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Sustainability, perceived quality and country of origin of farmed salmon: Impact on consumer choices in the USA, France and Japan

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ABSTRACT

Technological advancements that enable countries to produce farmed seafood domestically, including land-based production, could potentially improve sustainability measures. However, whether consumers prefer domestic farmed seafood to imported seafood is unclear. This paper aims to fill this gap by employing hypothetical choice experiments from the US, France, and Japan. We find that, in each country, there is a sizable consumer segment (varying from one-quarter to two-thirds of the market) with a strong preference for domestic farmed salmon, including those from land-based production. These consumers associate domestic origin with higher qualities in all relevant dimensions and are willing to pay a price premium. There is also a segment of consumers with a strong preference for imported Norwegian salmon (from one-fifth to two-thirds of the market), linking Norwegian origin to higher qualities, and willing to pay higher prices. Consumers' attitudes towards the environment and food, usage of label information, age, income, and consumption frequencies, are among the characteristics that explain consumer heterogeneity. Our results show the market potential for domestic farmed seafood, thus, providing consumers with reliable origin information for farmed seafood that also covers land-based production would be important. At the same time, the existence of a segment with a preference for imported seafood implies that active trade will remain, indicating the importance of continued international corporation for a holistic and transparent policy framework and common standards for a sustainable aquatic food system.

1. Introduction

The increasing concern for sustainability and climate change has raised awareness of the by-product of the global economy in the form of long and complex supply chains. Goods are typically produced in faraway countries and travel a long distance to reach the final consumers. This includes seafood—one of the most traded food items in the world (Anderson et al., 2018). As in other food sectors, supporting local producers and consuming locally sourced food have been identified as one of the motivators for seafood product choices among consumers (Altintzoglou et al., 2022). At the same time, with depleted marine resources and increasing pressure to manage fisheries sustainably, the growth of the seafood sector has been driven by *farmed* seafood. Global aquaculture production has grown five-fold during the past 30 years and now accounts for about half of the world's fish production (FAO, 2020) and is likely to continue its growth (Garlock et al., 2020a).

The significance of the aquaculture industry implies that the structures and practices of this sector and the corresponding markets can substantially impact sustainability. First, farmed seafood is considered less carbon intensive compared to other major protein sources such as beef and lamb (Poore and Nemecek, 2018). However, transporting fresh seafood can result in high overall carbon emissions, depending on the distance and the transportation mode. For example, about 52% of the carbon footprint from producing one kilogram of farmed salmon in Norway transported by air to Shanghai is related to air transport (Rotabakk et al., 2020).[1] Second, a number of ecological and fish welfare-related issues have been raised regarding salmon farming (e.g., Abolofia et al., 2017; Ellis and Tiller, 2019; Olesen et al., 2011), including fish welfare (exposure to diseases, sea lice, fish density, etc.), escaping fish (may disturb the genetic material of the wild salmon stock), pollution (fish excrements and unconsumed feed end up at the bottom of the sea floor), and the competing usage of coastal areas (e.g., fish farms, commercial fishing, tourism, and local recreation). Third, many countries rely on imports due to the high concentration of fish

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[1] Transportation by ship or truck will result in a lower carbon emissions than air transportation.

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farming in a handful of countries/regions. This not only leaves the importing countries vulnerable to unpredictable shocks (e.g., an outbreak of a pandemic) but also makes it difficult to achieve a closed-loop circular economy.

One possible way to mitigate at least some of these issues is by increasing local/domestic sourcing. However, farm sites are determined by the currently dominant technology of net pens, locations of which are constrained by environmental conditions (e.g., temperatures). Therefore, producing locally/domestically sourced farmed seafood has not been possible for many countries. The desire to produce seafood near the market, as well as the environmental/ecological concerns relating to conventional aquaculture production, led to an increased interest in land-based, closed-containment farming. The technology would enable high seafood consumption countries such as France and Japan or countries with the prospect of increasing consumption, such as China, to produce domestic farmed seafood even with challenging natural conditions. There are many initiatives globally, such as in the USA, Norway, Denmark, Canada, Poland, Switzerland, Japan, South Korea, and South Africa, to set up land-based production sites. However, current production volumes are still small due to start-up problems and higher production costs (Bjørndal and Tusvik, 2019).

Land-based production can address issues such as escaping fish, pollution, and competing land use, but the current evidence on the overall carbon emissions and rigorous Life Cycle Assessment (LCA) of land-based aquaculture production is still scarce. One available study indicates that Atlantic salmon produced in a recirculating plant on land in China is estimated to have 27% less carbon emissions than the air-transferred fish from Norway to China (Song et al., 2019). Thus, domestic production could potentially reduce CO_2 emissions compared to imported from faraway countries by air. Like any LCA, the results heavily depend on assumptions and conditions. For instance, in countries like France, where fish are transported by truck from Norway, the potential reduction in carbon footprint by producing in close-containment systems may not be high (Ayer and Tyedmers, 2009). Another potential issue is scalability—whether land-based production can meet high-volume demand at a reasonable cost is also unclear.

The technical issues notwithstanding, critical information currently missing to gauge the economic viability of domestically farmed seafood are the consumers' perceptions and acceptance. Consumers have very little knowledge about aquaculture production, to begin with (Feucht and Zander, 2015), and are known to be skeptical of new and unfamiliar food technologies (Siegrist, 2008). Seafood from land-based facilities, for example, could invoke skepticism, and the reduced perception of naturalness may lower the perceived quality of the product and the level of acceptance.

At the same time, consumers consider local/domestic food products of higher quality (Bosbach et al., 2015). Past studies clearly indicate that the country of origin is one of the most important attributes for seafood choices (Maesano et al., 2020), where preference for domestic origin seafood is reported in Germany (Risius et al., 2019), France (Zander and Feucht, 2018), Japan (Uchida et al., 2014), the USA (Fonner and Sylvia, 2015) and the UK (Asche et al., 2015). If local/domestic origin also improves the perception of product sustainability (e.g., Onozaka et al., 2010), consumers may also be willing to pay a premium, as found in seafood eco-label studies (e.g., Asche et al., 2021; Brecard et al., 2009; Bronnmann and Asche, 2017; Jaffry et al., 2004; Johnston and Roheim, 2006; Rickertsen et al., 2017; Uchida et al., 2014). However, other studies report that consumers put less priority on sustainability when selecting products (Grunert et al., 2014; Rondoni and Grasso, 2021) and put more emphasis on self-oriented benefits (Lang and Rodrigues, 2021)[2] or ignore the sustainability labels altogether (de Andrade Silva et al., 2017).

Consumer preference for geographic origin can also depend on the strength of the link between quality perceptions and the geographical brand image. For products like wine, the country/region's brand image and reputation could be a more prominent indicator of quality (Schamel, 2006), while domestic preference is less important (D'Alessandro and Pecotich, 2013). Farmed salmon is mainly considered a commodity (Asche and Oglend, 2016), but Norway is proactively building a salient brand image. The annual surveys by the Norwegian Seafood Council (NSC) report that Norway is the preferred country of origin of Atlantic salmon in most European countries, Japan, and China. In a recent study, Garlock et al. (2020b) find that farmed domestic seafood will likely be in direct competition with imported seafood, but they only consider the generic imported attribute without any association with branded country of origin. Overall, how consumers compare local/domestic farmed seafood to branded imported ones (e.g., Norwegian salmon) is unclear.

Yet, another important consideration is the anticipated degree of heterogeneity in perceptions and acceptance. There have been numerous studies documenting heterogeneity among fish consumers due to the diverse individual beliefs and preferences (e.g., Bronnmann and Asche, 2017; Costanigro and Onozaka, 2020), as well as the country-specific market and cultural contexts (e.g., Lang and Rodrigues, 2021; Olsen et al., 2007; Onozaka et al., 2014). Thus, the possible impact of domestic farmed seafood production should also be considered with consumer and country heterogeneity in mind.

In sum, whether the increased domestic sourcing of farmed seafood, including using the new technology of land-based aquaculture, has the potential to contribute to improved sustainability is largely unknown. This paper aims to focus on the demand side and examines the complex landscape surrounding domestic, imported, and land-based *farmed salmon* by looking into three internationally important markets: the USA, France, and Japan. We select Atlantic salmon as it is among the most traded and consumed farmed seafood, both in quantity and value (FAO, 2019), with annual production estimated to reach 2.7 million tonnes in 2020 (Globefish, 2021). Furthermore, salmon is among the most advanced species in terms of product development and diversity (Asche and Smith, 2018; Cojocaru et al., 2021). We employ conjoint choice experiments and a latent class analysis framework to investigate how consumers' motivations, evaluations, and choices are linked to the country of origin (domestic vs. Norwegian), while explicitly accounting for between- and within-country heterogeneity.

2. Theory

We follow the general framework of Costanigro and Onozaka (2020), which draws from Steenkamp (1990)'s conceptualization of the lens model. We conceptualize that consumers' product choice is based on evaluation and trade-offs among product attributes, where quality perceptions are formulated through observable cues (Fig. 1). As our main aim is to investigate the effect of origin, we put this as our central cue. We also include price, eco-label, and package type in addition to the origin to make the choices more realistic.[3] Price is obviously an important cue and is also theoretically an essential factor in consumer choices, representing the monetary trade-offs among attributes and purchases. Another relevant attribute and a subject of much research is eco-label, and the general finding is that consumers are willing to pay a premium for eco-labeled seafood (e.g., Brecard et al., 2009; Bronnmann and Asche, 2017; Jaffry et al., 2004; Johnston and Roheim, 2006;

[2] Self-oriented benefits could also lead to the heightened importance of sustainability labels, as found in Bronnmann et al. (2021) through the warm-glow effect.

[3] We note that one important aspect of seafood choices we do not consider in this study is the preference between wild vs. farmed seafood. In general, consumers tend to prefer wild to farmed seafood (Roheim et al., 2012; Uchida et al., 2014), although Garlock et al. (2020b) find no significant preference for wild-caught to farmed fish among wholesalers in the US.

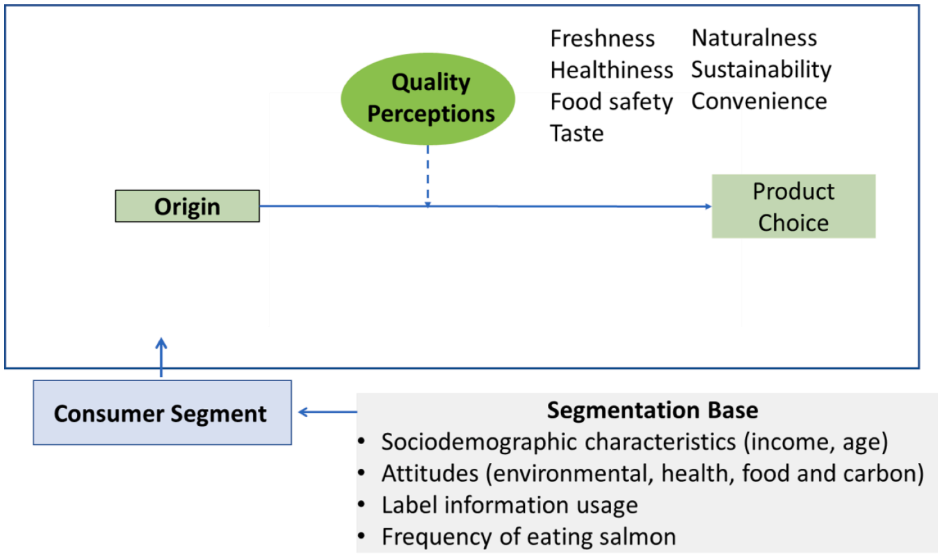

Fig. 1. Conceptual Framework.

Rickertsen et al., 2017; Uchida et al., 2014). It is particularly relevant when considering farmed salmon, as salmon farming has been criticized for its negative environmental impacts (Ellis and Tiller, 2019). Freshness is perhaps one of the most crucial aspects in assessing the quality of most seafood products. We account for the freshness attribute by explicitly including the package type that guarantees a certain level of freshness (e.g., vacuum-sealed pack).

Quality dimensions we consider are freshness, healthiness, food safety, taste, naturalness, sustainability, and convenience, and they, too, are selected based on the literature (Costanigro and Onozaka, 2020; Grunert, 2005). As the objective assessment of these quality dimensions is challenging at the time of purchase, consumers will formulate their beliefs about these qualities based on the available cues.

The literature discusses that consumers often use origin information as an indicator of quality (Götze and Brunner, 2019; Risius et al., 2019). However, it is unclear whether local/domestic origin is a cue for superior quality (similar to fresh produce) or if the regional/brand reputation dominates (as with wine) in a farmed salmon purchase. Accordingly, we will empirically test if a domestic cue for farmed salmon (as opposed to Norwegian farmed salmon) positively influences (1) the product choice of consumers; and (2) the perceived product qualities. We further investigate if the effect of the origin cue differs among consumer segments based on their characteristics (attitudes, demographics, and consumption frequencies). The three countries we consider, the US, France, and Japan, represent different continents and markets, as well as different cultures and heritage. Thus, it seems plausible that there could be significant country differences (Olsen, 2003; Pieniak et al., 2008; Verbeke and Vackier, 2005). Thus, the above investigations are conducted for each country to draw similarities and differences.

3. Survey

We utilize an original online survey collected from three countries: the US, France, and Japan, in November 2020. These countries are selected to reflect the significance of the market in the international seafood market and trade, as well as the diverse geographic locations and food cultures. From each country, approximately 1,000 responses are collected from the stratified sample that replicates the population in terms of age, gender, and geographic distribution.

3.1. Conjoint choice experiment

The main survey instrument to elicit consumers' product choices and associated quality perceptions is the Discrete Choice Experiment with four attributes: country of origin, eco-label, packaging, and price (Fig. 1). The attributes and levels are shown in Table 1.

Country of origin has two levels, domestic and foreign. For all the countries, foreign salmon comes from Norway.[4] For domestically sourced products, only the US currently has the possibility of producing domestically farmed salmon in traditional pens in the ocean.[5] For France and Japan, where outdoor production is not possible due to the lack of suitable locations for farming Atlantic salmon, it is communicated that

Table 1
Conjoint Choice Experiment Attributes and Levels.

Attribute	Levels
Country of Origin	1. Domestic 2. Foreign (Norway)
ASC label	1. No label 2. Aquaculture Stewardship Council (ASC) Certified
Packaging	1. Normal-packed 2. Skin-packed 3. Fresh-packed
Price	Four levels of prices based on the market conditions for each country **US:** Normal and skin-packed ($6.99, $9.99, $12.99, $14.99/lb) Fresh packed ($10.49, $14.99, $19.49, $22.49/lb) **France:** Normal and skin-packed (€4.50, €5.75, €7.00, €8.25/250g) Fresh packed (€6.75, €8.63, €10.50, €12.38/250g) **Japan:** Normal and skin-packed (¥240, ¥290, ¥340, ¥400/100g) Fresh packed (¥360, ¥435, ¥510, ¥600/100g)

[4] The two major farmed salmon producing counties are Norway and Chile, and they comprise about 80% of the world's supply (Iversen et al., 2020). We note that the setting in which all imported salmon are from Norway is selected for simplicity and is a good approximation for France, while Chile and Canada are the primary suppliers of Atlantic salmon in the US (Salazar and Dresdner, 2021). Thus, including Norwegian salmon in these countries also assesses a potential to increase its presence as a premium product, as discussed in Altintzoglou et al. (2022).

[5] The current production level of farmed salmon in pens in the US is quite low. Thus, this study evaluates the market potential for farmed domestic salmon if pen production increases in the US. In the current conditions, most domestic salmon in the US is wild, while most salmon is imported (Love et al., 2022).

domestic farmed salmon comes from land-based facilities.[6]

Since we only consider farmed salmon in our experiment, a product with an eco-label is said to be certified by the Aquaculture Stewardship Council (ASC), which is the most commonly recognized third-party certification label for aquaculture products (Bronnmann and Asche, 2017). In the information, the ASC logo and a simple explanation were provided. Packaging was included in the experimental design to explicitly account for freshness, and we included three packaging types (normal, skin-pack, and fresh-pack—see Appendix A for details). Price points were selected based on the historic market conditions in each country and consultation with industry experts.[7] Because fresh-packaging products are more costly, we selected four price points for normal and skin-packed products and four higher price points for fresh-packed products. Each choice set contains two products, with an option to opt-out. Each respondent answered four choice sets containing the product choice task and the quality sorting task.[8]

3.2. Quality perceptions

In addition to the standard conjoint discrete choice experiment, we include quality perception comparisons following Costanigro and Onozaka (2020). These are simple extensions of the choice cards already designed for the choice experiment. In the survey, before asking respondents to make purchase decisions, we asked them to compare which product they perceived as higher quality in each quality dimension (sustainability, freshness, better taste, food safety, healthiness, sustainability, and convenience), with an option to choose “they are of the same quality.” This allows us to investigate which origin of salmon is perceived as of higher quality by consumers.

3.3. General attitudes

We also elicit general attitudes regarding the environment, health, food, carbon emissions from seafood transport, and reliance on product labels as an information source, as well as the consumption frequencies, to model consumer heterogeneity.

Attitudes towards the environment are measured using the Neo Environmental Paradigm (NEP) scale developed by Steger et al. (1989), containing the items: (1) the balance of nature is very delicate and easily upset by human activities; (2) the Earth is like a spaceship with only limited room and resources; (3) plants and animals do not exist primarily for human use; (4) modifying the environment for human use seldom causes serious problems; and (5) mankind was created to rule over the rest of nature. Responses were on a five-point Likert scale (from strongly disagree to strongly agree).

General health interest was measured based on the items: (1) the healthiness of food has little impact on my food choices; (2) I am very particular about the healthiness of food I eat; (3) I eat what I like and I do not worry much about the healthiness of food; (4) it is important for me that my diet is low in fat; (5) I always follow a healthy and balanced diet; (6) it is important for me that my daily diet contains a lot of vitamins and minerals; (7) the healthiness of snacks makes no difference to me; and (8) I do not avoid foods, even if they may raise my cholesterol” (Roininen et al., 1999). Responses were on a five-point Likert scale (from strongly disagree to strongly agree).

The pleasure of food orientation was measured using the items: (1) I do not believe that food should always be a source of pleasure; (2) the appearance of food makes no difference to me; (3) when I eat, I concentrate on enjoying the taste of food; (4) it is important for me to eat delicious food on weekdays as well as weekends; (5) an essential part of my weekend is eating delicious food; and (6) I finish my meal even when I do not like the taste of a food (Roininen et al., 1999). Responses were on a five-point Likert scale (from strongly disagree to strongly agree).

Attitude towards the climate impact from air transport of salmon was measured by the question “How concerned are you about the climate impact of salmon products transported by air?” with the response categories “never thought about it before,” “Don’t know,” “Not at all concerned,” “Moderately concerned,” “Very concerned,” and “Extremely concerned.”.

The use of product labels as an information source was measured by respondents selecting “labelling on the product” as one of the main information sources they rely on to get information about salmon products. The responses were binary (selected or not selected).

4. Methodology

The empirical models follow the standard random utility framework for discrete choice models (McFadden, 1974; Train, 2003) combined with latent class analysis (LCA) (Chintagunta, 1996; Kamakura and Russell, 1989). We estimate the probability that individual i chooses an alternative j with attribute A_{ij} among J alternatives.[9] For simplicity, we illustrate the case where $J = 2$ but the extension to $J > 2$ is straightforward. Between the two alternatives $J = 1$ and 2, an individual chooses alternative 1 over alternative 2 if the utility of consuming alternative 1 is greater than that of alternative 2. This can be written in a probability statement:

$$\Pr(PC_i = 1) = \Pr(U_{i1} > U_{i2}) = \Pr(V_{i1} + \varepsilon_{i1} > V_{i2} + \varepsilon_{i2}) \tag{1}$$

where PC_i stands for product choice for individual i, U_{ij} is the utility associated with selecting alternative j. The deterministic component of the utility (V) is a function of attributes and the preference parameter β’s:

$$\begin{aligned} V_{ij} &= \mathbf{A}_{ij}^{'}\boldsymbol{\beta} \\ &= \beta_{0j} + \beta_1 Origin_{ij} + \beta_2 VacPac_{ij} + \beta_3 FreshPac_{ij} + \beta_4 ASC_{ij} + \beta_p Price_{ij}. \end{aligned} \tag{2}$$

By assuming the *iid* Extreme Value distribution for the error terms, the probability in equation (1) boils down to a logit probability;

$$\Pr(PC_i = 1|\mathbf{A}_{i1}, \mathbf{A}_{i2}, \boldsymbol{\beta}) = \frac{\exp(\mathbf{A}_{i1}^{'}\boldsymbol{\beta})}{\sum_{k=1}^{2}\exp(\mathbf{A}_{ik}^{'}\boldsymbol{\beta})}. \tag{3}$$

However, equations (2) and (3) assume that the attribute specific utility weights $\boldsymbol{\beta}$ are the same across individuals. As the previous literature indicates, it is too restrictive and does not reflect reality. To allow for more flexibility, we assume that the utility parameters $\boldsymbol{\beta}$ differ across consumer segments.

Assuming that a market can be divided into C distinctive groups (classes), wherein individuals within the same group share similar preferences. We can, then, denote P_{ij} as the probability that a consumer i who selects alternative j as:

[6] See Appendix A for the exact wording used in the survey.

[7] As salmon has a global market with common price determination processes (Salazar and Dresdner, 2021), it is not surprising that the price levels are quite similar across countries. The mid-point prices in all three countries are around $11/lb.

[8] The experimental design was created using the software NGene, with restrictions such that two products in each comparison always contain one domestic and one foreign product; one eco-labeled and one non eco-labeled product; two products have different packaging and different prices. A total of 20 choice sets are generated, segmented into five blocks with four choice sets in each block based on the blocked factorial design. The D-Optimality of the final design was 0.85.

[9] We suppress notations for country (the US, France and Japan) and multiple choice sets per individual for simplicity. See Train (2003) for an extension to cases with more than two alternatives.

$$P_{ij} = \sum_{c=1}^{C} \pi_{ci} \left[\frac{\exp\left(\mathbf{A}_{ij}^{'}\boldsymbol{\beta}^{c}\right)}{\sum_{k=1}^{2}\exp\left(\mathbf{A}_{ik}^{'}\boldsymbol{\beta}^{c}\right)} \right], \quad (4)$$

where π_{ci} is the probability that consumer i belongs to class c and $\boldsymbol{\beta}^{c}$ are the class-specific utility weights. In this specification, the deterministic part of the utility function becomes also class-specific;

$$\mathbf{A}_{ij}^{'}\boldsymbol{\beta}^{c} = \beta_{0j}^{c} + \beta_{1}^{c} Origin_{ij} + \beta_{2}^{c} VacPac_{ij} + \beta_{3}^{c} FreshPac_{ij} + \beta_{4}^{c} ASC_{ij} + \beta_{p}^{c} Price_{ij} \quad (5)$$

where β_1^c represents the preference weight for the origin attribute that consumers in class c assign in selecting a product. A significant difference in β_1^c across classes indicates heterogeneous preferences regarding the product origin.

The number of classes C and the class probability π_{ci} are determined via LCA. As shown in Fig. 1, class membership is governed by attitudes, socioeconomic factors, consumption frequency of salmon, and label usage. Denoting a vector of these covariates as $\mathbf{Z}_i$ and parameters linking covariates to the membership for each class as $\boldsymbol{\gamma}^c$, class membership is a logit probability;

$$\pi_{ci} = \frac{\exp\left(\mathbf{Z}_i^{'}\boldsymbol{\gamma}^{c}\right)}{\sum_{c=1}^{C}\exp\left(\mathbf{Z}_i^{'}\boldsymbol{\gamma}^{c}\right)}, \quad (6)$$

with a normalization $\boldsymbol{\gamma}^c = 0$ for a base class.

In order to investigate how each quality dimension is assessed by consumers in a different class, we assign each individual to a class with the highest estimated class probability and estimate the quality choice model conditional on the class membership. The class probability is obtained by estimated $\boldsymbol{\gamma}^c$ into the equation (6);

$$\widehat{\pi}_{ci} = \frac{\exp\left(\mathbf{Z}_i^{'}\widehat{\boldsymbol{\gamma}}^{c}\right)}{\sum_{c=1}^{C}\exp\left(\mathbf{Z}_i^{'}\widehat{\boldsymbol{\gamma}}^{c}\right)} for c = 1, ..., C, \quad (7)$$

and the probability that consumer i who belongs to class c chooses alternative j as superior in quality q can be written as a logit probability:

$$\Pr\left(QC_{iq} = j \middle| \mathbf{A}_{i1}, \mathbf{A}_{i2}, c, \boldsymbol{\delta}_q^c\right) = \frac{\exp\left(\mathbf{A}_{ij}^{'}\boldsymbol{\delta}_q^c\right)}{\sum_{k=1}^{2}\exp\left(\mathbf{A}_{ik}^{'}\boldsymbol{\delta}_q^c\right)}, \quad (8)$$

where $\boldsymbol{\delta}_q^c$ is the class-specific weight that each consumer assigns to attributes in evaluating the specific quality dimension (q) of the product i for a given c.

It is of interest to obtain the market-level distribution of willingness-to-pay (WTP) for the domestic origin in order to assess the economic viability of land-based aquaculture. The value that a consumer in class c is willing to pay to obtain an attribute k (i.e., domestic origin) can be computed as the negative of the ratio between the attribute preference parameter β_k^c and the price coefficient β_p^c, i.e., $w_k^c = -\beta_k^c/\beta_p^c$. The individual-level WTP can be computed by taking the weighted average of class-specific WTP with associated class probabilities $\bar{w}_k = \sum_{c=1}^{C}\pi_{ci}w_k^c$. However, this measure would be common to an individual who has the same socio-demographic characteristics (the segmentation base) but make different choices (Hess, 2014). The individual-level WTP conditional on the observed choices (thereby producing the WTP reflecting both individual characteristics and choices) can be obtained by utilizing the posterior probability

$$\widehat{\pi}_{ci} = \frac{\pi_{ci}L_i(\beta^c)}{L_i(\beta^c, \pi_i)}, \quad (9)$$

where $L_i(\beta^c)$ is the likelihood of observing the choices that individual i made, conditional on belonging to class c (Hess, 2014). The most likely value of an individual-level WTP can then be computed as

$$\widehat{w}_{ik} = \sum_{c=1}^{C}\widehat{\pi}_{ci}w_k^c. \quad (10)$$

5. Results

We first provide some descriptive results, then proceed to a more comprehensive statistical analysis with choice model estimations described in the empirical section.

5.1. Sample characteristics

As the sample was stratified based on gender, age, and geographic distribution of each country, we expect these characteristics to generally match the population. For the survey to be meaningful, we further screen the respondents by two conditions: (1) the person does at least 30% of the household food shopping; and (2) the person has purchased seafood products in the past six months. We also eliminated individuals with missing information for the critical variables in the estimation, resulting in the analytical sample of 731, 680, and 666 individuals for the US, France, and Japan, respectively. The descriptive statistics of the key variables are shown in Table 2.

The three attitude variables (NEP, health attitude, and food pleasure) are measured with multiple items, as discussed in Section 3.3. We find it acceptable to use the simple average to represent the NEP, but it was not the case for the other two. We removed a few items from the health attitude scale to achieve internally consistent measures and obtained two factors representing the food pleasure orientation for each country.[10] Table 2 shows the summary of the original items (*original*) and used items (*selected*). Among the attitude measures, we do not see qualitatively large differences across countries, although some are statistically significant. One exception is that Japanese consumers have substantially lower concerns about carbon emissions from food transport. This is consistent with a previous finding (e.g., Eom et al., 2016).

In terms of salmon consumption frequencies, 17%, 12%, and 23% of respondents stated that they eat salmon once a week or more in the US, France, and Japan. Proportions for those who consume salmon less than once a week but more than once a month are 28%, 44%, and 53% in each country. These results are as expected, given that salmon is one of the most popular seafood products and the fish-eating culture of France and Japan. Label usage shows that US consumers report less label usage (67%) compared to other countries (72% and 71% for France and Japan).

5.2. LCA model selection

The class-specific preference weights $\boldsymbol{\beta}^c$ in equation (4) and the individual class probability π_{ci} in equations (4) and (6) are all jointly estimation in LCA.[11] As the number of classes is determined exogenously, we estimate models with up to five classes and compare various criteria to determine the most useful model. We note that no-heterogeneity models (one class model) are rejected (both AIC and BIC are large, indicating poor fit compared to multiple class models). This indicates the presence of heterogeneous groups in each market, and estimating one model for the entire market could lead to misleading results by depicting the “average” consumer who fits no one. The optimal number of classes is determined by looking at several relevant statistics, as well as the interpretability and usefulness of the results (Geiser, 2013). Based on various criteria, we deemed that the four-class solution for the US and the three-class solution for France and Japan yielded the most meaningful results and selected them as our optimal

[10] The details of the operationalization of the attitude variables are provided in Appendix B.

[11] Estimations are conducted using the Apollo package in R (Hess and Palma, 2019a; 2019b) as panel latent class logit.

Table 2
Sample Summary Statistics.

		USA	France	Japan
Attitudes	NEP	4.83^{a,c}	5.23^{a,b}	5.03^{b,c}
(7-point scale)		(1.43)	(1.04)	(0.98)
	Health Attitude (original)	4.35^{a}	4.49^{a}	4.42
		(0.86)	(0.82)	(0.74)
	Health Attitude (selected)	4.66	4.65	4.53
		(1.14)	(1.02)	(0.94)
	Food Pleasure (original)	4.65^{a}	4.88^{a,c}	4.74^{c}
		(0.73)	(0.88)	(0.77)
	Food Pleasure 1 (items1,2,(6))	4.04	4.47	4.42
		(0.88)	(1.34)	(0.74)
	Food Pleasure 2 (items 3,4,5)	5.26	5.29	4.53
		(1.06)	(1.00)	(0.95)
Concerned about climate impact of salmon products	Never thought about it before	30%	21%	44%
	Don't know	3%	8%	6%
	Not at all concerned	18%	9%	12%
	A little concerned	16%	15%	18%
	Moderately concerned	17%	23%	12%
	Very concerned	11%	18%	5%
	Extremely concerned	5%	5%	2%
Gender	Female	54%	53%	55%
Income category^{d}	Category 1	21%	27%	33%
	Category 2	32%	45%	36%
	Category 3	31%	20%	17%
	Category 4	11%	7%	7%
	Category 5	5%	1%	6%
Age category^{d}	18–29	15%	9%	17%
	30–39	24%	17%	14%
	40–49	18%	19%	16%
	50–59	18%	18%	14%
	60 and over	25%	37%	38%
Consumption Frequency^{d}	> Once a week	17%	12%	23%
	< Once a week, > Once a month	28%	44%	53%
Geographic Region	Region 1	19%	17%	4%
	Region 2	21%	26%	6%
	Region 3	36%	20%	38%
	Region 4	24%	25%	17%
	Region 5		11%	18%
	Region 6			5%
	Region 7			3%
	Region 8			9%
Use Label	Yes	67%^{a}	72%^{a}	71%
N		731	680	666

Note: NEP is based on the simple average across all the items. Health attitude and food pleasure are shown with the average of all original items (denoted as original) as well as the average of items used in the estimation (denoted as selected, see Appendix B). Food pleasure 1 and 2 are the average of items included in the two factors. Factor summaries are not included as they are standardized to mean zero and standard deviation one for each country by construction. *Income categories* are country specific. USA: Category 1 < $39,999; Category 2: < $80,000; Category 3: < $150,000; Category 4: < $250,000; Category 5: above $250,000; France: Category 1 < €20,000; Category 2: < €40,000; Category 3: < €60,000; Category 4: > €100,000; Category 5: above €100,000. Japan: Category 1 < 4 million yen; Category 2: < 7 million yen; Category 3: < 10 million yen; Category 4: < 13 million yen; Category 5: above 13 million yen. Geographic regions are also country-specific. USA: Regions 1 to 4 are Northeast, Southwest, South, and West. France: Regions 1 to 5 are Northeast, Northwest, Paris area, Southeast, and Southwest. Japan: Regions 1 to 8 are Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku, and Kyushu. Superscripts a, b, and c represent the statistically significant difference by pairwise *t*-test. Superscript d represents that the chi-square tests for independence rejected that the frequency counts are independent of countries (i.e., there are significant country differences). Alpha = 0.05.

results. See Appendix C for more details.

5.3. Product choice and quality perceptions

We first interpret the product choices by comparing the estimated preference parameters. Then, we link this to the quality perception logit estimation conditional on the most likely class. The presentation of the results focuses on the effect of origin and is organized and discussed by country.

5.3.1. The US Market

The product choice estimation results for the US consumers are presented in Table 3, which includes the estimated class size, estimated preference parameters associated with product attributes (β^c; the top part of the table), and those with the segmentation base (γ^c; the bottom part of the table). The positive (negative) origin preference parameter indicates the preference for domestic (Norwegian) origin. Among the four consumer segments, two of them (Classes 2 and 4) evaluate the domestic origin significantly, with opposite signs. Consumers in Class 2 (38% of the market), with the significantly positive origin parameter, prefer domestic origin, whereas those in Class 4 (19% of the market) significantly prefer Norwegian origin. Consumers in Classes 1 (13% of the market) and 3 (30% of the market) do not exhibit statistically significant preferences for either origin.

The investigation of the segmentation base parameters reveals that those in Class 2 are younger, have lower food pleasure orientation, and utilize label information than those in the base class (Class 1). Class 4 consumers have significantly higher environmental consciousness (high NEP scores) and lower food pleasure orientation and utilize label information more than Class 1 consumers. Compared to Class 1, Class 3 consumers tend to be younger and more frequent salmon consumers, as well as using label information. We did not find any significant effect of carbon concerns, health concerns, or income.

Our augmentation with quality tasks can enlighten *why* consumers differ in the evaluation of attributes. Table 4 shows how consumers in each segment associate the origin attribute to each quality dimension (sustainable, fresh, healthy, safe, taste, natural, and convenience), i.e.,

Table 3
Product Choice Model: USA.

		Class 1	Class 2	Class 3	Class 4
Class Size		0.13	0.38	0.30	0.19
Choice Attributes	Origin	0.810	1.547***	−0.299	−1.615***
		(0.483)	(0.270)	(0.150)	(0.379)
	Skin	−0.262	−0.262	0.841***	0.493
		(0.185)	(0.185)	(0.184)	(0.275)
	Fresh	2.387***	−0.925	1.411***	−0.363
		(0.752)	(0.428)	(0.341)	(0.444)
	ASC	0.290	0.791***	0.183**	1.655***
		(0.418)	(0.172)	(0.104)	(0.369)
	Price	−0.731***	−0.155***	−0.062*	−0.215***
		(0.067)	(0.028)	(0.029)	(0.039)
Segmentation Base	NEP		0.077	−0.122	0.504***
			(0.107)	(0.107)	(0.153)
	Health		0.019	0.182	−0.019
			(0.170)	(0.122)	(0.142)
	Food1		−0.017	0.134	−0.229
			(0.150)	(0.162)	(0.184)
	Food2		−0.571***	−0.229	−0.664***
			(0.167)	(0.171)	(0.218)
	Income2		0.357	−0.336	0.580
			(0.366)	(0.385)	(0.476)
	Income3		0.546	0.109	0.750
			(0.355)	(0.362)	(0.463)
	Age		−0.029***	−0.031***	−0.009
			(0.010)	(0.011)	(0.013)
	Freq1		0.392	1.466***	0.775
			(0.515)	(0.488)	(0.608)
	Freq2		0.497	1.090***	0.157
			(0.341)	(0.350)	(0.434)
	Carbon		0.350	0.379	0.108
			(0.228)	(0.239)	(0.269)
	Label		0.923***	0.988***	0.992***
			(0.295)	(0.320)	(0.375)

Note: Robust standard errors using the "sandwich" estimator in parentheses (Hess and Palma, 2019b). *p < 0.1, **p < 0.05, ***p < 0.01.

Table 4
Origin's Influence on Quality Perceptions by Class: USA.

	Class 1	Class 2	Class 3	Class 4
Fresh	0.617***	0.476***	−0.356***	−0.424***
	(0.176)	(0.079)	(0.102)	(0.134)
Healthy	0.104	0.596***	−0.148	−0.616***
	(0.202)	(0.105)	(0.108)	(0.158)
Safe	0.212	0.559***	−0.173*	−0.652***
	(0.160)	(0.086)	(0.095)	(0.131)
Taste	0.313	0.692***	−0.309**	−0.895***
	(0.260)	(0.108)	(0.102)	(0.165)
Natural	0.056	0.577***	−0.172*	−0.888***
	(0.210)	(0.097)	(0.100)	(0.158)
Convenience	0.560**	0.583***	−0.147	−0.277
	(0.218)	(0.102)	(0.095)	(0.171)
Sustainable	0.105	0.587***	−0.126	−0.544***
	(0.184)	(0.089)	(0.086)	(0.131)

Note: Parameters from origin attribute from separate quality perception estimation. Robust standard errors using the "sandwich" estimator in parentheses (Hess and Palma, 2019b). Full estimation results are in Appendix D. *p < 0.1, **p < 0.05, ***p < 0.01.

δ^c in equation (8).[12] Consumers in Class 2, who prefer domestic origin, used this attribute to infer higher quality in all dimensions, as indicated by the positive and significant coefficients. On the contrary, consumers in Class 4 used Norwegian origin to infer higher quality for all the dimensions (except for convenience).

Class 1 consumers, who have a positive but insignificant preference for origin, show very limited use of origin information to infer product quality. They consider domestic farmed salmon fresher and more convenient, but not enough to matter in the product choice. Those in Class 3, with a negative and insignificant coefficient for the origin, infer higher quality in freshness and taste for Norwegian salmon, but they use other product attributes more extensively than origin information. These two classes also value fresh packaging highly, indicating that the freshness of the fish is very important for these segments regardless of the origin. Further, class 3 consumers also value the skin and fresh packs and the ASC label and put more emphasis on freshness and ASC than origin. Consumers in Classes 2, 3, and 4 tend to rely on label information but seem to put different weights on different labels. Classes 2 and 4 consumers use origin information (but with a divergent preference for domestic/imported), and they all use the ASC label with a positive evaluation.

5.3.2. French Market

Unlike the US, France was found with three segments. As Table 5 indicates, we still identify two segments using origin in their choices, with opposite signs. Class 2 consumers (23% of the market) exhibit a positive and significant preference for domestic origin. This segment of consumers tends to be moderately high-frequency users with lower food pleasure orientation and utilize label information. Consumers in Class 3 have a low food pleasure orientation and frequent salmon buyers who use label information. They comprise 68% of the market and prefer Norwegian origin, and have significantly positive valuations towards the ASC label. Those in Class 1 do not consider the origin information when making purchasing choices, but whether the fish is fresh-packed is a significant determinant. Also, with high price sensitivity, French Class 1 consumers seem quite similar to the US Class 1 consumers.

Table 6 shows the results for quality perception determinants. Like those in the US, Class 2 French consumers also consider domestic farmed salmon as higher quality in all dimensions. Class 3 consumers who significantly value Norwegian origin believe Norwegian farmed salmon is fresher, tastier, healthier, and more natural. However, compared to the US Class 4 consumers who used Norwegian origin extensively as a quality cue, French Class 3 consumers' association with Norwegian origin is targeted to a small set of quality dimensions of freshness, taste, and naturalness (and a marginal use on healthiness). For consumers in Class 1, the origin is an insignificant indicator of quality, and they seem to use other cues, such as fresh packaging when they choose which product to buy.

Table 5
Product Choice Model: France.

		Class 1	Class 2	Class 3
Class Size		0.09	0.23	0.68
Choice Attributes	Origin	0.190	2.956***	−0.208***
		(0.427)	(0.879)	(0.077)
	Skin	−0.425	−0.906	0.007
		(0.637)	(0.504)	(0.090)
	Fresh	2.587***	−2.288	0.285
		(0.717)	(0.980)	(0.200)
	ASC	−0.354	0.157	0.730***
		(0.524)	(0.217)	(0.069)
	Price	−0.730***	−0.116**	−0.006
		(0.069)	(0.061)	(0.036)
Segmentation Base	NEP		0.131	0.147
			(0.200)	(0.174)
	Health		−0.078	0.197
			(0.184)	(0.162)
	Food1		−0.488*	−0.553***
			(0.230)	(0.206)
	Food2		0.146	0.330
			(0.188)	(0.168)
	Income2		−0.127	−0.193
			(0.452)	(0.406)
	Income3		−0.639	−0.550
			(0.483)	(0.417)
	Age		−0.027	−0.038
			(0.017)	(0.016)
	Freq1		1.250	1.302***
			(0.713)	(0.650)
	Freq2		0.883**	1.105***
			(0.412)	(0.360)
	Carbon		0.018	−0.190
			(0.250)	(0.223)
	Label		1.566***	0.764*
			(0.440)	(0.335)

Note: Robust standard errors from a "sandwich" estimator are in parentheses (Hess and Palma, 2019b). *p < 0.1, **p < 0.05, ***p < 0.01.

Table 6
Origin's Influence on Quality Perceptions by Class: France.

	Class 1	Class 2	Class 3
Fresh	0.238	1.052***	−0.178**
	(0.240)	(0.123)	(0.058)
Healthy	0.263	1.347***	−0.107*
	(0.257)	(0.140)	(0.067)
Safe	−0.026	1.220***	0.017
	(0.249)	(0.131)	(0.066)
Taste	−0.067	1.614***	−0.252***
	(0.296)	(0.159)	(0.070)
Natural	−0.045	1.386***	−0.173**
	(0.285)	(0.143)	(0.069)
Convenience	0.230	1.256***	−0.108
	(0.330)	(0.147)	(0.073)
Sustainable	0.053	1.435***	−0.011
	(0.267)	(0.156)	(0.068)

Note: Parameters from origin attribute from separate quality perception estimation. Robust standard errors using the "sandwich" estimator in parentheses (Hess and Palma, 2019b). Full estimation results are in Appendix D. *p < 0.1, **p < 0.05, ***p < 0.01.

[12] The results come from the seven separate multinomial logit estimations of selecting an alternative A or B (or neither) as higher quality in the corresponding quality dimension for each country. Table 4 summarizes the results for the origin attribute from *each* estimation. The full estimation results from each quality choice logit model from each country (seven quality dimensions for three countries = 21 tables) are provided in Appendix D.

5.3.3. Japanese Market

Like France, the Japanese market is also segmented into three classes, with one class each of positive and negative origin preferences. As shown in Table 7, Class 2 consumers (24% of the market) tend to prefer Norwegian origin, wherein Class 3 consumers (66% of the market) prefer domestic origin. The strong domestic orientation among Japanese consumers is consistent with previous findings (Uchida et al., 2014). Class 2 consumers strongly prefer skin- and fresh-packed salmon, while Class 3 consumers show negative preferences for both. Classes 2 and 3 consumers tend to have higher incomes and are more frequent salmon shoppers than Class 1 consumers. The main distinction between Classes 2 and 3 comes from the high scores on NEP among Class 3 consumers. Unlike the other two countries, food pleasure orientation or label utilization does not influence segmentation in Japan.

Results from the quality perception choices are shown in Table 8 and show similar patterns as in the US, where the origin is used as a strong indicator for all quality dimensions. Class 1 consumers who have a positive but not statistically significant preference for domestic farmed salmon indicate that they also view domestic salmon as safer and fresher to a marginal degree, but these evaluations are not substantial enough to influence the product choices.

5.4. Willingness to pay

Willingness to pay (WTP) for the origin attribute computed as equation (9) for each market is plotted in Fig. 2, and the descriptive summaries are shown in Table 9. In Fig. 2, positive values indicate WTP for domestic farmed salmon, while negative sign indicates WTP for Norwegian Salmon. All three markets exhibit sizable masses on both sides, indicating the heterogeneous valuations of domestic vs. foreign origins in all countries. In the US, WTP for domestic and Norwegian origins are fairly compactly distributed, mostly between $5–10, wherein both French and Japanese markets, the WTP spread across much wider ranges. This may reflect the uncertainty towards unfamiliar land-based production. In France, a sizable mass is at the left end, reflecting the high volume of consumers who put a value on Norwegian salmon, but an opposite pattern is observed in Japan. The resulting WTP measures are quite high in France, about €10 for domestic and €26 for imported. This is due to the small (near-zero) price coefficients in some segments, possibly because of the hypothetical nature of the experiment, where consumers put less emphasis on prices. Additionally, it could result from the rejection of land-based production where consumers select non-domestic salmon regardless of prices. In the Japanese market, the WTP shows a large spike at around ¥300-400/100 g of domestic salmon, while the rest of the distribution is sparsely distributed. The average WTPs are ¥314 and ¥313 (for 100 g, roughly a quarter pound) for domestic and imported salmon.

Table 7
Product Choice Model: Japan.

		Class 1	Class 2	Class 3
Class Size		0.09	0.24	0.66
Choice	Origin	0.182	−0.920***	1.478***
		(0.362)	(0.211)	(0.146)
Attributes	Skin	−0.196	0.947***	−0.431***
		(0.452)	(0.192)	(0.119)
	Fresh	2.202***	1.263***	−1.076***
		(0.658)	(0.383)	(0.275)
	ASC	0.505	−0.001	0.183***
		(0.331)	(0.129)	(0.081)
	Price	−0.017***	−0.002	−0.004***
		(0.002)	(0.001)	(0.001)
Segmentation	NEP		0.143	0.539***
			(0.216)	(0.187)
Base	Health		0.354	0.251
			(0.220)	(0.194)
	Food1		0.316	0.164
			(0.191)	(0.169)
	Food2		−0.193	−0.200
			(0.208)	(0.184)
	Income2		0.699	0.169
			(0.412)	(0.346)
	Income3		1.942***	1.214***
			(0.518)	(0.468)
	Age		0.000	−0.015
			(0.012)	(0.010)
	Freq1		0.126	0.178
			(0.477)	(0.397)
	Freq2		1.066***	0.971***
			(0.427)	(0.368)
	Carbon		0.105	0.209
			(0.427)	(0.278)
	Label		−0.451	0.044
			(0.384)	(0.346)

Note: Robust standard errors from a "sandwich" estimator are in parentheses (Hess and Palma, 2019b). *p < 0.1, **p < 0.05, ***p < 0.01.

Table 8
Origin's Influence on Quality Perceptions by Class: Japan.

	Class 1	Class 2	Class 3
Fresh	0.375*	−0.345**	0.785***
	(0.212)	(0.130)	(0.069)
Healthy	0.419	−0.334**	0.940***
	(0.322)	(0.127)	(0.087)
Safe	0.586**	−0.199	1.301***
	(0.224)	(0.126)	(0.081)
Taste	0.432*	−0.554***	0.853***
	(0.258)	(0.137)	(0.083)
Natural	0.015	−0.462***	0.979***
	(0.249)	(0.127)	(0.083)
Convenience	0.152	−0.360**	0.639***
	(0.249)	(0.123)	(0.075)
Sustainable	0.081	−0.277**	0.770***
	(0.280)	(0.118)	(0.084)

Note: Parameters from origin attribute from separate quality perception estimation. Robust standard errors using the "sandwich" estimator in parentheses (Hess and Palma, 2019b). Full estimation results are in Appendix D. *p < 0.1, **p < 0.05, ***p < 0.01.

6. Discussion and conclusion

With substantial usage of natural resources and high trade volume, the seafood sector has been challenged by society to find innovative ways to organize and manage the industry more sustainably. One possible avenue is to increase the local/domestic sourcing of farmed seafood. This paper investigates consumers' preferences for domestic farmed salmon, including those produced in land-based farms, while controlling for other important product factors, such as freshness, ecolabel, and product price, using a conjoint choice experiment; and specifically accounting for consumer heterogeneity by latent class analysis and surveying three different countries: the US, France, and Japan.

In the three countries we investigated, we identified at least one segment of consumers with a strong preference for domestic farmed salmon. The estimated size of this segment is 38%, 23%, and 66% in the US, France, and Japan, respectively. Thus, our results show that there exists consumer interest in seeking domestic farmed salmon, and domestic farmed salmon are associated with higher sustainability and naturalness in all countries by at least a sizable portion of consumers. The local/domestic preference is particularly strong in Japan, consistent with past research (Altintzoglou, et al., 2022; Uchida et al., 2014). Given the long transport to Japan for imported products and the concern for the sustainability of wild-captured salmon (Uchida et al., 2014), Japan may be a particularly promising market for land-based production.

However, it does not immediately follow that all consumers prefer domestic farmed seafood, as we also identified at least one segment in each country with a strong preference for imported Norwegian salmon, with estimated sizes of 19%, 68%, and 24% in the US, France, and

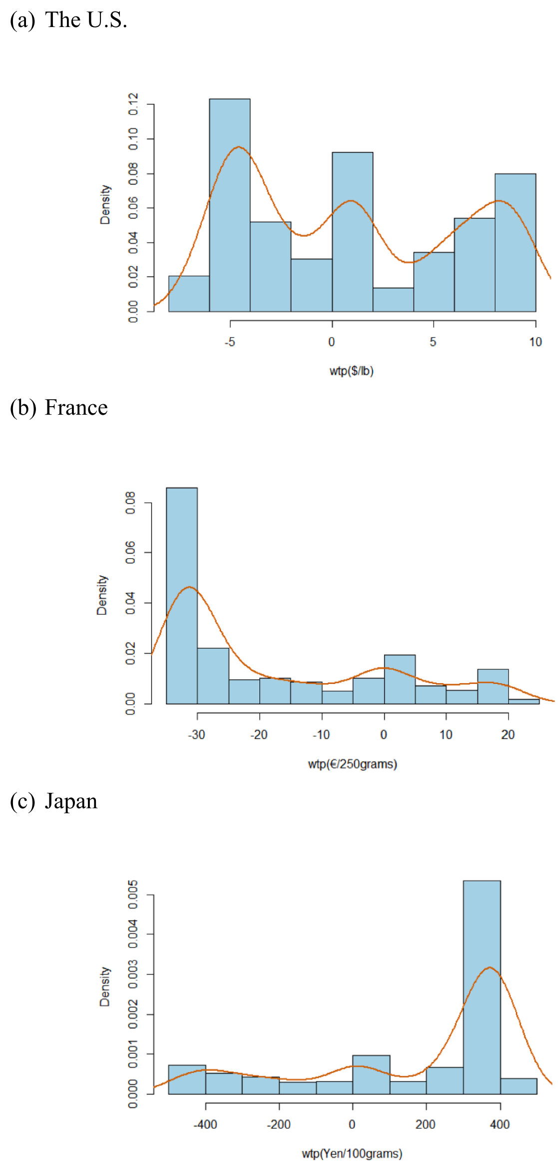

Fig. 2. Willingness-to-Pay Distribution by Country. Note: The figures show the 90% trimmed distribution of the market-level WTP for domestic farmed salmon as opposed to Norwegian farmed salmon as specified in equation (9). Positive WTP indicates the positive WTP for the domestic farmed salmon, wherein negative WTP shows the (negative of) WTP for Norwegian farmed salmon.

Japan. This does not contradict previous studies finding that consumers prefer domestic/local origin, as these studies usually concern consumer preferences "on average" (e.g., Jaffry et al., 2004). Rather, this study highlights the existence of heterogeneous preferences for geographic origin.

We also find one consumer segment in each market, with a size of about 10%, with a strong preference for fresh-packed salmon but also the most price sensitive. They are perhaps occasional salmon shoppers who buy fresh-packed premium salmon when they are on sale. These are also the consumers who put no emphasis on the origin or ASC labels and are found not to utilize label information when purchasing seafood products. Thus, this segment may be irresponsive to information dissemination regarding more sustainable seafood consumption.

Geographic origin is found to be a salient cue for inferring higher quality in a multitude of dimensions (sustainable, fresh, healthy, safe, taste, natural, convenience), even after accounting for freshness and the ASC label. For the US consumers, where pen production is possible but currently at a low level, we show that farmed salmon is viewed favorably in terms of quality perceptions. For France and Japan, as land-based aquaculture is a newly developed technology, fish produced in land-based facilities could invoke skepticism and negative valuations, as seen in, e.g., genetically modified food. However, we find that, at least in our hypothetical experimental setting, a significant proportion of consumers in France and Japan associated domestic farmed salmon with higher quality, including sustainability, food safety, and naturalness. At the same time, consumers who prefer Norwegian salmon use the Norwegian origin in a similar way—as an indicator of higher quality. This reinforces the points discussed by Costanigro and Onozaka (2020) that consumers interpret the same cue differently to infer the unobserved qualities using their subjective beliefs. Combined with the generally low knowledge of consumers about aquaculture, the extent to which origin is used to infer qualities may signify misinformation and misinterpretation, which could lead to confusion or mistrust. Even though it is difficult to communicate full information in a digestive manner to consumers, it would be an important task for policymakers and the seafood industry.

The large segment of French consumers preferring Norwegian salmon is somewhat surprising, given the negative perceptions surrounding Norwegian farmed salmon (Norwegian Seafood Council, 2022a).[13] However, the share of Norwegian salmon is high in France (70%), much larger than in the US and Japan (Norwegian Seafood Council, 2022b, 2019)[14], so familiarity may be one reason. It is also possible that respondents selected Norwegian origin to avoid products from unfamiliar land-based production. As the quality sorting tasks indicate (Table 6), French consumers who prefer Norwegian salmon do not think Norwegian salmon is more sustainable or safer, but they do believe it is more natural. Our experimental design, where wild-caught salmon is not available as an alternative, could also have impacted the choices. As respondents could choose a no-buy option, we believe that the rejection of land-based farmed salmon or the unavailability of wild-caught salmon were not the only reasons for selecting the Norwegian

Table 9
WTP Summary.

		USA	France	Japan
Production Method		Net Pen	Land Based	Land Based
Experimental Price Range		$6.99–14.99/lb	€4.50–8.25/250 g	¥240-400/100 g
Domestic	Average WTP	$5.32/lb	€10/250 g	¥314/100 g
	Range	[0.10, 9.51]	[0.02, 20.65]	[10.77, 401.32]
	% positive	55%	24%	77%
Imported	Average WTP	$4.23/lb	€26/250 g	¥313/100 g
	Range	[0.03, 6.51]	[0.10, 32.4]	[3.19, 474.97]
	% positive	45%	76%	23%

Note: Based on the 90% trimmed distribution of conditional WTP from each country. % positive indicates the percentage of respondents with positive WTP for the respective product (domestic or imported). For instance, 55% of the US consumers show positive WTP towards domestic salmon (the right-hand-side of zero in Fig. 2) while 45% showed positive WTP for imported salmon (the left-hand-side of zero in Fig. 2).

[13] It is reported that Norwegian salmon is often associated with large-scale farming, which is a negative perception (Norwegian Seafood Council, 2022b).

[14] In the US, the market share of Norwegian salmon is 18% (Norwegian Seafood Council, 2019). The farmed salmon here competes with wild salmon and Chilean farmed salmon (Norwegian Seafood Council, 2019). In Japan, the share of Atlantic salmon in the market is 18%, while the wild Pacific species Coho and Chum are bigger, 39% and 19%, respectively (Norwegian Seafood Council, 2021), but most of this is also imported (primarily from Australia and Canada). Japan has a domestic share of 20% (Norwegian Seafood Council, 2021), while the Norwegian share of imports of fresh Atlantic salmon in Japan is 89%.

alternative. The finding that some consumers prefer Norwegian salmon is also consistent with the view that Norway was able to establish a salient image as a premium farmed salmon producer that overrides the preferences for domestic seafood for at least some consumers, as the Norwegian seafood industry allocates significant resources to reach that exact goal. Still, it is interesting to note that French consumers seem more skeptical of land-based production than Japanese consumers.

Country differences also materialize in the usage of the ASC labels. French and US consumers seem to use the ASC label more extensively to infer the higher quality in many dimensions, including health and food safety. However, Japanese consumers do not even infer higher sustainability from ASC label except those in Class 3 (see Appendix D for the full results tables). The way the ASC labels are used to infer various qualities and in different ways by the different consumer segments is a topic worth investigating in future research, as it is beyond the scope of the current study.

The results of the market-wide willingness to pay (WTP) mirror the results from the latent class analysis that preferences for both domestic salmon and salmon imported from Norway exist in each market. However, while the WTP estimates seem reasonable for the US and Japan, French consumers' valuations are spread across a wide range, including somewhat unrealistically high values. Mathematically speaking, this is due to the small (near-zero) price coefficient, particularly for the segment with a high valuation of Norwegian origin. As the WTP measures are somewhat inflated due to the small magnitude of price coefficients, these high WTP measures should be interpreted with caution and considered more as upper bounds.

The literature is mixed in terms of consumers' evaluation of the sustainability attribute in consumption decisions, and this study provides several insights. First, our results show that domestic/local sourcing, often linked to sustainability due to shorter supply chains and preserving the local/domestic industry, is also linked to other quality perceptions, e.g., freshness and safety. The positive evaluation found in past studies could at least partly be attributed to these factors. In other words, when such additional (perceived) benefits are not explicitly accounted for, the valuation of the "sustainable" attribute can be inflated. Second, our results illustrate that consumers are quite heterogeneous, to the point that two segments with completely opposing preferences are found in each of the three countries. Thus, depending on included markets and how consumer heterogeneity is modeled, research findings can vary substantially, which could lead to mixed findings in the literature.

We included several attitude measures, as well as the consumption frequencies and demographic variables, to test if they explain consumer heterogeneity. We did not find any common patterns across countries. For instance, attitude towards the environment measured by the Neo Environmental Paradigm (NEP) was associated with a preference for Norwegian salmon in the US, but it was linked with a preference for domestic salmon in Japan, whereas it has no effect in France. Health attitudes and food pleasure attitudes both had limited effects, only significant in France, such that high food pleasure orientation was associated with no origin preference (Class 1). Concern for carbon emissions from transportation did not have any effect on consumer segmentation. For other consumer characteristics, younger age was associated with domestic preference in the US, but no effect in France and Japan. The only consistently influential consumer characteristic is consumption frequency, but no consistent association with either domestic or imported. At least, those with moderate to high consumption frequencies seem to care about the origin more than those who are not frequent consumers. In terms of label usage, those who indicated that they use label information tend to value either origin and/or the ASC label attributes in the US and France, while Japanese consumers show no effect of label usage in regard to attribute preferences.

As in any study, we made decisions to keep our design focused and feasible, resulting in some limitations. First, this study is based on hypothetical behavior and is subject to hypothetical bias (Hensher, 2010). For instance, the very high (and unrealistic) WTP estimates for France may be due to some consumers downplaying the importance of prices and selecting the product they wanted regardless of the prices, resulting in a statistically insignificant (but still negative) price coefficient, which inflated the WTP. Second, this study only explores consumer preference and evaluations for farmed salmon of domestic/foreign origin, and it does not comprehensively evaluate if domestic farmed seafood is indeed more carbon-friendly or sustainable. Still, we note that domestic production could provide a higher potential to "close the circle" of materials to be reused and recycled and by diversifying the food sources for improved food security.

Third, we did not consider wild-captured fish in this study. Although this simplification was necessary to keep the design simple and feasible, it poses a significant limitation as many consumers report preferring wild salmon. Accordingly, our results could be, at least partly, attributed to consumers selecting the second-best alternative (in the absence of wild salmon), which could inflate the estimated preference and WTP.

Finally, as discussed above, sustainability is a very complex concept, including biological, ecological, social, and economic aspects, and impacts are likely to differ across geological, sociodemographic, and intergenerational dimensions. For instance, we did not consider the social and economic impact of moving the fish farm from a foreign to a domestic location. Future research is needed to conduct a more careful and comprehensive evaluation of the entire supply chain to fully examine the potential carbon reduction and other broader socioeconomic contexts (e.g., creation and reduction in jobs). Such knowledge is essential for policymakers and consumers in advancing sustainable food consumption.

These limitations notwithstanding, we believe the current study provides new evidence that domestically produced farmed salmon could find segments in important seafood markets with consumers who value this attribute. This could potentially present the seafood sector with a viable alternative to improve sustainability by reducing overall carbon emissions and achieving shorter supply chains by providing locally produced salmon.

7. Policy implications

There are several policy implications derived from this study. First, we find that consumers' favorable perception of domestic seafood seems to extend to land-based farmed salmon, implying that there can be a viable market for extended domestic sourcing, including land-based aquaculture. The industry might consider utilizing the existing origin labeling scheme to communicate domestic origin, as consumers are already familiar with the origin label, and familiarity is crucial in generating awareness and acceptance of new technologies. These consumers also tend to be the ones utilizing label information when making purchase decisions. However, the two markets where farmed salmon from land-based facilities were tested exhibit different reactions. The majority of Japanese consumers (66%) prefer domestic farmed salmon, whereas only 23% of French consumers show the same preference. This is interesting from the policy perspective, as we might expect a larger impact on carbon emission reduction from reduced transport from the Japanese market (air transport) than from the French market (land transport). Japanese market may be more promising for land-based production where consumer acceptance and environmental impact may be higher. It also implies that French consumers may be more skeptical and require more preparation (e.g., an information campaign) for the majority of French consumers to accept land-based production.

Second, consumers are found to link a broad range of qualities to the country of origin information. Assessing food qualities, including the implications for sustainability, is a complex task as it comprises broad effects on carbon emissions, domestic economy, food security, and circular use of resources. Our results indicate that consumers use the origin cue as a proxy for these implications, which may or may not be correct. Thus, narrowing an information gap between what a cue signifies and what consumers perceive from that cue would play an important role for policymakers and regulators in order to improve transparency, gain long-term consumer trust and make an impact on sustainable food consumption. As consumers' knowledge of aquaculture is limited, using the existing framework of environmental performance measures (e.g., ISOs) could benefit land-based aquaculture to avoid confusion and information overload.

Third, this study also shows that there exists at least one segment of consumers who prefer and perceive higher quality for imported salmon, even in the presence of locally sourced alternatives. From an industry perspective, this implies that there is room for both types of products in each market serving different consumer segments. Considering that domestic farmed salmon production is still at an early stage in most countries and is not likely to achieve a high enough volume to serve the entire market in the near future, the demand for imported farmed salmon will remain. Our analysis shows that the availability of imported salmon serves consumers well, as a significant portion of consumers does prefer imported farmed salmon. Then, it would be crucial to continue the international corporation with a holistic and transparent policy framework for implementing common standards for the sustainable aquatic food system.

Finally, even with transparent and reliable origin information and extension of "local" productions with new technology, it is important to acknowledge that it only addresses a small part of the complex landscape of sustainable seafood. For instance, sustainable aquaculture standards not only concern environmental sustainability (e.g., managing the supply chain for sustainable inputs) but also include food safety (e.g., monitoring the types of antibiotics), community (e.g., labor conditions) and animal welfare (Roheim et al., 2012). Land-based production may prove advantageous to some extent due to its controllability of production and potential to benefit community development. However, how the closed-contaminant production is perceived from an animal welfare perspective is not clear. Thus, all aspects of land-based production should be considered against best sustainable practices and communicated to consumers.

Author Contributions Statement

All authors contributed to the funding acquisition, study conception, design, and data collection. Data analysis were performed by Yuko Onozaka. The initial draft of the manuscript was written by Yuko Onozaka and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Supplementary materials

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