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A Hybrid Fuzzy TOPSIS Method to Analyze the Coverage of a Hypothetical EU Ecolabel for Fishery and Aquaculture Products (FAPs)

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Abstract: This study presents a hybrid fuzzy technique for order preference by similarity of the ideal solution (TOPSIS) method (FTOPSIS) to analyze the coverage of a hypothetical EU ecolabel for fishery and aquaculture products (FAPs) by integrating a synthetic indicator to determine the level of acceptance for the inclusion of different types of information apart from environmental issues, considering different stakeholders and other segments of analysis. Data were obtained from a public consultation of the EU on "ecolabels for FAPs". The results indicate that ecolabels should not only include environmental issues but also other types of information, with social and ethical issues being the most relevant, followed by animal welfare issues, health and safety issues and food quality issues. The findings also show that consumers, producers and stakeholders who are more interventionist and support the fact that public bodies and governments should be involved in the control of eco-labeling are more accepting of including additional information apart from environmental issues. Synthetic indicators (SIs) have also been found to be mostly inelastic, except for the owners of ecolabels on social and ethical issues. The implications of the future implementation of the EU ecolabel for FAPs are discussed based on the findings.

1. Introduction

The EU is the world's leading nominal trader for fishery and aquaculture products (FAPs) [1]. In addition, the EU has a higher average per capita consumption (24.33 kg) [2] than the global average (20.3 kg) [1]. In light of this value, EU regulations such as the Common Market Organization (CMO) have become important tools for the proper functioning of the market and industry [3].

The CMO ensures that the information that consumers receive from FAPs sold in the European Union is of the expected quality, regardless of the origin of the product [4]. The CMO is currently ruled by the EU regulation 1379/2013, which provides mandatory information on the labeling of FAPs and other aspects [3]. The regulation also includes a list of voluntary data that can be incorporated into the FAPs, including information on the environmental, ethical or social aspects of products, information on production techniques and practices and other types of information [5]. Furthermore, the EU regulation 1379/2013 requires the EU Commission to submit a report on the feasibility of a union-wide FAP eco-labeling scheme [6].

Food labeling is an important feature for consumers to obtain information on the products of the market and allows them to improve their knowledge and interest in seafood and can have a significant impact on food choice [7]. Ecolabels are based on approval seals for products that are considered to have less environmental impacts than functionally or competitively similar products [8]. Furthermore, ecolabels provide both private benefits

(e.g., taste, freshness and health) that can be easily internalized by consumers and public benefits or externalities that consumers cannot fully benefit from (e.g., environmental sustainability and fair employment practices) [9]. In the case of externalities or public goods' dimensions, the main benefits can be associated with social, ethical or animal welfare issues rather than environmental issues.

According to the United Nations Conference on Trade and Development [10], ecolabels are characterized as being voluntary and based on criteria established by a third-party scheme. The determination of criteria and the selection of product categories shall be carried out by independent experts who consider a variety of interest groups and technical inputs. The information shall be made available to the public and needs to be transparent and credible. Products that meet the criteria may use the eco-logo for a fixed period of time after fees payment and application costs.

Since the 1990s, several eco-labeling schemes for fisheries have been developed in response to public and non-governmental organizations' (NGOs) concerns about the sustainability of fish stocks, the direct impact of fisheries on other species and the indirect impact of fisheries on marine habitats [11]. These eco-labeling schemes aim to differentiate products based on their environmental impact, thus enabling consumers to make informed purchasing decisions. Eco-labeling schemes are also designed to encourage industries to adopt better practices alongside or without effective regulation.

As said, the EU Commission was obliged to submit a report on the feasibility of a union-wide FAP eco-labeling scheme. To that end, a public questionnaire was developed, among different aspects, to know what type of information apart from environmental issues should be included if the EU created its own fisheries and aquaculture EU ecolabel [6]. An integrated EU ecolabel for fisheries and aquaculture products might be a good alternative to surpass certain issues of current private eco-labeling schemes that have been questioned in the literature, such as their high volume of available options with conflicting messages that undermine their effectiveness [12], the anti-competitiveness environment that they might generate if some firms are capable of exerting market power [13], their lack of effectiveness and rigor [14], their inability to promote consumer demand [12] or their inability to pursue significant environmental change [15].

The present investigation uses a hybrid fuzzy technique for order preference by similarity of the ideal solution (TOPSIS) methodology (FTOPSIS) to analyze the coverage of a hypothetical EU ecolabel for FAPs based on the mentioned public consultation and it extends the previous research in two important aspects: (1) using a synthetic indicator, it identifies the differences of opinions on the level of acceptance for the inclusion of different issues in an EU ecolabel for FAPs, considering various types of stakeholders and segments of the sample according to their opinion on whether public bodies/governments should be involved in the control of ecolabels (governmental intervention segments); and (2) it estimates the elasticities related to the synthetic acceptance indicator for each stakeholder and governmental intervention segment to discuss some policy implications based on the results.

Thus, the present investigation sets out three main objectives: (1) to extend the current literature proposing a methodology that jointly analyzes the importance of including different types of information in a hypothetical ecolabel for FAPs; (2) to compare the values of the synthetic indicator by type of stakeholder and by respondents' opinions on whether public bodies/governments should be involved in the control of ecolabels; (3) to determine the sensitivity of the synthetic indicator for each group of interest with respect to each type of information apart from environmental issues (animal welfare, health and safety, food quality and social–ethical issues) included in the ecolabel scheme.

To our knowledge, this study contributes to the eco-labeling literature in two important aspects that have not been analyzed up to now. First, it is an attempt to provide more insights on a topic that has not been analyzed at the EU scale. Second, two important segmentation variables are selected to analyze the main results regarding the level of acceptance for the inclusion of different types of information apart from environmental

issues in the ecolabels: stakeholder type and the support of the respondents to the fact that public bodies and government should be more involved in the control of eco-labeling.

The rest of the paper is organized as follows: Section 2 presents the relevant literature review of ecolabels highlighting more features on FAPs; Section 3 details the data used for the estimation of the synthetic indicators and the elasticities; Section 4 describes the proposed methodology; Section 5 describes the main results based on the application of the methodology; Section 6 discusses the results and Section 7 offers some conclusions.

2. Literature Review

According to our literature review, there seems to be no evidence of studies assessing the possible creation or consideration of an ecolabel for FAPs that can be implemented for the entire EU, apart from a report that was constructed based on the same public consultation assessed in the present investigation [16]. However, the report focuses neither enough on the issues that should be assessed in the ecolabel nor on the differences of opinions between different segments about them.

In contrast, the literature is rich in assessing the impacts and importance of ecolabels and the different types of information that might be included. Nevertheless, most of the investigations are focused on the perspectives of consumers, assessing their preference for the different types of labels; meanwhile, other stakeholders are basically ignored in the literature. The scale of the studies is also very limited as most of the studies only analyze one country or, in the best of the cases, a small group of European countries.

Taking into consideration the limitations discussed above, this section presents the main findings on the different issues assessed by FAP ecolabels, subdivided according to the type of information included in the ecolabels (environmental, animal welfare, health and safety, food quality and ethical issues).

2.1. Environmental Issues

Consumers in Europe are deeply concerned about the environmental impact of both caught and farmed fish [17]. It is, therefore, not surprising that the environmental conditions of FAPs are important to consumers' choices. In fact, a study found that consumers preferred wild-caught products to farmed products because the latter group have a negative environmental impact and are of a lower quality in comparison [18].

Moreover, the environmental concerns related to the products may also have an impact on the frequency of consumption of FAPs. One investigation found that consumers who care about the environment are more likely to consume oysters in Italy [19], while another found that a higher concern about the environmental performance of the salmon farming industry is related to a lower tendency to purchase salmon [20].

On the other hand, some studies highlight that consumers are willing to pay premiums for products labeled with environmental advantages [21–26]. Two investigations found that consumers in Norway were willing to pay a premium of around 15% for organic-labeled salmon compared to conventional salmon with the same color; however, the results show that the importance of this label is considerably low compared to salmon color [24,25]. Another study found that consumers were willing to pay an average premium of 21.5% for salmon and 26.8% for crab bearing a sustainable label, ensuring that the fish population from which the seafood was harvested is healthy and sustainable and that fisheries cause minimal environmental damage [21]. Moreover, two investigations highlight that consumers are willing to pay premiums for lower levels of contamination, evidenced in low levels of polychlorinated biphenyls [26] or the absence of Bisphenol A (plastic) [23].

In addition, some environmental labels refer to the certification of innovative production practices that favor the environment such as Integrated Multi-Trophic Aquaculture (IMTA), which is an alternative production method that includes a number of species combined in the production process, offering a lower environmental impact through nutrient cycling and natural filters, and may also have economic advantages [27]. Two investigations have shown that consumers are willing to pay more for sustainably produced fish

based on IMTA: one in the UK, Italy, Israel and Norway for salmon and seabream [27] and the other in Ireland for sustainable salmon [28].

2.2. Animal Welfare Issues

Animal welfare can be described as the lack of suffering in animals and focuses on animals' health and their needs [29]. Economic considerations and state regulations on fish welfare have incorporated knowledge of fish behavior and ecology into the aquaculture industry [30]. This has promoted research and development of better feed and nutrition processes, prevention and elimination of conditions that contribute to marine lice infestation, other parasites and diseases and the pursuit of enhanced environments with reduced stocking densities, the re-circulation of aquaculture systems and integrated multi-trophic aquaculture. On the contrary, there is almost no consideration of the welfare of fish in capture fisheries, probably because there are fewer welfare regulations for wild fish and less scientific attention compared to farmed fish. An example can be found in the manner in which fisheries typically kill their caught fish, which are asphyxiated or gutted while alive on board fishing vessels, before being transported for processing [31].

In the literature, several studies have studied the possible acceptance of animal welfare labels and claims [24,25,32,33]. In Norway, two studies identified a preference and higher willingness to pay (WTP) for animal welfare-labeled salmon (Freedom Food salmon) compared to conventional salmon with the same color [24,25]. However, the effect of the color completely outweighed the effect of the label. Similarly, another investigation asked consumers from different European countries regarding additional WTP for different sustainability claims related to seafood [33]. Higher animal welfare standard-related WTP was observed in Finland, Spain, the UK, Germany and Italy, and in these last two countries, the figures were even greater than for other types of information provided such as locally, organically and sustainably produced. In addition, a different investigation determined that fish welfare information increased the preference and value of organic-labeled farmed trout products in Germany [32].

In addition, in the same context, unintentional capture of non-target species (by-catch) such as marine mammals and sea turtles is a major concern in fisheries' management. An investigation included the hypothetical label "turtle safe" in a discrete choice experiment (DCE) with a label indicating that the fish had been harvested by fisheries with highly strict controls to prevent by-catch of sea turtles, finding that consumers were willing to pay a premium of around 31.3% of the average price for tuna carrying that label in Hawaii (US) [34]. Similarly, a DCE for tuna in Mexico found that consumers who had been informed about the "dolphin-safe" ecolabel were more eager to consume canned tuna [35]. Another study found that the by-catch concern can be overcome or mitigated by the introduction of special fishing gear and methods [36].

2.3. Health and Safety Issues
2.3.1. Health Issues

A study in British Columbia (Canada) found that consumers who purchase seafood because of its health and nutritional benefits tend to consume seafood more frequently [37]. While these benefits may correspond to different aspects, a different investigation found that in a focus group of European countries (France, Italy, Germany, Greece, Norway, Spain and the UK), almost a third of the discussions towards the health benefits of fish consumption focused on the benefits of Omega 3 [17].

Some studies highlight that consumers are willing to pay premiums for seafood products including labels or claims supporting health benefits associated with Omega 3 [26,38,39]. An investigation found that Canadian consumers were willing to pay premiums for farmed salmon products with increased Omega 3 rather than for products which reduced local or global impacts, suggesting that health benefits were considered more relevant than the environmental performance of the production process, as in this case, the benefits are clearly internalized [26]. Nevertheless, in general, attributes associated to decreased

levels of contamination or the origin of the product were ranked higher than the health benefits. Similarly, a different study found that consumers were willing to pay a premium for seabream that includes a natural Omega 3 claim; however, other attributes such as the origin, the harvest method (wild or farmed) and the sustainability claim were more important [39]. Interestingly, there were differences when the authors applied the same experiment to retailers, which evidenced that consumers and retailers could value the importance of attributes differently. Moreover, for amberjack in the European context (including Germany, France, Italy, Spain and the UK), another study found that consumers were willing to pay premiums for nutrition claims related to Omega 3 richness and health claims for improved heart function [38]. However, these factors were less valued than others such as the origin, price and the Aquaculture Stewardship Council (ASC) ecolabel.

Moreover, the literature also highlights the preference for other health benefits different from those related to Omega 3. For canned tuna in the US, an investigation found that a heart-healthy label certified by the American heart association had a higher WTP than the Marine Stewardship Council (MSC) ecolabel and a Bisphenol A (BPA) free product label [23]. In addition, in the southern region of the US, a different study found that parents with children are willing to pay premiums for nutritional and health claims associated to seafood, with nutritional information being more relevant [40]. Curiously, the study also determined that providing the nutrition and health benefits information together did not increase the marginal willingness to pay for seafood products more than providing the information of health benefits or nutrition on its own.

2.3.2. Safety Issues

Consumption patterns may be affected by consumers' opinions on the safety of products. In South Korea, for live fish, an investigation found that consumers with higher consumption frequencies usually consider safety to be a more relevant factor than the price [41]. In Italy, for oysters, a different study found that consumers with specific expertise in judging the safety of oysters tend to eat them just at home, while consumers who are concerned about the safety of the product prefer to consume it more often outside the home [19].

Moreover, some studies indicate that consumers are willing to pay premiums for improved safety products [21,42,43]. For the salmon industry in Canada, it was found that consumers welcomed the proposal to use the traceability method and quality control systems for safety reasons, even though they may increase the cost of the product [42]. A study in the US for shrimp and imported tilapia from China determined that consumers were willing to pay the highest premium for enhanced food safety followed by the non-antibiotic use and environmentally friendly production methods [43]. A different investigation in Portland (US) for crab and salmon found that amongst four labels related to safety, eco-labeling, quality and local products, the safety label that meets the US Food and Drug Administration (US FDA) standards and that declares that the seafood is low in mercury and other contaminants was ranked third, and they also identified that women had stronger preferences for safety labels [21].

2.4. Food Quality Issues

In the literature, a DCE that took place in the UK found that the quality certification attribute for seafood products was the most important factor alongside the sustainability label and surpassed other important attributes such as origin and mode of production [44]. On the contrary, in the US, for salmon, another study included a premium quality certification that stated that the product had received premium handling and that it was extremely fresh and found that this label was the least important of all the labels included in the experiment such as safety, ecolabels and local products [21].

Moreover, the food quality of the products is sometimes evaluated through the sensory qualities of the product, including taste, smell and appearance. A study determined that the most important factors affecting the decision to purchase seafood were those related

to the sensory quality of the product [37]. Another investigation also found that regular consumers of fish and shrimp in France consider important the sensory quality of the products [45]. On the other hand, a different study found that in Belgium, taste and health are the most important drivers for the attitude to eat fish, which is directly correlated to the frequency of fish consumption [46].

2.5. Social and Ethical Issues

Seafood consumers usually attach secondary importance to social and ethical issues over other attributes. An investigation in the US that included a DCE in which social sustainability was represented by two labels: a label that promotes community and another label that certifies opportunities for fishers to increase their participation in decisions, as well as fair distributions of profits that benefit coastal communities [47]. The results indicate that the WTP for social benefits was the lowest and that consumers usually have a high degree of overlap between the social benefits and those from locally sourced seafood, which suggested that there is a need for education about social problems of fisheries. In Germany, another investigation included a fictitious fairtrade claim as a separate attribute from the sustainability certification attribute in a DCE, finding that generic fair trade had a positive impact on purchasing choices, and consumers were willing to pay premiums for it, even though they were willing to pay more for certifications such as ASC and Naturland, which focus more on environmental aspects [48].

On the contrary, in the case of coffee in the US, a study found that social/ethical benefits were valued higher than environmental benefits, as there was a higher WTP estimate for the fairtrade program (fair opportunities for producers of developing countries), followed by shade-grown (conservation of the habitat of birds and wildlife) and, finally, organic coffee (environmental benefits) [49].

Moreover, in Belgium, a study found that although consumers rate fish sustainability and ethics as very important, it was not correlated with their patterns of consumption or attitudes towards eating fish [50]. However, consumers refused to eat wild fish because of sustainability and ethical concerns.

3. Data

The database used for this investigation is based on a public consultation on options for an EU ecolabel for FAPs [51], executed by the European Commission between April 30 and 1 July 2015. This consultation contributed to a feasibility report on options for a union-wide ecolabel scheme for FAPs looking to understand opinions on the impacts and issues from different stakeholder groups, following a commitment acquired by the commission in the regulation on a Common Market Organization for FAPs (CMO, Reg. EU 1379/2013). The final sample consisted of 433 individuals surveyed, mainly from different European countries, representing different stakeholders such as consumers (individual or group), ecolabel owners, producers (individual fish farmer, fishery/aquaculture company or producer organization), retailers and public organizations (government, public, non-governmental organization or research). Out of the 433 surveys, only 407 were used for our analysis because the remaining lacked essential information.

At the public consultation, there was a module asking for the level of acceptance (from 1 to 5) to include different types of information in an EU ecolabel for FAPs (Table 1). The responses to this question were the basis for constructing the triangular fuzzy numbers, while the socio-demographic characteristics of the respondents (Table 2) were used to distinguish the different segments and groups.

Table 1. Coverage of the EU ecolabel system in fishery and aquaculture products (FAPs).

If the EU Created Its Own Fisheries and Aquaculture Ecolabel, What Should the Scope of the Ecolabel Include (in Addition to Environmental Standards)? Please Indicate How Strongly You Agree or Disagree with the Following Statements:					
A1: An EU ecolabel should be limited to environmental issues only	1	2	3	4	5
A2: An EU ecolabel should include social and ethical issues	1	2	3	4	5
A3: An EU ecolabel should include food quality issues	1	2	3	4	5
A4: An EU ecolabel should include health and safety issues	1	2	3	4	5
A5: An EU ecolabel should include animal welfare issues	1	2	3	4	5
1. Strongly disagree. 2. Disagree. 3. Do not know. 4. Agree. 5 Strongly agree.					

Source: [51].

Table 2. Socio-demographic characteristics of the respondents.

Variable	Categories	N	Frequency %
Country	Netherlands	88	21.62
	Spain	66	16.22
	France	37	9.09
	Germany	32	7.86
	United Kingdom	29	7.13
	Belgium	22	5.41
	Italy	22	5.41
	Sweden	20	4.91
	Portugal	13	3.19
	Other	78	19.16
Stakeholder	Consumers	181	44.47
	Ecolabel owner	10	2.46
	Producers	62	15.23
	Retailers or suppliers	55	13.51
	Public/non-governmental/research organization	99	24.32
Government Intervention	No	77	18.92
	Do not know	59	14.50
	Yes	271	66.58

The survey was an Internet-based public consultation not considering any type of sample representativeness, methodology or control. The public consultation was widely publicized, but respondents chose to participate without any further prerogative than interest in the FAP ecolabels framework in the EU. For that reason, the results do not necessarily reflect the opinions of EU citizens, but rather the views of those who were interested in the consultation [6].

4. Methodology

The methodology is derived from a hybrid approach based on Fuzzy Set Theory (FST) and techniques for order preference by similarity of the ideal solution (TOPSIS). TOPSIS techniques are considered appropriate tools to handle different decision-making processes and they are especially attractive when respondents make choices with multiple attributes in consideration [52]. Moreover, the essence of the human ambiguity judgement when dealing with multidimensional attributes can be captured by fuzzy methods [53], which is an important task when using Likert scales based on linguistic terms. The hybrid fuzzy TOPSIS method developed in the study has demonstrated to be a more effective tool than other statistical methods based on averages and other multi-criteria methods not only to deal with the uncertainty associated to the Likert scales but also to provide synthetic indicators and elasticity values [54].

The dataset used for the methodology consists of the level of acceptance to include certain types of information in an EU ecolabel (environmental only, social and ethical, food quality, health and safety or animal welfare, apart from environmental). The answers to the level of acceptance expressed by respondents were based on a five-point Likert scale according to (I strongly disagree (1); I disagree (2); I do not know (3); I agree (4); I strongly agree (5)). Likert scales, as other qualitative semantic scales used in social sciences, provide uncertain and vague information which is not appropriate for quantitative analysis. For that reason, FST has become a good alternative to cope with this type of information—more than other traditional methods [55,56]. Table 3 shows how the raw information of the dataset is transformed into the form of triangular fuzzy numbers (TFNs) as a good alternative for handling this vague information. The TFNs consist of three parameters (*a*, *b*, *c*), with *b* being the most likely value and *a* and *c* being the minimum and maximum values, respectively. Thus, the first step in the methodology was to transform the responses into TFNs according to the default values shown in the table.

Table 3. Triangular fuzzy numbers. Default values of linguistic terms.

Linguistic Terms	Fuzzy Number
I strongly disagree (1)	(0, 0, 30)
I disagree (2)	(20, 30, 40)
I do not know (3)	(30, 50, 70)
I agree (4)	(60, 70, 80)
I strongly agree (5)	(70, 100, 100)

Source: Own elaboration.

Then, in the second step, mean TFNs were calculated for each segment of analysis, which covers diverse segmentation variables *p* (country, opinion on governmental intervention, firm size and stakeholders) and various categories *s* that correspond to each of them (e.g., Cyprus or Bulgaria for the country; and consumers or producers for the stakeholders' segments). Moreover, the mean TFNs were calculated separately according to the type of information *q* that should be included in the EU ecolabel for FAPs (e.g., environmental issues only, social and ethical issues apart from environmental issues, animal welfare issues apart from environmental issues, etc.). In this context, the mean TFN ($\widetilde{A}$) for a category *s* that corresponds to the segmentation variable *p* and is related to an issue *q* can be calculated as the mean of the TFN responses of the individuals 1 to *n* that are a part of that particular segment of analysis, as shown in Equation (1).

$$\widetilde{A} = (a_{s,p,q}, b_{s,p,q}, c_{s,p,q}) = \left(\frac{\sum_{i=1}^{n} a_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} b_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} c_{s,p,q}}{n} \right) \tag{1}$$

where *s*: 1, . . . , *s*; *p*: 1, . . . , *p* and *q*: 1, . . . , *q*.

In the third step, we clarified the TFN information matrix obtained in the previous step through a defuzzification process that transforms each of the elements of the matrix into crisp values (CVs). The CVs were calculated according to Equation (2) for simplicity and objectivity [57] and indicate the level of acceptance for the inclusion of a particular issue *q* in a hypothetical EU ecolabel by each category *s* that belongs to a segment *p*.

$$CV_{s,p,q} = \frac{a_{s,p,q} + 2 \times b_{s,p,q} + c_{s,p,q}}{4} \tag{2}$$

where *s*: 1, . . . , *s*; *p*: 1, . . . , *p* and *q*: 1, . . . , *q*.

The fourth step consisted of determining the ideal (CV_q^+) and negative ideal (CV_q^-) solutions per issue *q*, as the maximum and minimum CVs of all the segments of analysis,

as shown in Equation (3). While the ideal solution maximizes the level of acceptance on the inclusion of each particular issue q, the negative ideal solution minimizes it.

$$CV_q = \{CV_{1,1,q}, \ldots, CV_{s,p,q}\}$$

where

$$CV_q^+ = \max_q(CV_q) \text{ and } CV_q^- = \min_q(CV_q) \tag{3}$$

where $s: 1, \ldots, s; p: 1, \ldots, p$ and $q: 1, \ldots, q$.

The fifth step, as shown in Equation (4), was to calculate the Euclidean distances of each category s of the segment of analysis p with respect to the ideal solutions. Because $q = 1$ represents the inclusion of environmental issues only, the CVs associated with it were not considered in the estimation of the synthetic indicator (SI). This way, the SI represents the level of acceptance for the inclusion of other issues apart from the environmental issues in the EU ecolabel; thus, a value closer to 1 would indicate a higher acceptance to include more issues apart from the environmental issues in the ecolabel for that segment of analysis, while the values closer to 0 indicate the opposite. The estimation of these SIs by segment of analysis was the sixth step of the methodology and was carried out using Equation (5), which simultaneously characterizes the distance to the ideal and negative ideal solutions.

$$d_{s,p}^+ = \sqrt{\sum_{q=2}^{q} (CV_q^+ - CV_{s,p,q})^2} \text{ and } d_{s,p}^- = \sqrt{\sum_{q=2}^{q} (CV_{s,p,q} - CV_q^-)^2} \tag{4}$$

where $s: 1, \ldots, s; p: 1, \ldots, p$ and $q: 1, \ldots, q$.

$$SI_{s,p} = \frac{d_{s,p}^-}{d_{s,p}^+ + d_{s,p}^-} \tag{5}$$

where $s: 1, \ldots, s$ and $p: 1, \ldots, p$.

The seventh step involved the estimation of the elasticities per segment of analysis of the SIs towards percentual changes in the response given for each issue A (Equation (6)). This information allows the understanding of how a percentage change in each of the issues affects the SI per each of the analyzed segments.

$$\eta_{s,p,q} = \frac{\Delta\% SI_{s,p}}{\Delta\% A_{s,p,q}} \tag{6}$$

where $s: 1, \ldots, s; p: 1, \ldots, p$ and $q: 1, \ldots, q$.

5. Results

The methodology was applied to determine the level of acceptance for the inclusion of different issues in a hypothetical EU ecolabel for FAPs, as well as to prioritize them in terms of acceptance for inclusion. After the application of the first three steps of the methodology, we obtained the mean CVs for each type of information and segment of analysis. Table 4 presents the TFNs and the CVs for the total of the sample and the governmental intervention segments, while Table 5 presents the same information for the stakeholders' segments. The results indicate that in all cases, the lowest value was assigned to include only environmental issues in the ecolabels, indicating that ecolabels should include not exclusively environmental issues but also other types of information. Amongst them, the most important for the total of the sample surveyed was social and ethical issues, followed, in order, by animal welfare issues, health and safety issues and food quality issues.

Table 4. Triangular fuzzy numbers (TFNs) and crisp values (CVs). Total and governmental intervention segments of analysis.

Attributes	Total		Gov. Intervention (No)		Gov. Intervention (DK)		Gov. Intervention (Yes)	
	TFN	CV	TFN	CV	TFN	CV	TFN	CV
Only environmental issues	(30.76, 42.80, 57.27)	43.41	(27.14, 38.44, 54.81)	39.71	(28.14, 40.17, 57.29)	41.44	(32.36, 44.61, 57.97)	44.89
Social and ethical issues apart from environmental issues	(50.00, 66.29, 76.90)	64.87	(40.39, 54.81, 68.83)	54.71	(45.25, 61.69, 74.58)	60.81	(53.76, 70.55, 79.70)	68.64
Food quality issues apart from environmental issues	(43.39, 58.38, 70.05)	57.55	(32.99, 46.36, 62.08)	46.95	(38.31, 51.69, 66.10)	51.95	(47.45, 63.25, 73.17)	61.78
Health and safety issues apart from environmental issues	(45.09, 60.27, 71.62)	59.31	(35.71, 49.87, 64.42)	49.97	(39.66, 54.75, 68.81)	54.49	(48.93, 64.43, 74.28)	63.02
Animal welfare issues apart from environmental issues	(46.83, 63.29, 74.52)	61.98	(39.22, 54.55, 68.70)	54.25	(40.34, 56.61, 70.34)	55.97	(50.41, 67.23, 77.08)	65.49

Source: Own elaboration.

Table 5. TFNs and crisp values. Stakeholders' segments of analysis.

Attributes	Consumers		Ecolabel Owners		Producers		Retailers or Suppliers		Gov./Public/Research	
	TFN	CV	TFN	CV	TFN	CV	TFN	CV	TFN	CV
Only environmental issues	(30.28, 42.32, 56.85)	42.94	(15.00, 23.00, 46.00)	26.75	(33.06, 45.32, 58.06)	45.44	(32.00, 45.09, 59.82)	45.50	(31.11, 42.83, 57.27)	43.51
Social and ethical issues apart from environmental issues	(52.32, 68.95, 78.78)	67.25	(35.00, 50.00, 65.00)	50.00	(48.23, 64.68, 74.84)	63.10	(48.00, 63.64, 75.45)	62.68	(49.49, 65.56, 76.77)	64.34
Food quality issues apart from environmental issues	(44.86, 60.22, 71.10)	59.10	(17.00, 25.00, 48.00)	28.75	(51.61, 68.23, 77.58)	66.41	(39.45, 54.55, 68.00)	54.14	(40.40, 54.34, 66.77)	53.96
Health and safety issues apart from environmental issues	(46.13, 61.55, 72.49)	60.43	(27.00, 37.00, 56.00)	39.25	(51.45, 68.55, 77.42)	66.49	(41.27, 56.36, 69.82)	55.95	(43.13, 57.27, 68.99)	56.67
Animal welfare issues apart from environmental issues	(49.28, 66.46, 76.35)	64.64	(29.00, 39.00, 58.00)	41.25	(46.13, 61.77, 73.06)	60.69	(44.73, 62.91, 75.09)	61.41	(45.76, 61.11, 73.43)	60.35

Source: Own elaboration.

Moreover, all the governmental intervention segments assigned the same rank of importance to the different issues as the total sample according to the CVs. Similarly, for the stakeholders' segments, we found that consumers, ecolabel owners, retailers or suppliers and organizations (government, public, non-governmental organization or research) assigned the same rank of importance to the different issues as the total sample; however, producers ranked them differently, with the most important issues being health and safety, followed very closely by food quality issues. This result has shown that the producers are the stakeholders who valued the relative importance of some types of information more differently.

In addition to what was previously discussed, it is important to consider that despite the fact that most of the analyzed segments shared the same ranking of issues, the distances between them could vary, indicating a high heterogeneity in the level of acceptance on the inclusion or not of different issues apart from environmental issues.

In the fourth step, we calculated the ideal and negative ideal solutions and the respective percentage of variation between them for each of the issues, as can be seen in Table 6. Ideal and negative ideal solutions indicate which segment of analysis has given the most and least importance to the issues, while the percentage of variation is a measure of the heterogeneity between opinions on the possible inclusion of issues for the EU ecolabel. The findings indicate that in general, the level of acceptance to include particular issues in an ecolabel are highly heterogeneous, with more than 200% of percentage variation between ideal solutions, but in particular, the inclusion of only environmental issues varied up to 983% between the ideal and negative ideal solutions, which reaffirms that the biggest decision for the implementation of the ecolabel would be whether or not to just consider only environmental issues, which is common in current eco-labeling schemes, or, on the contrary, whether it should add other issues apart from the environmental issues.

Table 6. Coverage of the EU ecolabels. Ideal solutions.

Attributes	Positive	Segment	Negative	Segment	Perc. Variation
Only environmental issues	81.25	Croatia	7.50	Bulgaria	983%
Social and ethical issues apart from environmental issues	92.50	Cyprus	30.00	Estonia	208%
Food quality issues apart from environmental issues	92.50	Cyprus	28.75	Ecolabel owner	222%
Health and safety issues apart from environmental issues	92.50	Cyprus	30.00	Estonia	208%
Animal welfare issues apart from environmental issues	92.50	Bulgaria	30.00	Luxembourg	208%

Source: Own elaboration.

An interesting fact that can be highlighted from the results of Table 6 is that most of the segments of the ideal solutions are obtained at the country level, with the exception of the ecolabel owners that appear in only one component. A word of caution is needed here as some countries are only represented by a very limited number of respondents. Thus, the commented results of the table are made for a description of the figures that will be used in the subsequent steps of the model. Cyprus has been found to have the highest valuation for the inclusion of social and ethical, food quality and health and safety issues, while Bulgaria has been identified for animal welfare issues. In addition, Croatian citizens are the segment of analysis that contend the most that ecolabels should only cover environmental issues, while Bulgarians are the segment of analysis that least accept the inclusion of that type of issue. Estonian stakeholders are the segment of analysis that assigned the lowest valuation to the inclusion of social and ethical issues as well as health and safety issues, while those from Luxembourg assigned the lowest valuation to animal welfare. Curiously, ecolabel owners are the segment of analysis that assigned the lowest valuation to the inclusion of food quality issues in the ecolabel.

Following the implementation of steps 5 and 6, the SIs were calculated and are shown in Figure 1 for the total sample, the governmental intervention segments and the stakeholders segments. The results show that citizens who consider that public bodies and governments should be more involved in the control of eco-labeling accept more to include issues that are different from environmental issues than those who do not or who do not know. Similarly, from the group of stakeholders, producers and consumers have higher SIs. On the other hand, ecolabel owners are the group of stakeholders that least accept inclusion of other types of information apart from environmental issues.
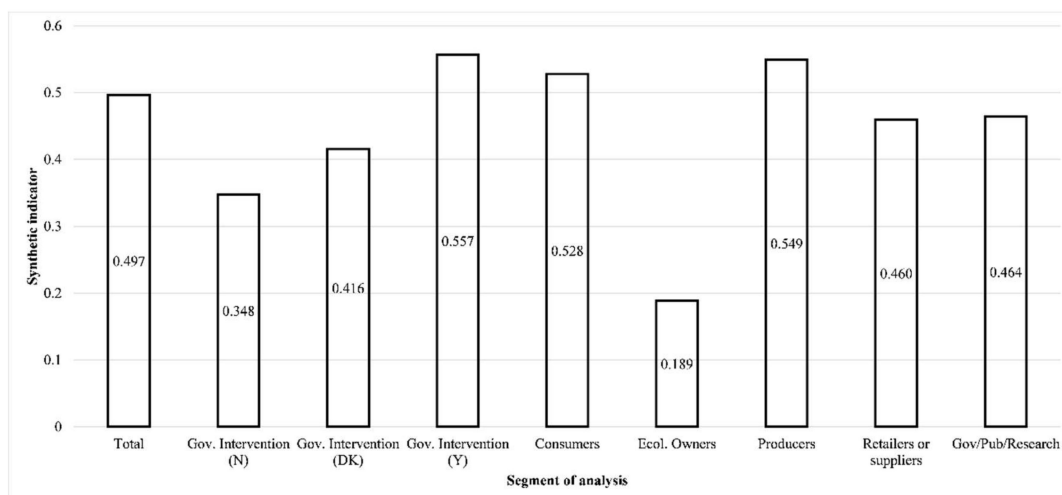

Figure 1. Level of acceptance for the inclusion of additional issues apart from environmental ones on a hypothetical EU ecolabel for the different segments of analysis.

Finally, for the last step, we calculated the elasticities of the SIs (Table 7). The general results indicate that the SIs are mostly inelastic with respect to all the issues and segments of analysis, except for the owners of ecolabels on social and ethical issues, which was the highest value of elasticity in all segments of analysis. In addition, the lowest elasticity value was obtained for ecolabel owners regarding food quality issues.

For the total sample and most of the analyzed segments of analysis, the higher elasticities were related to social and ethical issues, with the exception of producers who have higher sensitivity towards the inclusion of food quality issues. On the other hand, the lowest elasticity value for the total sample and most of the analyzed segments was related to food quality issues, while for consumers, food quality issues and health and safety issues had similar elasticity values. Besides, the lowest elasticity value for producers was related to animal welfare issues.

Table 7. Elasticity values of the level of acceptance for the inclusion of additional issues apart from environmental ones on a hypothetical EU ecolabel for fishery and aquaculture products (FAPs). Total, governmental intervention and stakeholders segments of analysis.

Attributes	Total	Governmental Intervention Segments				Stakeholders' Segments			
		Gov. Interv. No	Gov. Interv. Do Not Know	Gov. Interv. Yes	Consumers	Ecolabel Owners	Producers	Retailers or Suppliers	Gov./Public/Research
Social and ethical issues apart from environmental issues	0.5139	0.6560	0.6031	0.4709	0.4912	1.4776	0.4550	0.5448	0.5547
Food quality issues apart from environmental issues	0.4639	0.4947	0.4812	0.4530	0.4533	0.1312	0.4761	0.4609	0.4540
Health and safety issues apart from environmental issues	0.4689	0.5419	0.5047	0.4509	0.4532	0.6309	0.4687	0.4696	0.4716
Animal welfare issues apart from environmental issues	0.4905	0.6446	0.5271	0.4601	0.4770	0.7664	0.4446	0.5303	0.5109

Source: Own elaboration.

6. Discussion

The main outcome of the investigation is that the majority of all the analyzed segments consider that FAP ecolabels in the EU should not only include environmental issues, but also other types of information. For the majority of the segments of analysis considered, the highest valued issue different from the environmental type was social and ethical issues. The result contrasts with those obtained from an extensive review of fisheries/aquaculture ecolabel schemes which found that only a small number deal directly with social issues, and even those schemes that include this type of information with some policy statements and general principles which mention social issues unanimously give far more emphasis to the environmental issues [58]. In fact, for example, the MSC ecolabel, which covers about 10% of total seafood catch globally [23], strongly emphasizes environmental information over social issues. In addition, another investigation contends that although it has been widely accepted since the 1990s, sustainability is based on three pillars (economic, environmental and social); in reality, the economic and environmental aspects have tended to dominate the sustainable agenda and social aspects have been neglected [59].

Furthermore, progress in the ethics of seafood can be accomplished through government regulations and the participation and cooperation of the seafood industry and civil society in establishing acceptable ethical standards and performance benchmarks [30]. Furthermore, ethical concerns for people, fish and the environment should be addressed along the entire supply chain of seafood goods, considering that focusing only on growing seafood production systems to tackle global food security could miss food ethics concerns in parts of the logistics chain [30].

Moreover, we also found that for the majority of the segments of analysis considered, the second-highest valued issue other than the environmental type was animal welfare issues. The progress of animal welfare for fish can be accomplished by adopting the five freedoms that should be respected by those who manage farm animals in order to promote animal welfare and to avoid animal suffering [60]. The five freedoms consist of freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury and disease, freedom to express normal behavior and freedom from fear and distress. Furthermore, an investigation found that according to the opinion of different stakeholders, the most relevant elements that influence fish welfare are ensuring a good physiological condition and good feed quality [61]. These two elements facilitate routine monitoring and a safe stock density and are more relevant than other aspects such as husbandry practices, quality of water and quality of the rearing environment.

Considering the preferences of consumers, which is the largest sample considered in the survey, our findings of the higher importance of social and ethical issues and animal welfare issues in comparison to health and safety and food quality issues is contrary to the findings of a study in the analysis of the importance of different food shopping criteria in Sheffield, England [62]. The authors found that attributes related to food quality and safety were valued higher than animal welfare and fair trade (ethical issue). However, these comparisons should be done carefully, as it should be noted that our study considers a wider sample of countries apart from England and, most importantly, that the other study focused on general food shopping and not on a specific type of products such as FAPs.

Along the same line, our finding that, for consumers, animal welfare issues are more important than health and safety issues contradicts the results of a systematic literature review of studies assessing food label preferences or choices within the context of sustainable diets for diverse food products that include seafood, which found that nutrition-related attributes are preferred to social responsibility attributes related mainly to animal welfare [63].

Furthermore, it was found that the only group that evidenced a different ranking of the issues in comparison to the total sample was the producers, whose elasticity values indicated that health and safety and food quality issues were the most relevant. The stakeholders' differentiation in the importance of the issues to be included in the EU ecolabels for FAPs indicates that there is an important mismatch between the preferences of other stakeholders and producers that might end with sub-optimal eco-labeling if producers

decide to label FAPs or not according to their preferences. The reasons for that are clear, because if regulators decide, as expected, to place more emphasis on issues that were more important for most of the analyzed segments, especially listening to consumers' voices (social, ethical and animal welfare), this action could reduce the interests of producers to voluntarily adopt an ecolabel as their preferences are neglected or are less taken into account. Therefore, the proponents of the ecolabel must analyze why the producers give more importance to health and safety and food quality issues in order to propose actions and strategies that might not lead producers to lose interest in the ecolabel. More consensus is needed before a formal eco-labeling regulation can be established for FAPs in the EU.

Moreover, the results of the SIs evidence that amongst the different stakeholders, consumers and producers are the segments of analysis which have higher values. Thus, it indicates that these two groups of stakeholders accept most the inclusion of additional information on the EU ecolabels, apart from environmental issues. Similarly, results also show that SIs for the citizens who consider that ecolabels should be monitored through public bodies and the government (public intervention) are higher than for those who do not want or do not know if they want public intervention. The results suggest that governmental trust could be a driver to include additional information apart from environmental issues in the ecolabel, probably because citizens infer that ecolabels provide more credible information when they are controlled by the government instead of being a simple market mechanism transfer.

On the other hand, the low values of the SIs for those that consider that public bodies/governments should not be involved in the control of the ecolabel and, especially, for the ecolabels' owners indicate a low acceptance for the inclusion of other issues apart from environmental ones by them, which is aligned with the idea that these two groups might not be so proactive with the benefits of providing additional information apart from environmental issues. This may be due to several reasons: (1) they consider other issues that were not considered in the analysis to be more important, (2) the inclusion of the issues despite their importance might be non-appropriate for diverse reasons in certain contexts or particular products of FAPs. Furthermore, for the ecolabel owners' segment, apart from the mentioned reasons, it may be that they have given less importance to some of the issues because, as owners of ecolabels, they may judge issues more strictly based on their previous experience and consider that other aspects can be more important for ecolabels apart from the issues that they should consider—for example, the administrative steps needed to establish such a scheme.

Considering that it was found that the SI of ecolabel owners was elastic on social and ethical issues, ecolabel promoters should make efforts in convincing ecolabel owners about the benefits of including these issues in the ecolabel, considering that achieving this would increase their acceptance for the inclusion of additional information different from environmental issues.

Finally, it is important to consider that the study is not exempt from limitations which might represent risks in the interpretation of the results described previously and that should be considered for improvement in future studies. First, it should be noted that the data are based on a voluntary online questionnaire, which offers a lot less control over the conditions in which the respondents answer the questions. Furthermore, the survey design used for the questions does not allow to evaluate scenarios with different types of issues simultaneously as a discrete choice experiment would, which would allow reducing the risk of overrating some of the options presented. In addition, the differences in the magnitude of the sample size per type of stakeholder are considerable, with groups such as ecolabel owners just represented by 10 respondents, which represents a risk of over-interpreting results with such a small sample for these under-represented groups.

7. Conclusions

This study presents a hybrid fuzzy method that analyzes the coverage of a hypothetical EU ecolabel for fishery and aquaculture products (FAPs) by integrating a synthetic indicator

that allows for determining different segments of analysis, the level of acceptance for the inclusion of different types of information apart from environmental issues. The segments of analysis considered were selected according to the different stakeholder groups and whether the citizens do or do not agree with governmental eco-labeling control.

The results indicate that ecolabels should provide information not exclusively on environmental issues but also on other types of information, of which social and ethical issues are the most relevant, followed, in order, by animal welfare, health and safety and food quality issues. Almost all the segments of analysis equally ranked the issues, with the exception of producers. For this segment, it is more important to provide information on health and safety and food quality issues. Moreover, the findings show that consumers, producers and citizens who support the control of ecolabels by public bodies or governments have a higher level of acceptance to include other additional information apart from environmental issues. The results indicate that the synthetic indicator is mostly inelastic with respect to all the issues and segments of analysis, with the exception of the pair ecolabel owners and social and ethical issues. On the other hand, the lowest elasticity value was obtained on food quality issues for ecolabel owners.

The results of this investigation are based on the public consultation made in the European Union in which the respondents pointed out many concerns towards the proposition of a new EU ecolabel. These concerns should be further analyzed in future investigations that aim to guarantee the total success of a future EU ecolabel for FAPs. It is likely that the origin of these concerns is due to the existing eco-labeling systems in use in the EU.

One of these concerns was related to the confusion that the term ecolabel might bring, considering that according to regulation 834/2007, the abbreviation "eco" to food products relates to organic production in certain member states [64]. In addition to this, a lack of transparency in the market exists because consumers do not have enough knowledge about the term [65]. Another concern that was highlighted is that a future EU ecolabel for FAPs should be independently developed for different species of fishery and aquaculture products considering the extreme differences that can exist between them. Finally, the most important concern raised in the public consultation is that, as many citizens pointed out, there are already many ecolabels on the market and that they do not see any benefit in adding a new one given that it would create even more confusion for consumers, and therefore, they recommended, as a much better approach, to improve the existing regulations on the current eco-labeling schemes. On the other hand, curiously, other citizens expressed that it would be beneficial to add a label with EU standards that could help consumers to reduce their confusion and the lack of credibility of the current market ecolabels.

Li [66] analyzed the eco-labeling competition issue theoretically through a dynamic Bertrand duopoly in which two eco-labeling programs (sponsored by the industry or by an environmental NGO) compete strategically in setting the ecolabel features. The author found that competition between the programs may lead to the same high environmental benefits in comparison to when only the NGO program exists, and that competition may yield a higher social welfare.

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