts for the vast majority of Canada's rich variety of harvested, farm-raised and processed fisheries products exported worldwide [3]. All these accomplishments have not been acquired without costs, though. The adverse impact of environmental effects has also been raised against these achievements. For instance, Cole et al. (2009) and Naylor and Burke (2005) listed some of these negative effects, such as mismanagement in discharging wastes; gradual increase in the amount of consolidated nitrogen, phosphorus and other nutrients, chemicals and pathogens. In addition, wild stocks and natural ecosystems might be affected by the escape of cultured organisms [4-6].

Farm-raised Atlantic salmon is the most important finfish species produced by the Canadian aquaculture industry. The industry has been observing drastic reduction in the demand for farm-raised Atlantic salmon caused by the food incidence of polychlorinated biphenyls (PCBs) although it has been rebounded in recent years [7, 8]. Policymakers have been trying to introduce different proposals for Atlantic salmon farming in various stages from production to processing, distribution channels, and marketing to mitigate the current consumers' mistrust in the quality of the product [9]. One outcome of those policies led to improve public knowledge on issues like food safety and quality assurance of foods, especially for farm-raised Atlantic salmon. As a result, the fisheries and aquaculture industry in Canada has been facing

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an ongoing increased in demand for safe products. Consumers show their desire in purchasing high quality farm-raised Atlantic salmon, first, by increasing their willingness to accept the use of new technologies in the production of farm-raised Atlantic salmon, and second by revealing their behavior of willing to pay a premium price to purchase the product that is safe for consumption. To meet the increased demand for food safety, policymakers have been reviewing several policies that encompass the needs of both consumers and farm-raised Atlantic salmon producers. Amongst the suggested policies, the industry would have to choose the one that is most comprehensive, applicable, affordable, and containing with the least production costs. All these criteria can be collectively observed in newly enhanced technologies known as the integration traceability methods and quality control systems (ITM-QCS). The most comprehensive definition of traceability is proposed by Archipelago (2005, p.9) who described traceability as "the ability to systematically identify a unit of production, track its location and describe any treatments or transformations at all stages of production, processing and distribution" [10]. The International Organization of Standardization (ISO) also defined traceability as "the ability to trace the history, applications, or location of that which is under consideration" [11]. According to Magera and Beaton (2009) traceability systems are two-fold; internal and external traceability systems [12]. The former one allows us to look for reasons if something occurs to a product throughout a production process in a firm. The latter one, which contains in-depth information-sharing systems, allows us to look for reasons if something occurs to a product throughout a production process within a supply chain in both inside-and-outside of a firm. The ITM-QCS is comprised of a series of consecutive mechanisms in Atlantic salmon farming, such as the GlobalGAP and Quality Management Program (QMP), the Hazard Analysis and Critical Control Points (HACCP), and the radio frequency identification (RFID) and quick response code-systems that enable consumers to have access to details information about the food they purchase, curtail their mistrust in Atlantic salmon farming, and boost their confidence in the authenticity of the product [13]. It is expected that the use of the ITM-QCS in Atlantic salmon farming would presumably drive up the product price as it increases its production cost.

The objectives of this study are twofold. First, we analyze consumer preferences to purchase certified farm-raised Atlantic salmon in the province of Newfoundland and Labrador, Canada. A certified farmed Atlantic salmon is defined as the product that is passed through the ITM-QCS. As mentioned above, consumers show their interest to buy this product by paying a premium price in addition to what they used to pay for a conventional one. However, there is a divergence between what consumers are willing to accept (WTA) versus what they are willing to pay (WTP) a premium price to purchase the product [14]. The divergence amount depends upon the consumers' reservation price, or what they psychologically have in their minds as opposed to what they actually show their behavior. While most economists believe that the divergence amount is substantial especially when the disparity in income distribution level is quite noticeable, Willig (1976) stated that, under certain circumstance, the divergence amount would be very small and simply around five per cent [15]. Second, we examine the economic analysis of the divergence amount between consumers' WTA and WTP for purchasing certified farm-raised Atlantic salmon in the region.

The rest of the paper is organized as follows. The second section briefly reviews recent studies in which consumer perceptions towards the integrating traceability methods and quality control systems in the agricultural food products are analyzed. The third section presents the empirical analysis of this research which includes summary of the sample observations, methods of survey, and provides the results of the regression analysis followed by an in-depth discussion about the findings of the empirical analysis. The fourth section concludes the article by presenting some remarkable points, indicating the limitations of the research and providing new directions for further research.

Recent studies on traceability systems

Evidence shows that the idea of implementing traceability systems in the global food industries has come to the minds of stakeholders including producers, food professionals, economists and policymakers since 2000. In general, we recognize five groups who might be interested in the concept of traceability, labeling, and identity preservation systems for farm-raised Atlantic salmon. These groups are identified as domestic and foreign consumers, environmental advocates, domestic and international producers, policymakers, and governmental agencies. Consumers continuously inquiry about food safety; environmental supporters seek for sustainability in agricultural production; domestic and foreign producers persistently try to assure consumers that their products are safe; policymakers and researchers carefully examine consumers and producers' attitudes toward traceability and labeling systems in different food sectors; and governmental agencies actively work to find proper solutions to mitigate consumers mistrust in the food safety. This type of classification has also been noticed more or less in other industries [16]. In addition, three functions of implementing traceability systems in Atlantic salmon farming would justify their nontrivial role in the food safety. These three functions are ability to (*i*) reduce both public and private costs by tracking down a safety problem when it occurs, (*ii*) strengthen the enforcement of Tort Liability Law that requires producers to consider safety of food they produce, and (*iii*) raise public awareness on information related to animal well-being, product ingredients, environmentally-friendly agricultural practicing through proper and comprehensive labeling.

Zheng et al. (2018) examined the production and consumption of sustainable wild salmon by focusing on the condition of its food security and product quality in the Chinese market [17]. At present, the country represents one of the most rapidly emerging economies in the world with a substantial number of population and state-owned largest consumer markets which can significantly impact global trade flows, ecosystem and the environment. One of the objectives of the researchers was to evaluate the demand for imported wild and sustainable Alaska salmon fillet and varietal parts in China using the consumers stated purchase intentions model for the product. To do this, Zheng et al. (2018) used an ordered logit model to identify factors that affect consumers' purchasing decisions. Some of these factors show how households shape their consumption habits, how consumers' perceptions are formed, and what are the socio-economic factors that affect consumers' decisions in purchasing imported wild and sustainable Alaska salmon fillet and varietal parts [17]. It is expected that the pattern of consumption habits varies between the Western society and the Chinese inhabitants. Zheng et al. (2018) found that not all parts of salmon fish products were proportionally purchased by the households [17]. For instance, Western

consumers, unlike Chinese, seem not to be interested in consuming low-value salmon heads and bones. The researchers suggested that these parts of the fish products may be worth more if they are exported to the Chinese markets. Zheng et al. (2018, p.13) concluded that the findings of their study provided straight directions for policy makers and producers in allocating scarce resources efficiently, helping consumers to choose healthy foods, reducing the amount of food waste and therefore, increasing the value added of the products.

Haghiri (2017) analyzed consumers' behavior in purchasing certified farm-raised Atlantic salmon in the province of Newfoundland and Labrador, Canada [18]. The researcher defined certified farmed Atlantic salmon when it was passed through certain standards, known as the integration traceability methods, to boost consumers' trust in the safety of the product. A series of laboratorial experiments, including QMP, HACCP, and RFID on the production of farmed Atlantic salmon encompasses the traceability system. Haghiri (2017) stated that the price of farmed Atlantic salmon would possibly increase after the implementation of traceability systems [18]. This might have a negative impact on households' consumption behavior despite the fact that a certified farmed Atlantic salmon provides food safety. In addition, the researcher argued that the increase in the price of the product would generate conflict of interest since it is unknown who should pay for the additional costs of implementing traceability methods. Haghiri (2017) proposed the establishment of intermediary firms to market certified farm-raised Atlantic salmon [18]. This suggestion can be justified by the fragmentation of the market for credence attribute products since public regulators are weak. The researcher concluded that in the absence of intermediary firms, the adoption of new technologies might be associated with substantial delay and that the market might not be fully discovered which could further translate in research and development investment.

Policymakers and other stakeholders in the aquaculture industry have recently reached to a consensus that traditional aquaculture activities cannot be a reliable practice anymore and that the aquaculture producers should use more innovative, cost-effective, and viable technologies in their production process to be able to stay in highly competitive markets. As one solution, Chopin (2013) suggested that the aquaculture industry should use the Integrated multi-trophic aquaculture (IMTA) technique consisting of a method in which "one species always finds a feeding niche in the waste generated by another species" [19, 20]. Martinez-Espineira et al. (2016, p.2) stated that the purposes of using the IMTA technique are three-fold: "environmental sustainability, economic profitability and stability, and social acceptability" [6]. The first task is implemented through an ecologically balanced systems designed primarily for a sustainable environment. The second task can be done through lowering production cost per unit, product diversification, reduction of both output and price risk, and increasing job opportunities in rural and coastal regions. The third task is done through improving the overall functionality of the economy by making transparent governmental regulations, employing efficient management approaches, producing differentiated outputs, and prioritizing safety of products in the production process. In a recent study conducted by Martinez-Espineira et al. (2016), the non-used benefits of adopting the IMTA techniques in producing Atlantic salmon was estimated using both Contingent Valuation (CV) and Contingent Behavior (CB) methods. The targeted participants in the survey were those who did not consume farm-raised salmon within a one year prior to the date of the survey [6]. The participants in the survey were asked about a new proposed policy that sought their support on imposing an additional tax rate on their annual income taxes levied to support the cost of implementing the IMTA techniques used by 50 per cent of the current number of Atlantic salmon growers. One of the outcomes of implementing the aforementioned policy was to reduce the waste production obtained from growing Atlantic salmon when compared to the conventional farmed aquaculture practicing. The researchers argued that the implementation of the innovative methods of production (e.g., IMTA techniques, traceability systems, etc.) will eventually drive up the product price. Previous studies have also reached the same conclusion [21-25]. On the other hands, Martinez-Espineira et al. (2016) stated that the increase in the cost of production per unit may be offset by several factors including (*i*) the increase in the product price as a result of establishing a credence attribute, (*ii*) improvement in the ratio of output/input or the output productivity (e.g., shellfish, algae, etc.) and (*iii*) ongoing increase in the consumers' demand for innovative products [6]. The only shortcoming of this policy is that if the output markets are not regulated, "any non-use values generated by IMTA would be ignored" (Martinez-Espineira et al. 2016, p.2) [6]. The findings of the researchers' study showed that the targeted participants in the survey could gain about CAD 43 million per year within the next five years.

Haghiri (2014) examined consumers' willingness to pay a premium price for certified farm-raised Atlantic salmon in the province of Newfoundland and Labrador, Canada [13]. The researcher stressed that the adoption of bar code systems in associated with the utilization of GlobalGAP at the farm level and the implementation of HACCP in the processing and packaging plants would help the industry ensure consumers that the product is safe. Haghiri (2014) used the contingent valuation method and specified a probit regression model to measure consumers' attitudes toward purchasing certified farm-raised Atlantic salmon [13]. The author used a primary sample data collected from 120 participants who resided in Newfoundland and Labrador at the time of survey. The consumers' questionnaire was comprised of information related to the demographic, socio-economic characteristics, and attitudinal variables. The dependent variable of the model was designed as a yes/no type of response implying whether the participants in the survey were willing to pay a 15 per cent premium price to buy certified farm-raised Atlantic salmon. A summary of Haghiri's conclusion is as follows. First, the respondents with higher level of education and higher income bracket as well as seniors were among the participants in the survey who were most willing to pay the premium price to purchase the certified farm-raised Atlantic salmon. Second, the respondents welcomed the use of integrated traceability methods and quality control systems in the salmon industry in spite of the fact that such implementation could possibly drive up the price of farm-raised Atlantic salmon. Finally, the implementation of the integrated traceability system in the salmon industry could potentially shift the demand for such product (i.e., safe and high-quality product) stemming from changes in taste and preferences of consumers for purchasing these types of products.

Finally, Asioli et al. (2011) studied factors that affect costs and benefits of implementing traceability systems in Italy [26]. Following Golan et

al. (2004), the researchers made their hypotheses upon the three aspects of traceability: precision, breadth, and depth. Precision refers to a solely traceable lot or batch which may include a single product or an entire production line throughout a day [27]. Breadth lists the type of information gathered from a lot or a batch. Depth points out to the time-frame that a systematic related trace is in effect. The main objective of the Asioli et al. (2011) study was to conduct a cost-benefit analysis of implementing traceability system in the Italian fish industry (60 processors) and examine the differences obtained from conducting the policy under both *ex-ante* (expected) and *ex-post* (actual or perceived) conditions to assess the matter of investment uncertainty [26]. The result of the research showed that (*i*) individual firm's specific characteristics did not significantly affect cost and benefit measures, (*ii*) firm size had positive impact on cost and benefit measures under both *ex-ante* and *ex-post c*onditions, and (*iii*) the expected and actual costs and benefits from implementing the traceability system substantially differed from each other.

Empirical analysis

This article examines consumers' acceptability of using prominent new technologies in Atlantic salmon farming in the province of Newfoundland and Labrador, Canada. In particular, a contingent valuation (CV) method was used by specifying a multinomial logit (MNL) regression model which quantified consumers' willingness to accept (WTA) and willingness to pay (WTP) a premium price to purchase certified farm-raised Atlantic salmon that was passed through several traceability systems. The CV method is a widely used approach in (*i*) reflecting an individual's stated preference as opposed to his/her revealed preference, and (*ii*) estimating the values of goods that are not marketable (yet privately owned) at the same time yielding non-use values. In addition, Whitmarsh and Wattage (2006) stated that the CV method is a proper approach in some occasions which markets for some aspect of a good might not be observed [28]. For instance, when we want to estimate consumer's willingness to pay a premium price for purchasing safe seafood products for animal welfare and for certified fish products that was passed through traceability systems [29]. We modified Hoffman and Spitzer's (1993) definition of WTA and WTP and applied it to this study. In particular, we hypothesized that WTA refers to the minimum amount that consumers would like to spend to acquire certified farm-raised Atlantic salmon and WTP indicates the maximum amount they would be willing to spend on the product to purchase it. The parameters of the regression models were estimated using an extension of the maximum likelihood approach, known as maximum a posteriori (MAP) estimation method [30].

To estimate the parameters of the MNL model we approached 728 individuals during September 2018 to February 2019 and were able to collect data from 480 residents in the province of Newfoundland and Labrador, yielding a response rate of 65.9 per cent. We received different reasons from those participants in the survey who did not finish the questionnaires. Some of the reasons were "not interested," "not a resident of Newfoundland and Labrador," and "not have time." The participants in the survey were divided into four separate regions, including east (41.7 per cent), central (10 per cent), west (37.5 per cent), and the Labrador shire (10.8 per cent) depending upon where they resided. We randomly chose sample data from the provincial telephone directory by quotas on the basis of the above sampling structure and interviewed the participants in the survey on every days of a week in different times of the day. Following Haghiri and Simchi (2012) we designed a consumer survey questionnaire and for every participant in the survey we completed the questionnaire which is comprised of four distinct sections [22]. Section 1 includes questions related to the demographic information (e.g., gender, age, marital status, household size, etc.), whereas the second section consisted of socio-economic variables (e.g., education, income level, employment status, etc.). Section 3 contained attitudinal variables, also known as psychographic variables (e.g., consumer attributes related to values, personality, attitudes, interests, beliefs, lifestyles, etc.). The latter information is based on a five-point Likert scale where one indicated a minimum level of agreement and five implied the maximum level of agreement. The last section included information related to consumer attributes on the quality of farm-raised Atlantic salmon. Moreover, we collected other data such as where (i.e., home or restaurants) and what type of Atlantic salmon (i.e., fresh, frozen, wild-caught, and farm-raised) the participants in the survey ate, and how much their monthly consumption was on the grounds of four categories (i.e., less than one pound, between one and two pounds, between two and four pounds, and more than four pounds), and finally, their common knowledge on food safety (e.g., the hazardous of PCBs). As Haghiri (2014, p.1097) stated the results of any consumer surveys is associated with time-and-region specific that put some limitations on the credibility of the surveys [13]. This study is aware of such limitation and it believes that the findings of the study present information that might be of interest of stakeholders in the industry.

Table 1 shows summary statistics for the variables used in this study. Of the total participants in the survey, 53 per cent were female and 47 per cent were male (GEN). This is approximately corresponding to the half a million population of the province of Newfoundland and Labrador in 2010 of which female population (51 per cent) outweighed male population [31]. It is also observed that 50 per cent of respondents were less than 50 years of old (AGE) and 25 per cent were seniors (more than 65 years of age), 46 per cent were singles (MARIT), and 36 per cent were holding university degrees (EDU). (Table 1) shows that more than 49.8 per cent of the participants in the survey earned (INC) less than CAD 49,999 in 2017. The province of Newfoundland and Labrador used to have a high migration rate for those labor forces who were actively seeking job opportunities in the other parts of the country, especially the energy sectors of Alberta and Saskatchewan. As Haghiri (2014, p.1097) mentioned, Newfoundland and Labrador is hosting people who were born in the region but worked most of their lives outside of the province and ultimately returned hometown after they retired [13]. This pattern is barely seen nowadays with the economic turmoil that the aforementioned provinces are facing. The rate of labor migrants had significantly declined after the world oil prices plunged and as a result the energy sector has severely been affected. This means more people in the province would apply for the government financial assistance which put substantial pressure on the provincial government budget. In total, 84.5 per cent of respondents preferred to consume fresh Atlantic salmon instead of the frozen one (SALPREFER), and 47 per cent inclined to consume the wild-caught Atlantic salmon instead of the farm-raised one (SALTYPECON). Due to the implementation of the provincial quota system in place total demands for wild-caught salmon is usually not met and thus most of the Newfoundlanders and Labradoreans would

normally consume farm-raised Atlantic salmon.

The results of the descriptive analysis showed that 35 per cent of respondents thought that fresh salmon means wild salmon (PUBKNOW), 77 per cent were the primal decision maker in purchasing salmon fish (PRIMBUYER), only 35 per cent usually visiting fish markets (VISFISHMKT) to buy the product, and 51.3 per cent read the product's label (READLABEL) prior to purchasing (Table 1). The color of salmon fish (SALCOLOR) also affects consumers' decisions to buy the product. The results of the survey indicated that 54.2 per cent of respondents declared that the color of salmon fish mattered to them and 55.4 per cent believed that color, freshness, and quality of salmon meat (SALQUA) were integrally related to each other. Finally, of the total participants in the survey, 57.3 per cent were familiar with the adverse effects of PCBs on human lives (PCBKNOW), however it did not prevent them from consuming salmonid products as the summary of descriptive analysis showed that more than 48.5 per cent of respondents stressed that their households' salmon consumption (NUTRI) was more than two pounds per month, which was highly above the national average consumption (4.5 pounds) of salmon per annum [32].

Table 1: Summary statistics for the explanatory variables

Variable name		Frequency	Mean	S.D.ζ
Gender				
	Female	254	0.5292	0.4997
	Male*	226	0.4708	0.4997
Age				
	Less than 35 years of age*	108	0.2250	0.4180
	Between 35-50 years of age	132	0.2750	0.4511
	Between 51-65 years of age	120	0.2500	0.4335
	More than 65 years of age	120	0.2500	0.4335
Marital Status				
	Singles*	220	0.4583	0.4988
	Married	260	0.5417	0.4988
Family Size		480	2.5292	1.2085
Education				
	High school or less*	159	0.3313	0.4712
	Some college	148	0.3083	0.4623
	University degree	173	0.3604	0.4812
Annual Household Income				
	Less than $29,999*	112	0.2333	0.4234
	Between $30,000 - $49,999	127	0.2646	0.4416
	Between $50,000 - $79,999	126	0.2625	0.4405
	$80,000 or more	115	0.2396	0.4273
Salmon Type Consumption				
	Wild-Caught	226	0.4708	0.4997
	Farm-Raised*	254	0.5292	0.4997
Salmon Type Preference				
	Fresh	406	0.8458	0.4997
	Frozen*	74	0.1542	0.4997
Public Knowledge –Does fresh salmon mean wild salmon?				
	Yes*	169	0.3521	0.4781
	No	311	0.6479	0.4781
Primary Salmon Buyer				
	Yes*	370	0.7708	0.4993
	No	110	0.2292	0.4993
Visiting Fish Market				
	Yes*	170	0.3542	0.4788

	No	310	0.6458	0.4788
Does color of salmon matter?				
	Yes*	260	0.5417	0.4989
	No	220	0.4583	0.4989
Read Salmon Label				
	Yes*	246	0.5125	0.5000
	No	234	0.4875	0.5000
Knowledge on salmon quality				
	Yes*	266	0.5542	0.4976
	No	214	0.4458	0.4976
Public Knowledge on PCBs				
	Yes*	275	0.5729	0.4952
	No	205	0.4271	0.4952
Monthly Salmon Consumption				
	Less than 1 pound*	118	0.2458	0.4310
	Between 1-2 pounds	129	0.2688	0.4438
	Between 2-4 pounds	120	0.2500	0.4335
	More than 4 pounds	113	0.2354	0.4260
Sample Location				
	East*	200	0.4167	0.4935
	Central	48	0.1000	0.3003
	West	180	0.3750	0.4846
	Labrador	52	0.1083	0.3111

ς S.D. means standard deviation.

* shows the group-category explanatory variable omitted from the regression model to avoid the problem of perfect collinearity.

Source: Sample data.

Results and Discussions

Using the MNL regression model, we measured factors that affected consumers to pay a minimum premium price (i.e., WTA) and a maximum premium price (i.e., WTP) to purchase certified farm-raised Atlantic salmon. The response variable of the model is, therefore, three-fold: (*i*) respondents who were not willing to pay a premium price to purchase certified farm-raised Atlantic salmon, (*ii*) respondents who were willing to pay a premium price to purchase the product but their reservation price was only 5 per cent more than of the regular product price, and (*iii*) respondents who were willing to pay up to 15 per cent to purchase certified farm-raised Atlantic salmon that was passed through traceability systems. The above premium price percentages were sample-and-data specific and were derived directly from the descriptive analysis of the survey. More than 41 per cent of the participants in the survey chose 15 per cent as additional payments made to purchase certified farm-raised Atlantic salmon, while almost 32 per cent of respondents declared that they were not willing to pay more than 5 per cent extra to purchase the product, and the remained 27 per cent were not willing to pay a premium price in addition to the market price to buy farm-raised Atlantic salmon. It is worth mentioning that the use of the CV method in empirical analysis for non-market goods or new private goods is associated with some limitations, such as incentive compatibility and/or the presence of hypothetical bias. The first limitation occurs if the dominant strategy for a respondent is to reveal her/his preference truthfully, whereas the second limitation would make the participants in the survey to either over or understate their preferences when they disclosed their WTA and/or WTP [33]. We are aware of these limitations and suggest that the result of this study should be interpreted with these caveats in mind. The parameters of the MNL regression model were jointly estimated by using an extension of the maximum likelihood approach, i.e., the MAP method. The main purpose of extending the maximum likelihood method is to regularize the weights to prevent pathological solutions, which can be done by using a squared regularizing function that similar to placing a zero-mean Gaussian prior distribution on the weights. We used an iteration process so-called *iteratively reweighted least squares* (IRLS) by means of gradient-based optimization algorithms such as limited-memory Broyden-Fletcher-Goldfarb-Shanno (LM-BFGS) to estimate the parameters of the MNL regression model. It is noteworthy to mention that prior to the estimation we chose the 'not willing to pay the premium price group' as the reference category-level group.

Table 2 shows the overall estimation results of the MNL model along the computed figures of likelihood ratio (LR) statistic test for each of the independent variables excluding the category-level variables. Using the LR test, the calculated chi-square statistic was found to be 67.64, which rejects the null hypothesis that all slope coefficients are zero (*p*-value

0.071). It is shown that amongst all the demographic variables used in the model GENF and AGE3 were statistically significant at the 0.05 level. This implies that, in general, female respondents with 51-65 years of old were more willing to pay a premium price compared to the male participants with less than 35 years of old to purchase certified farm-raised Atlantic salmon that was passed through traceability systems. Moreover, only two independent variables (i.e., EDU3 and INC4) of the socio-economic category were statistically significant at the 0.06 level. (Table 2) shows that respondents holding a university degree with annual income of CAD 80,000 and above were more likely to pay a premium price compared to respondents with a high school degree or less earning an annual income of less than CAD 29,999 to buy the certified product. (Table 2) also shows that SALTYPE, PUBKNOW, and NUTRI3 and PCBKNOW and NUTRI4 of the psychographic variables were statistically significant at the 0.05 and 0.10 levels, respectively. This implies that respondents who preferred wild Atlantic salmon, knowledgeable about the adverse impact of PCBs on human lives, capable of distinguishing between fresh and wild salmon, with an average monthly consumption of salmon between 2 to 4 pounds and more were most likely to pay a premium price compared to those respondents whose monthly salmon consumption was less than 1 pound with lack of knowledge about the effects of PCBs on human health, and the difference between fresh and wild salmon to purchase the certified farm-raised Atlantic salmon.

Table 2: Model Fitting Information

Effect	Model Fitting Criteria -2 Log likelihood of Reduced Model	Likelihood Ratio Tests		
		Chi-Square	DF	*p*-value
Constant	966.215a	0.000	0	
GEN**	972.580	6.365	2	0.026
AGE2	966.935	0.720	2	0.698
AGE3***	973.628	7.413	2	0.013
AGE4	966.651	0.436	2	0.804
MARIT	967.244	1.029	2	0.598
FMSZ	966.268	0.053	2	0.974
EDU2	968.606	2.391	2	0.303
EDU3**	971.353	5.138	2	0.033
INC2	967.228	1.013	2	0.603
INC3	968.330	2.115	2	0.128
INC4*	971.856	5.641	2	0.060
SALTYPECON***	978.188	11.973	2	0.003
SALPREFER	968.396	2.181	2	0.336
PUBKNOW**	974.005	7.790	2	0.020
PRIMBUYER	968.185	1.970	2	0.374
VISFISHMKT	966.580	0.365	2	0.833
SALCOLOR	967.050	0.835	2	0.659
SALQUA	970.146	3.391	2	0.140
READLABEL	970.617	4.402	2	0.111
PCBKNOW*	971.012	4.797	2	0.091
NUTRI2	968.906	2.691	2	0.260
NUTRI3**	972.421	6.206	2	0.045
NUTRI4*	971.641	5.426	2	0.066
LOCC	966.914	0.699	2	0.705
LOCW	967.026	0.811	2	0.667
LOCL	967.469	1.254	2	0.534

Number of observations	480
Cox and Snell R-squared (Pseudo R–squared)	0.131
Nagelkerke R-squared (Pseudo R–squared)	0.148
McFadden R-squared (Pseudo R–squared)	0.065
Likelihood ratio statistic	67.64
Degrees of freedom	52
Prob [ChiSqd > value]	0.071

* Significant at 0.10, ** Significant at 0.05, *** Significant at 0.01.

Source: Sample data.

[a] This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Table 3 shows the estimation results of the MNL model when the response variable is WTA defined as the minimum amount (i.e., 5 per cent) that consumers would like to spend on purchasing certified farm-raised Atlantic salmon. The coefficient of gender (**GEN**) was negative (-0.105) and statistically significant at the 0.05 level. It implies that females, on average, were 10.5 per cent less willing than males to pay the 5 per cent premium price to purchase certified farm-raised Atlantic salmon when compared to those who would not be willing to pay the premium price at all. The result showed that respondents with 51-65 years of age (AGE3) were 7 per cent more likely to pay the 5 per cent premium price compared to those respondents with less than 35 years old. The AGE3 variable was positive and statistically different from zero (*p*-value 0.019). The coefficient related to the choice of wild-caught versus farmed Atlantic salmon (SALTYPE) was positive and statistically significant at the 0.01 level. Nonetheless, respondents were 71 per cent more likely to pay the 5 per cent premium price to acquire certified farm-raised Atlantic salmon, which means these groups of households put positive values on those farmed Atlantic salmon that passed through several stages of traceability systems. Another explanatory variable whose estimated coefficient was statistically different from zero at the 0.05 level was **PUBKNOW** that inquired whether fresh and wild salmon are the same. (Table 3) shows that respondents whose general knowledge was suffice believed that fresh salmon did not necessarily mean wild salmon. They were 72.8 per cent less likely to pay the 5 per cent premium price compared to those respondents who believed fresh and wild salmon were the same. (Table 3) shows that those respondents who read the product label (READLABEL) prior to purchase were 47.7 per cent more likely to pay the 5 per cent premium price compared to those participants in the survey who were not used to read the product label to buy certified farm-raised Atlantic salmon. Finally, consumers' habit play major role in their decision making process to pay a premium price to purchase farm-raised Atlantic salmon. Both coefficients of NUTRI3 and NUTRI4 were positive and statistically different from zero at the 0.05 level. In particular, respondents whose monthly consumption of salmon were between 2 to 4 pounds and more than 4 pounds were 85.9 and 86.3 per cent, respectively, more likely to pay the 5 per cent premium price to purchase farmed Atlantic salmon compared to those respondents whose salmon consumption was less than a pound per month.

Table 3: Estimation Results for the WTA Model

Effect	Coefficients(p-value)	Odds Ratio	Interval for Lower Bound	EXP (Coefficients) Upper Bound
Constant	-0.826 (0.610			
GEN**	-0.105 (0.051)	0.900	0.526	1.542
AGE2	-0.151 (0.687)	0.860	0.412	1.794
AGE3**	0.070 (0.019)	1.072	0.515	2.233
AGE4	-0.109 (0.767)	0.897	0.436	1.843
MARIT	-0.262 (0.427)	0.770	0.404	1.468
FMSZ	0.028 (0.830)	1.028	0.798	1.324
EDU2	0.015 (0.964)	1.015	0.520	1.984
EDU3	-0.100 (0.762)	0.905	0.474	1.727
INC2	0.371 (0.353)	1.449	0.662	3.171
INC3	0.212 (0.596)	1.236	0.565	2.705
INC4*	-0.717 (0.118)	0.488	0.199	1.200
SALTYPECON***	0.711 (0.012)	2.036	1.171	3.542
SALPREFER	-0.270 (0.339)	0.763	0.438	1.328
PUBKNOW**	-0.728 (0.016)	0.483	0.267	0.871
PRIMBUYER	-0.083 (0.791)	0.920	0.499	1.697
VISFISHMKT	0.044 (0.889)	1.045	0.559	1.955
SALCOLOR	0.228 (0.371)	1.257	0.762	2.072
SALQUA	0.190 (0.453)	1.210	0.736	1.989
READLABEL*	0.477 (0.068)	1.611	0.966	2.688
PCBKNOW	-0.295 (0.262)	0.744	0.444	1.247
NUTRI2	0.419 (0.254)	1.521	0.740	3.129
NUTRI3**	0.859 (0.017)	2.362	1.163	4.794
NUTRI4**	0.839 (0.021)	2.315	1.134	4.724
LOCC	0.288 (0.501)	1.333	0.577	3.083
LOCW	-0.213 (0.449)	0.808	0.465	1.404
LOCL	-0.281 (0.533)	0.755	0.312	1.825

* Significant at 0.10, ** Significant at 0.05, *** Significant at 0.01.

Source: Sample data

Finally, (Table 4) shows that the coefficients of the MNL model when the response variable is WTP defined as the maximum amount (i.e., 15 per cent) that consumers would like to purchase certified farm-raised Atlantic salmon. The coefficient of gender (GEN) was negative (-0.160)

and statistically significant at the 0.05 level. It indicates that females were 16 per cent less willing than males to pay the 15 per cent premium price to purchase certified farm-raised Atlantic salmon when compared to those who would not be willing to pay the premium price at all. (Table 4) exhibits that the participants in the survey who were between 51-65 years old (AGE3) were 14 per cent less willing to pay the 15 per cent premium price compared to those respondents with less than 35 years old. The AGE3 variable was negative and statistically different from zero at the 0.05 level of significance (*p*-value 0.016). The literature shows a positive relationship between households' income and premium price payments for highly qualified foods exists [34]. The result of this research also confirmed such relationship and indicated that those respondents whose annual household income was more than CAD 50,000 were most likely to pay the 15 per cent premium price to purchase certified farm-raised Atlantic salmon when compared to the participants in the survey whose annual household income was less than CAD 29,999. The coefficients of INC3 (0.747, *p*-value 0.058) and INC4 (1.009, *p*-value 1.009) were positive and statistically different from zero at the 0.05 level of significance, respectively. (Table 4) shows that the coefficient related to the choice of wild-caught versus farmed Atlantic salmon (SALTYPE) were estimated to be 0.92 and statistically significant at the 0.01 level. This implies that respondents were 92 per cent more likely to pay the 15 per cent premium price to purchase certified farm-raised Atlantic salmon when compared to those respondents who were not interested in consuming certified farmed Atlantic salmon. When asking whether respondents knew the difference between fresh and wild salmon the corresponding estimated parameter (PUBKNOW) was statistically significant at the 0.05 level (*p*-value 0.013). As it is shown in (Table 4), respondents with sufficient knowledge about the difference between fresh and wild salmon were 72.7 per cent less willing to pay the 15 per cent premium price top buy the product compared to those participants in the survey who thought there was no difference between fresh and wild salmon. The coefficient of READLABEL was positive and statistically different from zero (*p*-value 0.057). It showed those respondents who read the product label were 47.7 per cent more likely to pay the 15 per cent premium price to purchase farmed Atlantic salmon that was passed through traceability systems compared to those participants in the survey who were not used to read the product label. Finally, (Table 4) exhibits that consumers' knowledge on PCBs and its hazardous effects on human lives played important role in their decisions. The coefficient of **PCBKNOW** was negative and statistically different from zero with 95 per cent confident (*p*-value 0.03) implying that respondents with lack of knowledge about PCBs were 55 per cent less likely to pay the 15 per cent premium price to purchase certified farm-raised Atlantic salmon compared to those participants in the survey whose PCBs knowledge was suffice.

Table 4: Estimation Results for the WTP Model

Effect	Coefficients(p-value)	Odds Ratio	Interval for Lower Bound	EXP (Coefficients) Upper Bound
Constant	1.347 (0.391)			
GEN***	-0.160 (0.047)	0.852	0.507	1.433
AGE2	-0.301 (0.403)	0.740	0.366	1.497
AGE3***	-0.140 (0.016)	0.869	0.432	1.750
AGE4	0.109 (0.762)	1.115	0.551	2.255
MARIT	-0.312 (0.331)	0.732	0.390	1.373
FMSZ	0.008 (0.951)	1.008	0.787	1.290
EDU2	-0.393 (0.230)	0.675	0.356	1.282
EDU3	-0.114 (0.725)	0.892	0.472	1.685
INC2	0.325 (0.390)	1.384	0.659	2.903
INC3**	0.747 (0.058)	2.110	0.976	4.561
INC4***	1.009 (0.019)	0.365	0.156	0.850
SALTYPECON***	0.920 (0.001)	2.508	1.461	4.307
SALPREFER	-0.401 (0.143)	0.670	0.392	1.144
PUBKNOW***	-0.727 (0.013)	0.483	0.273	0.856
PRIMBUYER	-0.380 (0.210)	0.684	0.378	1.239
VISFISHMKT	0.169 (0.581)	1.184	0.650	2.158
SALCOLOR	0.097 (0.693)	1.102	0.679	1.788
SALQUA	-0.251 (0.308)	0.778	0.480	1.261
READLABEL**	0.477 (0.057)	1.611	0.985	2.633
PCBKNOW***	-0.551 (0.030)	0.576	0.351	0.947
NUTRI2	-0.066 (0.856)	0.936	0.459	1.911
NUTRI3	0.308 (0.381)	1.361	0.683	2.710
NUTRI4	0.489 (0.173)	1.631	0.807	3.298
LOCC	0.323 (0.431)	1.382	0.618	3.090
LOCW	-0.230 (0.400)	0.794	0.465	1.358
LOCL	-0.466 (0.271)	0.628	0.274	1.438

* Significant at 0.10, ** Significant at 0.05, *** Significant at 0.01.

Source: Sample data

Conclusion and implications for managers

The use of advanced technologies in the food industry has been the center of pivotal decisions amongst the industry's stakeholders. The food industry has been making substantial efforts to ensure consumers that foods they purchase are safe while maintaining high qualities. This is a natural response to continuously increase in demand for food safety. In general, food safety refers to the concept that diseases like pathogenic microorganisms, misuse of food additives and contaminants such as chemical or biological toxins and adulteration are prevented. For instance, the food incidence of polychlorinated biphenyls in the salmon industry could cause health hazards. One of the solutions that have been suggested by policymakers is the establishment of traceability systems. If this policy were to be successful, public awareness should be raised so that informed decisions are made. Consumers are mostly the ones whose positive response to the implementation of a new policy is inevitable and crucial. Studies like this would help policymakers analyze consumers' behavior in purchasing certified farmed Atlantic salmon. This paper is different from precedent studies in the sense that it examines consumer's willingness-to-accept (i.e., minimum price) and willingness-to-pay (i.e., maximum price) a premium price for buying the product. The result showed that some factors such as gender, age, annual household income, salmon type consumption (i.e., wild-caught, farm-raised), knowledge on difference between fresh and wild salmon, and reading label prior to purchase salmon, were commonly and statistically significant for both target groups of respondents (i.e., willing to pay a minimum premium price of 5 per cent, and willing to pay a maximum price of 15 per cent). The result also showed that respondents' knowledge about the adverse effects of PCBs on human health status placed great values on their decisions to purchase high quality certified farm-raised Atlantic salmon by paying a 15 per cent premium price. The monthly amount of consumption of farmed Atlantic salmon (i.e., 2 pounds and more) had a positive impact (although weak) on those respondents who were willing to pay a 5 per cent premium price to purchase the product. It appears respondents whose monthly expenditure on farm-raised Atlantic salmon did not have significant share in their total household budget were reluctant to the implementation of traceability systems. Any policies that focus on promoting new varieties of foods with a major ingredient of farmed Atlantic salmon might encourage consumers to increase their purchase of the product. Moreover, from policy perspective, marketing strategies on these two consumer-segments should be separated. In particular, strategies should focus more on improving public awareness on the matter of food safety and food quality and the adverse impact of PCBs on human lives. Generally, educating consumers on special products is associated with increasing in production cost. To establish a solid market initially, these types of products require intensive marketing operations, including attending multi-product trade shows, using non-traditional digital marketing tools, promoting product expos, improving search engine optimization, creating shareable content about the product, guiding potential buyers through the conversion funnel (i.e., pursue remarketing steps), creating a feedback system, spreading out marketing automation, participating in the Kickstarter events, and taking on-site food demonstrations. The intensive use of different social media marketing tools would also boost the volume sales of the product. Some examples of these tools are using close range marketing approach, promoting strategy and creating new description development, focusing on audience building and channel reporting through advertising for different targeted-group of Atlantic farm-raised consumers and monitoring their responses, product campaigning, and making brand management. By pursuing a combination of the above marketing strategies producers would be able to absorb most of the increase in the production cost for certified farmed Atlantic salmon. Furthermore, there is a great need for raising public awareness on the adverse impact of PCBs on human lives, health, and overall well-being. In particular, focusing on early childhood education, designing subject-oriented school textbooks, arranging workshops and seminars, and inviting keynote speakers in the field could be a series of options that is recommended. This research did not take into account the producers' side of the market; therefore, studies that contemplate their willingness to engage in implementing traceability systems are suggested. Finally, the concept of traceability systems could also be discussed for other seafood products which were not part of the objectives of this research.

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