Fishery and aquaculture products in the EU: an analysis of consumers' preferences, producers' risk management and stakeholders' labelling preferences

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Las Palmas de Gran Canaria
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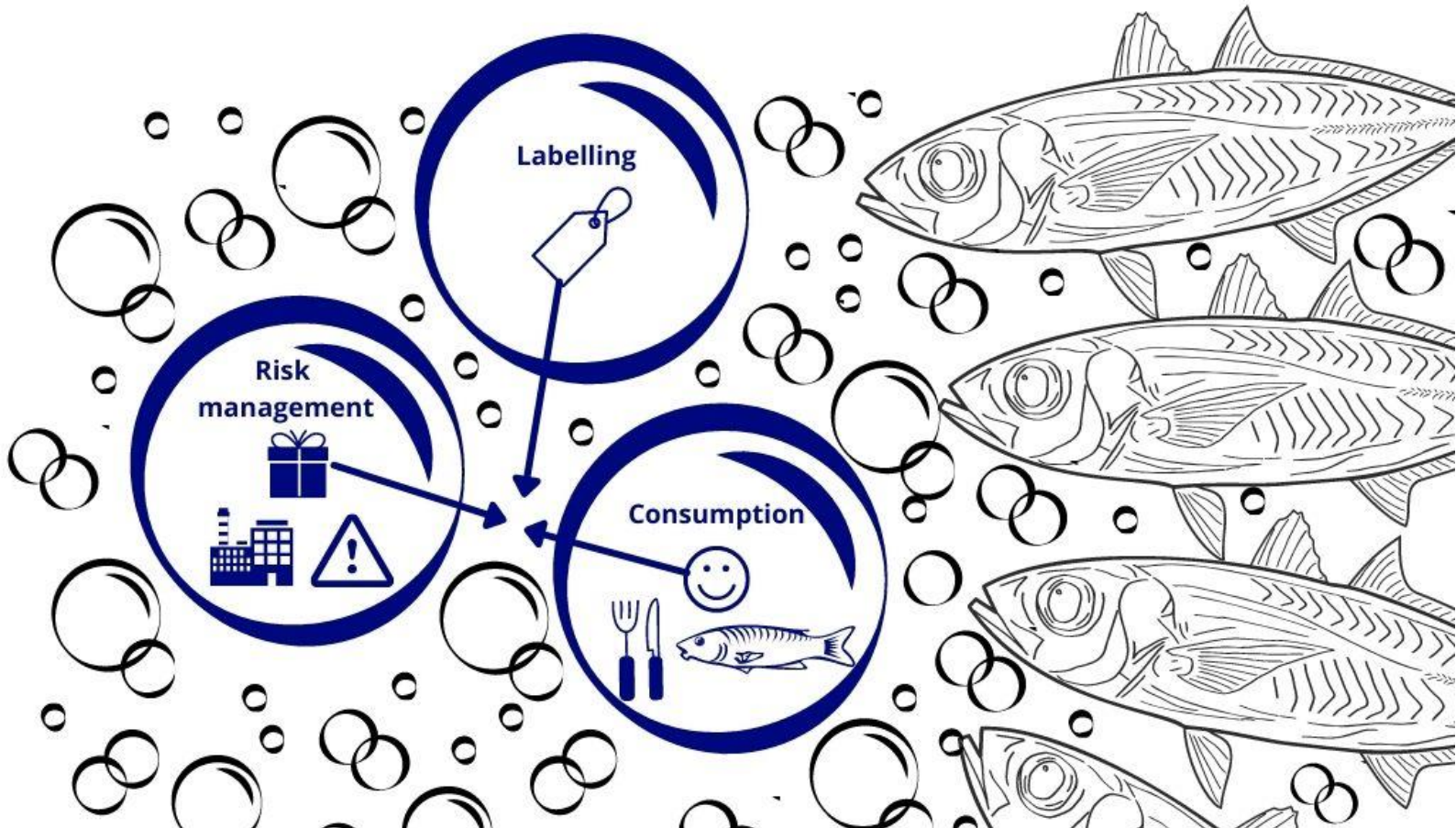

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“Put love into the things you do, and things will make sense. Withdraw love from them and they will become empty”

Saint Augustin

“Pon amor en las cosas que haces y las cosas tendrán sentido. Retírales el amor y se volverán vacías”

San Agustín

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Abstract thesis

Abstract thesis

Global fish consumption has increased remarkably over the last 60 years, from 9 kg/capita in 1961 to 20.5 kg/capita in 2018, more than doubling the annual average population growth over the same period (FAO, 2020a). The rise in consumption patterns can be attributed to several factors, the most notable of which is the significant increase in aquaculture production. During the last 40 years, aquaculture annual productivity has increased from around 10 million to 82 million tonnes, while fisheries production has remained stable at around 87 million to 96 million tonnes (FAO, 2020a). In fact, aquaculture is considered the fastest-growing food production technology and has surpassed wild catch as a source of seafood (Bronnmann and Asche, 2017). Nonetheless, modern aquaculture is one of the riskiest businesses to venture as an entrepreneur, farmer, or investor (Asche et al., 2008).

According to the FAO (2020a), global fish production in 2018 was around 179 million tonnes, with aquaculture accounting for 82 million tonnes. In terms of regions, the European Union (EU) is the world's largest market in nominal terms for fishery and aquaculture products (FAPs), which is not surprising due to the benefits of fish consumption, which is not only a source of protein and healthy fats but also an exceptional source of nutrients, fatty acids, iodine, vitamin D, and calcium (FAO, 2020b). Considering the previous, a better understanding of the internal market for FAPs will allow stakeholders, based on consumer demand, to improve their competitiveness and to adopt or modify their current strategies to strengthen and expand the internal market, thereby promoting job creation (European Union, 2018a).

Given the importance of FAPs, the present study aims to: (1) analyse the main determinants that explain the frequency of consumption of FAPs by European residents at home and away from home (Chapter I – Sections 1 and 2); (2) measure the level of importance and satisfaction of certain consumer attitudes toward the purchase of seabream and seabass in Gran Canaria – Spain- (Chapter I – Section 3); (3) comprehend the key insights into aquaculture companies' risk attitudes, identify the most significant risk sources and risk management strategies, and determine whether risk management and risk preferences differ between full-cycle and grow-out aquaculture companies (Chapter II – Section 4); (4) determine how aquaculture company managers can assess the most important risk sources using Simons' levers of control framework (Chapter II – Section 5); (5) analyse the scale related to the mandatory labelling information of FAPs proposed by EU regulation 1379/2013 (Chapter III – Section 6); and (6) comprehend different group segments' acceptance of a hypothetical EU ecolabel that includes other information apart from environmental issues -animal welfare, health and safety, food quality, and social-ethical issues- (Chapter III – Section 7).

Concerning the determinants, preferences, and attitudes of consumers toward the consumption of FAPs (Chapter I), the main determinants of FAPs consumption frequency at home and away from home were identified using ordered probit models. The results for at-home consumption (Chapter I – Section 1) show that the highest probability to consume more frequently FAPs are associated with consumers who believe that one of the main reasons for purchasing or eating FAPs is that they are healthy, whereas the highest probability of

consuming less frequently FAPs is related to consumers who do not understand any of the information accompanying the products. Similarly, the good taste and low relative price of FAPs are important reasons for increasing their consumption. Furthermore, results show that consumers who are over 55 years old, wealthy, prefer wild products, live in a household of three or more people, and are very satisfied with their lives consume FAPs at a higher frequency. In contrast, when it comes to consumption away from home (Chapter I – Section 2), we found that those in the upper classes of society are more likely to consume FAPs away from home more frequently. Furthermore, the main reasons for eating FAPs more frequently away from home are that they are less expensive than other foods, taste good, and are healthy and easy to digest. Moreover, British consumers are more likely than other nationalities to consume FAPs away from home. It was also found that consumers between the ages of 25 and 54 who do not live in rural areas, prefer wild-caught, local, and marine products, and are very satisfied with their lives have a higher frequency of away-from-home consumption of FAPs.

To better understand consumers' attitudes toward the consumption of seabream and seabass products in Gran Canaria (Chapter I – Section 3), we used two methodologies (traditional Likert-scales and best-worst scaling). According to the findings, the most important attributes identified were the product's hygiene and safety, health benefits, freshness, taste, and nutrients. At the same time, these attributes were ranked as the most satisfying to customers. Also, we noticed that the BWS methodology produces more consistent and clear results than traditional Likert-scale experiments.

In Chapter II, which is about risk management in European aquaculture companies, we used a mixed-methods approach to examine European aquaculture companies' perceptions of risk sources and risk management practices (Chapter II- Section 4). The findings show that diseases are the most important type of risk for both full-cycle and grow-out companies; however, there are still differences in the magnitudes and orderings of the ratings for the various types of risks between the two types of companies. Similarly, the results show that the ratings of risk management practices differ depending on the type of company. The findings also reveal that full-cycle companies are more willing to take risks than grow-out companies, although both types of companies perceive aquaculture as a risky business.

Using Simons' (1995) Levers of Control (LOC) framework, we developed a practical approach aimed at aquaculture production managers to improve their management of the most significant risk sources identified (Chapter II – Section 5). The results indicate that for full-cycle companies, the risks of fish price variability and the price of feed could be respectively mitigated and avoided using beliefs and boundary control systems, while the risk of fingerlings infected by diseases could be avoided using boundary control systems. Meanwhile, for grow-out companies, on the other hand, the risks of technical failure, high death rate due to diseases, inability to control diseases from environmental sources, bad weather and injuries or health problems among employees could be avoided using boundary control systems, whereas the risks of sufficient supply of competent labour and fish price variability could be avoided using beliefs control systems. The remaining risks for both types of companies should be either accepted and monitored using interactive controls systems or transferred to a third party.

Regarding the labelling preferences for FAPs in the EU (Chapter III), two critical issues (the interrelationship of the criteria as well as the relationship that exists at the country level) were assessed using a method based on a modified Consistent Fuzzy Preference Relation (CFPR) that employs the Geometric Bonferroni Mean (GBM) operator (Chapter III – Section 6). The findings indicate that not all EU countries are homogeneous, implying that the subsidiarity principle may have been applicable.

Moreover, in Section 7 of Chapter IIII, a hybrid-fuzzy TOPSIS method (FTOPSIS) is proposed to evaluate the coverage of a hypothetical EU ecolabel for FAPs (FAPs). According to the findings, ecolabels should include not only environmental issues, but also other types of information, with social and ethical issues being the most important, followed by animal welfare issues, health and safety issues, and lastly food quality issues. The findings also show that consumers, producers, and stakeholders who are more interventionists, defined as those who believe that public bodies and the government should be involved in the control of eco-labelling, are more willing to include additional information other than environmental issues.

Furthermore, various managerial implications were proposed based on the findings. Regarding the implications aimed at improving FAPs' market based on consumer preferences, we found that some aspects that may increase FAPs' consumption at home include making the information accompanying them clearer with special emphasis on their healthiness, fair cost, tastiness, and digestibility. Also, quick and easy-to-prepare FAPs may be a suitable alternative for increasing consumption at home, as well as improving the product's appearance. Finally, it was found that the FAPs industry must provide appealing products for younger generations to increase their consumption at home.

Concerning the implications of the findings for the away-from-home consumption of FAPs in Europe, the empirical evidence showed that to increase it, stakeholders should look for strategies to attract older customers and provide healthier recipes and dishes.

In terms of policies aimed at improving the aquaculture market and industry in Europe, it was found that authorities and stakeholders should invest in marketing campaigns to help change the current negative image of aquaculture products. Similarly, to improve risk management, the government and aquaculture institutions should increase their efforts in developing strategies to reduce the risk of diseases, which are particularly relevant to the aquaculture industry. In addition, aquaculture companies should be able to anticipate how to respond to large price fluctuations by using methodologies such as simulations and discrete choice models based on collected data. The results should allow them to define strategies in the face of changing market conditions. In addition, the LOC framework (Simons, 1994) can be used to assist managers in assessing the companies' risk management.

For the specific case of seabream and seabass products in Gran Canaria, the industries involved should look for ways to improve the hygiene and food safety of the products to increase consumer satisfaction and, as a result, increase customers' WTP and frequency of consumption. Similarly, producers are encouraged to invest in the development of fortified nutrient-rich products. Furthermore, stakeholders and authorities should invest in marketing campaigns

highlighting the health benefits of eating seabream and seabass, novel recipes for cooking seafood that enhance the flavour of the products, and how to evaluate the freshness of fish products.

Regarding the results of the labelling preferences for the mandatory information accompanying FAPs, we found that the "name of the product and species" and the "best before" should be highlighted above all else; whereas authorities should make more efforts to educate consumers about the importance of the fishing gear in fisheries products. More importantly, it may be necessary to evaluate the future mandatory information scale ex-ante to determine whether some countries exhibit significant differences so that the regulation can be adapted specifically for these cases through to the principle of subsidiarity.

To conclude, we found that, in addition to environmental information, a union-wide EU ecolabel for FAPs should include, in the following order of importance: social and ethical issues, animal welfare issues, health and safety issues, and food quality issues. Also, eco-label promoters of the union-wide EU ecolabel for FAPs should make efforts to persuade eco-label owners, in particular, of the benefits of including social and ethical issues in the ecolabel. Furthermore, proponents of the union-wide eco-label must investigate why producers ranked the issues differently than the overall sample to propose actions and strategies that will not cause producers to lose interest in eco-label.

List of abbreviations

BWS	Best worst
CFPR	Consistent Fuzzy Preference Relation
DMs	Decision makers
EU	European Union
FAPs	Fishery and Aquaculture products
FPR	Fuzzy Preference Relation
GBM	Geometric Bonferroni Mean
LOC	Levers of Control
MCDM	Multi-Criteria Decision Marking
RAS	Recirculating Aquaculture System
RUT	Random utility theory
SIs	Synthetic indicators

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Introduction

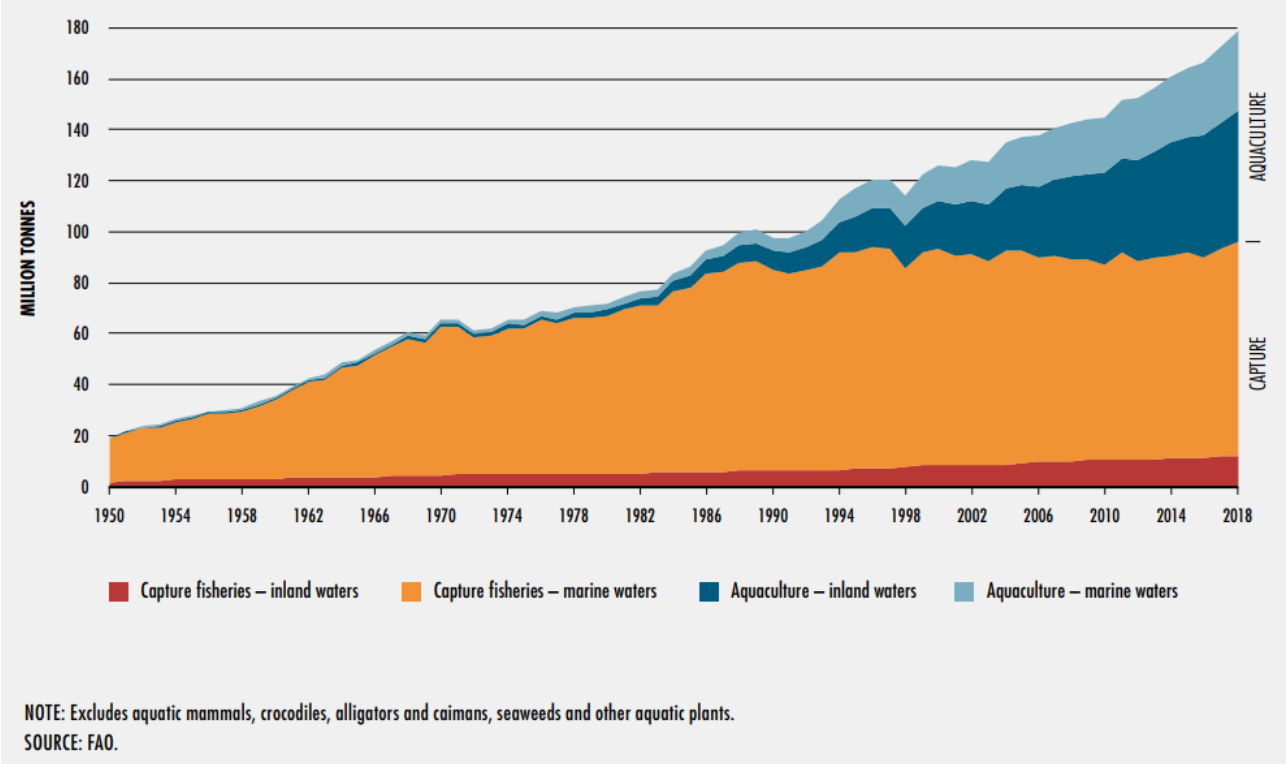
a Context and concepts

a.1 The evolution of fishery and aquaculture production

In the past 60 years, global fish consumption has increased impressively from 9 kg/capita in 1961 to 20.5 kg/capita in 2018, doubling the annual average population growth over the same period (FAO, 2020a). The increase in the pattern of consumption is linked to various factors, but the significant growth of fish production and in particular the growth in aquaculture production are highlighted among them. Aquaculture has indeed increased its production level from around 10 million to 82 million tons per year during the last 40 years, whereas fisheries production has remained stable from around 87 million to 96 million tonnes (FAO, 2020a).

The FAO (2020a) estimates that global production of fish was around 179 million tonnes in 2018 (Figure 0.1), of which 82 million tons come from aquaculture production. In total, 156 million tons of the global production of fish were associated with human consumption, representing an estimated annual supply of 20.5 kilograms per capita. The other 22 million tonnes were destined mainly to produce fish and fish oil. Aquaculture represented 46% of the total production of fish and 52% of fish for human consumption.

Figure 0.1. World capture fisheries and aquaculture production

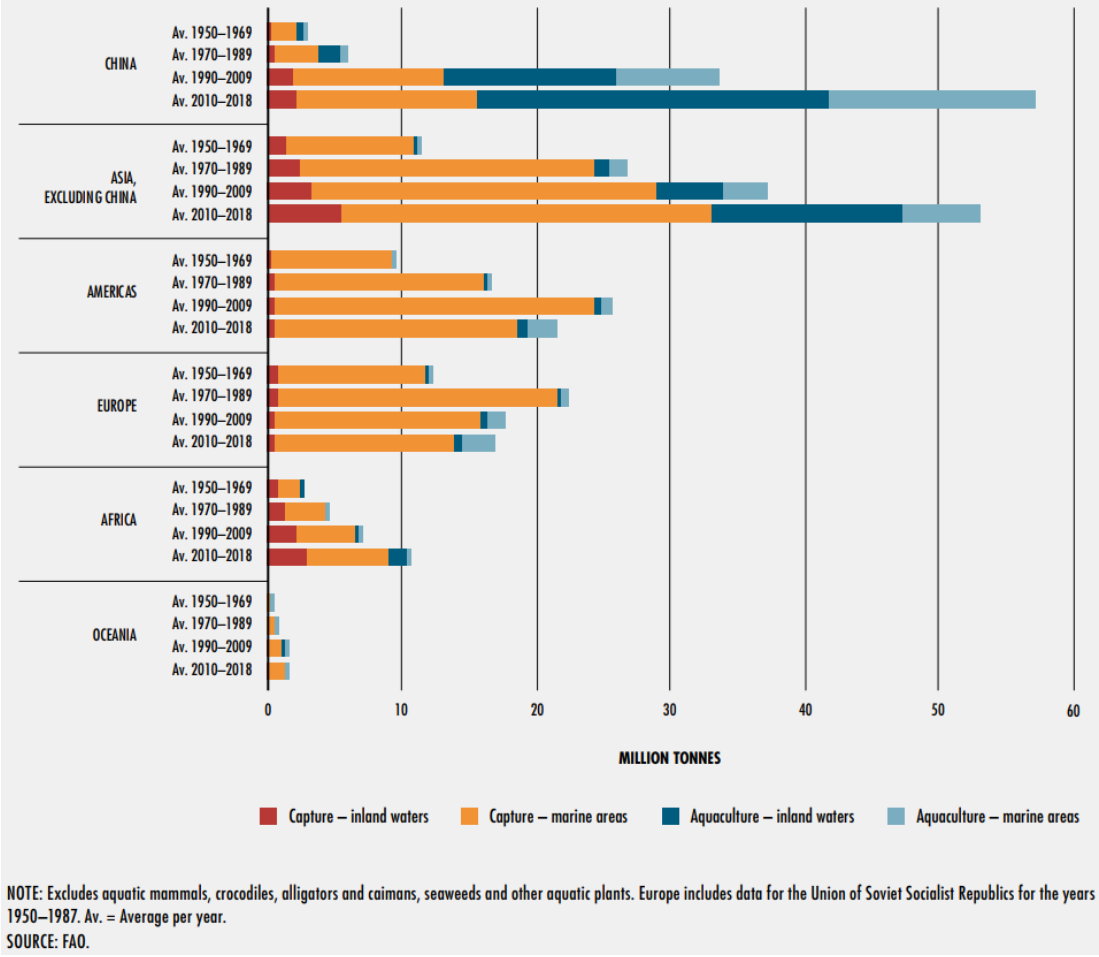


Source: FAO (2020a)

As seen in Figure 0.2, China is the major fish producer representing 35 per cent of world fish production in 2018 (FAO, 2020a). Beyond China, Asia (34%), the Americas (14%), Europe (10%), Africa (7%) and Oceania (1%) accounted for significant production share in 2018. Moreover, in the last couple of decades, the overall production of fish has seen substantial increases across all continents except for Europe (with a gradual decline in the late 1980s, but slightly recovering over recent years) and America (which has experienced several ups and downs since peaks of

the late 1990s, primarily due to fluctuations in anchoveta catch), whereas in Africa and Asia the production has almost doubled over the past 20 years (FAO, 2020a).

Figure 0.2. Regional contribution to world fisheries and aquaculture production



Source: FAO (2020a)

In addition, consumption patterns differed among regions as the consumption of fish depends on economic, cultural, and geographical factors. Therefore, while developing countries have increased between 1961 to 2017 from 6 to 24.4 kg/capita, the low-income countries only increased from 3.4 to 9.3 kg/capita during the same period (FAO, 2020a). Among regions, Asia is at the top of fish consumption with 108.7 million tonnes consumed (out of the global 152.9 total) and one of the highest per capita fish consumptions next to Oceania, whereas China itself consumes around 55,2 million tonnes of fish and consumes about 40 kg/capita on average.

Consumption growth in Asian countries (particularly China), can be related to the increase of population, increase in fish aquaculture, increased revenues and an increase in global trade in fish, whereas low consumption in certain countries and regions is predominantly based on restrictions on fish production (low technology and infrastructure), low revenue and poor marketing (FAO, 2020a). In contrast, Africa and Latin America consume around 10 kg per capita having the lowest per capita consumption; while Europe consumes about 16.1 million tons of fish and has an average consumption of approximately 21.6 kg/capita (FAO, 2020a).

a.2 Seabream and Seabass species in Spanish aquaculture

The European Union is the leading trader in nominal terms of fishery and aquaculture products (FAPs) (FAO, 2020c). Moreover, amongst EU countries, Spain occupies the third place in terms of per capita consumption and money-spending on FAPs. Also, it is by far the leading supplier of farmed species in the EU (EUMOFA, 2020). Spain is also the fourth largest country in the world in terms of total seabream and seabass production, which respectively, are the second and third largest Mediterranean aquaculture species production below trout (FEAP, 2020).

Specifically, the Canary Islands are the third-largest Spanish region in farmed fish species, accounting for 25% of seabass and 15% of seabream of the total national production (APROMAR, 2019). However, the average intake of fish is lower than the national average (Rodríguez Feijoo et al., 2018). Therefore, one aspect that is important to understand, is why such relevance in terms of production is not in line with consumption, given the significant impact on the Canary Islands on seabream and seabass production. Also, it is important to analyse consumer preferences and attitudes towards these products in order to facilitate the implementation of strategies that may increase consumption for these two species. Furthermore, a better understanding of the internal market for FAPs will allow stakeholders, based on consumer demand, to improve their competitiveness and to adopt or alter their current strategies to strengthen and expand the internal market, promoting job creation (European Union, 2018a). In addition, all these analyses in the context of the Canary Islands might serve as a starting point for analysing similar situations in other contexts.

Figure 0.3. Seabream (*Sparus Aurata*)

Source: (FAO, 2021a)

Figure 0.4. Seabass (*Dicentrarchus labrax*)

Source: (FAO, 2021b)

a.3 Consumers' preferences for fish products

a.3.1 Origin

In many studies, the origin is highlighted as the most important attribute for the decision to purchase finfish (Banovic et al., 2019; Lim et al., 2018; Mauracher et al., 2013; McClenachan et al., 2016; Miyata and Wakamatsu, 2018; Risius et al., 2019; Stefani et al., 2012; Thong et al., 2018; Wakamatsu and Miyata, 2017). The general pattern indicates that local products are the preferred choice (Ankamah-Yeboah et al., 2019, 2018; Ariji, 2010; Banovic et al., 2019; Davidson et al., 2012; Fernández-Polanco et al., 2013; Hinkes and Schulze-Ehlers, 2018; Jaffry et al., 2004; Lim et al., 2018; Mauracher et al., 2013; McClenachan et al., 2016; Risius et al., 2019, 2017; Rudd et al., 2011; Stefani et al., 2012; Thong et al., 2018, 2015; Uchida et al., 2014; van Osch et al., 2019, 2017; Witkin et al., 2015; Yip et al., 2017; Zander et al., 2018), which might be because of reasons like more confidence in local products, or for the ethnocentric nature of the consumers (Luomala, 2007; Verlegh and Steenkamp, 1999). Local products are also preferred in Germany because of food safety and health concerns (Hinkes and Schulze-Ehlers, 2018).

a.3.2 Production process

Production preferences are evidenced in the studies through attributes such as the harvesting method, production method, feed type and production practices. Regarding the harvest method, consumers usually prefer wild fish rather than farmed fish (Ariji, 2010; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Darko et al., 2016; Davidson et al., 2012; Fernández-Polanco et al., 2013; Ferrer Llagostera et al., 2019; Roheim et al., 2012; Thong et al., 2015; Uchida et al., 2014; Thong et al., 2018; Chen et al., 2015; Jaffry et al., 2004; Yip et al., 2017). This preference might be due to the fact that consumers usually describe farmed fish as less healthy and with lower quality than wild fish (Claret et al., 2014; Verbeke et al., 2007a). Also, the relatively lower costs, a feeling of artificial product and a lack of awareness on sustainable farming practices are key elements that have conditioned the image and acceptance of aquaculture fish (Altintzoglou et al., 2010; Claret et al., 2014; Vanhonacker et al., 2011). In addition, Darko et al. (2016) and Davidson et al. (2012) found that preferences for wild species relate more to issues such as availability and taste, whereas Schlag and Ystgaard (2013) concluded that it was due to non-scientific qualitative concerns such as a lack of confidence in farmed products that they were not seen as natural and familiar. Finally, Bronnmann and Asche (2017) found that sustainability issues were more important than quality issues if the preferences of wild and farmed fish were evaluated.

Numerous studies have examined the preference for alternative production methods. Some of them indicate that there is a preference for organic production (Ankamah-Yeboah et al., 2019; Mauracher et al., 2013; Olesen et al., 2010, 2006; Stefani et al., 2012). Ankamah-Yeboah et al. (2018) found that trout consumers in Germany favour a production method in accordance with the Aquaculture Steward Council (ASC) procedures. Moreover, Yip et al. (2017) found a preference for salmon produced using integrated multitrophic aquaculture (IMTA) and closed-containment aquaculture (CCA).

Concerning the type of feed, Stefani et al. (2012), Davidson et al. (2012) and Ankamah-Yeboah et al. (2018) have determined that purchase choices in Italy for seabream, Tuna in the US and Trout in Germany are not greatly affected by the type of feed used. It can therefore be concluded that other feed sources, such as insect protein or vegetables, can be utilized if cost reduction can be achieved with them. Finally, for production practices, Rudd et al. (2011) identified production preferences for Salmon in Canada with low pollution levels and low local and global environmental impacts.

a.3.3 Certifications

The literature presents two different ways in which the impact of certification labels is incorporated. The first is to specify a range of recognized labels that are generally managed by international or national agencies, while the second is to specify only whether or not the product has been certified or labelled.

Various studies show that products with certified labels are preferred over products without labels (Banovic et al., 2019; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Chen et al., 2015; Hinkes and Schulze-Ehlers, 2018; Jaffry et al., 2004; Lim et al., 2018; McClenachan et al., 2016; Miyata and Wakamatsu, 2018; Risius et al., 2019, 2017; Wakamatsu and Miyata, 2017; Zander et al., 2018). On the one hand, for farmed species, certain studies highlight the preferences of the certification label issued exclusively for aquaculture products by the Aquaculture Stewardship Council (ASC) (Banovic et al., 2019; Bronnmann and Hoffmann, 2018; Risius et al., 2019). On the other hand, for wild products, the Marine Stewardship Council (MSC) is notoriously preferred by consumers (Bronnmann and Asche, 2017; Lim et al., 2018; McClenachan et al., 2016; Miyata and Wakamatsu, 2018; Wakamatsu and Miyata, 2017).

Further, in the studies of Hinkes and Schulze-Ehlers (2018), Risius et al. (2017) and Zander et al. (2018), the Naturland certification label, applicable to both organic aquaculture and sustainable fishery, was the preferred option. Also, the French Agriculture Biologique (AB) label for French farmed products (Chen et al., 2015) and sustainably managed fishery were other certification labels that were preferred by consumers (Jaffry et al., 2004).

Moreover, when the certification is given as a yes/no option, consumers prefer labelled/certified products against non-labelled/uncertified products (Ariji, 2010; Johnston et al., 2008; Uchida et al., 2014; Yip et al., 2017).

a.3.4 Labels and claims

Labels and claims are used primarily to provide consumers with additional product details. Sustainability, health and nutritional benefits, safety and fair-trade labels/claims are the most used in the literature. In a study of Salmon and Seabream analysed in various EU countries (Ireland, the UK, Italy, Israel and Norway), Van Osch et al. (2019, 2017) noted that consumers were willing to pay premiums for sustainable products that incorporate an ecolabel that takes into consideration various levels of sustainability. In addition, Risius et al. (2019, 2017) and Zander et al. (2018) observed that products with claims indicating sustainable production or farmed in natural ponds were preferred over those without this claim.

Banovic et al. (2019) found that preference for nutritional and health claims vary across products and countries, with nutritional claims being considered more important. In particular, there is a strong preference for nutritional claims that emphasize a high omega 3 content as opposed to those products which do not include any information or that specify a low omega 3 content (Banovic et al., 2019; Bi et al., 2016; Fernández-Polanco et al., 2013; Rudd et al., 2011). Likewise, Rudd et al. (2011), on the other hand, found that there is a stronger preference for claims that emphasize health benefits over those that highlight production practices that improve environmental performance. For health claims, the preferences were higher for those that highlight an improvement of the heart function than those showing the benefits for brain function (Banovic et al., 2019). Lastly, for canned Tuna study in the US, Lim et al. (2018) showed that health labels (enhancing the cardiac function) have a higher preference over than safety labels (Bisphenol-A (BPA) free label).

Moreover, various studies show that consumers are willing to pay premiums for safety claims such as Anisakis free (Fernández-Polanco et al., 2013) and "Meets United States Food and Drug Administration (USFDA) Safety Guidelines" (Fonner and Sylvia, 2015). Likewise, a generic fair-trade claim also showed a positive preference over no inclusion (Hinkes and Schulze-Ehlers, 2018; McClenachan et al., 2016).

a.3.5 Product presentation

As regards the processing or storage form of the products, fresh products are usually preferred over frozen, smoked, dried or fried presentations (Ankamah-Yeboah et al., 2019, 2018; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Darko et al., 2016; Davidson et al., 2012). Furthermore, while the product form is mainly dependent on the species, some studies show that fillet presentation (Ankamah-Yeboah et al., 2019, 2018; Thong et al., 2015) and with no bones (Ankamah-Yeboah et al., 2019, 2018) are preferable. Furthermore, in the case of Tilapia in Tanzania (Darko et al., 2016) and seabass in Italy (Mauracher et al., 2013), the preference of consumers is for larger fish. Moreover, for the specific case of farmed salmon, the redder alternatives (especially the colour R27 from the SalmoFan scale) were preferred (Alfnes et al., 2006; Olesen et al., 2010, 2006; Steine et al., 2005). Regarding the presentation of the package, Heide and Olsen (2017) identified for cod consumers' in Norway, a preference for a black colour package is preferable over a silver package as well as a skin shape package rather than a modified atmospheric packaging (MAP) or vacuum package.

a.4 Factors affecting the frequency of consumption of fishery and aquaculture products

A wide number of studies evaluate fish and seafood consumption. Carlucci et al. (2015), claim that sensory drivers (tastes, smell and texture of fish), perceived benefits to health, and fish-eating habits are the main drivers of fish consumption, whilst the principal obstacles are sensory dislike of fish, health risk concerns, high-cost perception, lack of convenience, lack of availability of preferred products, and lack of knowledge to select and prepare the fish. In addition, Olsen (2004) argues that seafood consumption varies significantly among individuals, families, cultures, and countries. Similarly, the consumed species can be linked to cultural traditions which also change over time (Apostolidis and Stergiou, 2012).

Moreover, economic, demographic and attitudinal variables characterize the factors affecting the frequency of seafood consumption (Herrmann et al., 1994). For economic and demographic factors, most studies suggest that women (Can et al., 2015; Cavaliere et al., 2019; Thong and Solgaard, 2017), older people (Herrmann et al., 1994; Murray et al., 2017; Myrland et al., 2000; Thong and Solgaard, 2017), people with higher education (Can et al., 2015; Cavaliere et al., 2019; Islam et al., 2018; Myrland et al., 2000), higher incomes and class of society (Can et al., 2015; Cavaliere et al., 2019; Herrmann et al., 1994; Lee and Nam, 2019; Thong and Solgaard, 2017; Yousuf et al., 2019) and married or living with a partner (Cavaliere et al., 2019; Kumar et al., 2008; Thong and Solgaard, 2017) tend to have a higher frequency of consumption of seafood products. However, the literature's findings do not offer solid and clear tendencies for these factors, as results may vary according to the characteristics of the samples, the species studied, and the methodology used for the surveys.

On the other hand, factors associated with individual conditions or attitudes towards the attributes of seafood products show a more general frequency pattern. The positive drivers to a higher frequency of consumption are having a positive attitude towards seafood (Kumar et al., 2008; Lee and Nam, 2019), considering important the low calories and low fat of the products (Thong and Solgaard, 2017), care about health issues of the products (Can et al., 2015; Murray et al., 2017; Thong and Solgaard, 2017), preferring fresh products (Almendarez-Hernández et al., 2017; Can et al., 2015; Kumar et al., 2008; Yousuf et al., 2019) and caring about eco-labels and environmental issues (Almendarez-Hernández et al., 2017). Meanwhile, certain attitudes that favour a lower frequency of consumption of seafood products are: being uncomfortable cooking or preparing seafood (Murray et al., 2017; Thong and Solgaard, 2017); not purchasing wild seafood (Murray et al., 2017); or finding the products with higher prices (Hall and Amberg, 2013; Lee and Nam, 2019; Thong and Solgaard, 2017).

In addition, the trends for factors associated with familiarity, health and sensory characteristics depend on the species being studied. For familiarity, Hall and Amberg (2013) found that consumers familiar with aquaculture products tend to eat them more often, whereas Thong and Solgaard (2017) found different results for shrimp and mussels. In the context of health attributes, most studies state that those who care about food-related health issues, consume them more regularly. Moreover, Seafood products are generally considered healthy, although there were opposite results for the case of oysters (Santeramo et al., 2017).

Additional factors are related to the consumers' lifestyle. Consumers have been more likely to eat seafood products when they are used to consume seafood products (Yousuf et al., 2019); consumed seafood often at a young age (Murray et al., 2017); perform physical activity regularly (Myrland et al., 2000); and engage in fishing activities (Herrmann et al., 1994). In addition, Maciel et al. (2016, 2019) found that those who eat fish often have a better quality of life perception and are more active and healthier physically.

Moreover, the profession or occupation (Almendarez-Hernández et al., 2017; Can et al., 2015; Herrmann et al., 1994; Lee and Nam, 2019) living location (Herrmann et al., 1994; Islam et al., 2018; Lee and Nam, 2019; Myrland et al., 2000; Thong and Solgaard, 2017), preferred species (Lee and Nam, 2019), nationality (Yousuf et al., 2019), seasonal period (Can et al., 2015), and ethnical group, product origin, packaging presentation and type of stores (Kumar et al., 2008) were other factors analysed, that were found to influence the consumption frequency of seafood products.

a.4.1 Frequency of consumption at home vs Frequency of consumption away from home

Previous literature shows that the main factors affecting home consumption and away-from-home consumption of FAPs consumption are different (Almeida et al., 2015; Herrmann et al., 1994). The frequency of consumption at home was considerably higher than the frequency of consumption away from home in the study of Almeida et al. (2015). Nevertheless, In recent decades, demand for away-from-home food has risen, especially in developed countries, due to various aspects, such as increased income (Binkley, 2006; Gäl et al., 2007; Ham et al., 2004; Ma et al., 2006), increased search for comfort through time savings (Binkley, 2006; Gäl et al., 2007; Mutlu and Gracia, 2004). The increase in female employment has also promoted higher spending on leisure activities (Binkley, 2006; Gäl et al., 2007; Mutlu and Gracia, 2004). Furthermore, the growth of urban development gives families more access to restaurants that allow them to eat away from home more often (Ma et al., 2006; Mutlu and Gracia, 2004).

a.5 Labels in fishery and aquaculture products

Food labelling is an important feature to give consumers information about products on the market and to enhance their knowledge and interest in seafood and can have an important effect on food choice (Conte et al., 2014). Food labelling can be evaluated from two perspectives: (1) labels related to strict public laws that look to reduce consumers' asymmetrical information on the market (Caswell and Anders, 2011), and (2) third party or private own labels. Concerning the first type of labels, under the consumers' perspective, EU Regulation 1379/2013 aims to provide information for the consumer in FAPs. D'Amico et al. (2016) contend that the application of EU Regulation 1379/2013 is the result of three key pillars that support the Common Fisheries Policy foreseen in 1970, and reformed in 2013: traceability, sustainability, and the right of consumers to informed purchases. The mandatory information to be declared on FAPs can be found in Article 35 of the European Regulation 1379/2013, and it includes information of (1) the name for the species and its scientific name; (2) the production method, as e.g., "caught in freshwater" or "farmed"; (3) area of catching or farmed product, (4) the fishing gear category used, (5) whether it has been defrosted or not; and (6) the date of minimum durability.

With respect to third-party or private-own labels, independent experts are responsible for determining criteria and selecting the categories of the product. The information is made public and must be transparent and credible. Products that satisfy the criteria may, after payment and application costs, use the label or logo for a specified period.

a.6 The analysis of risks in aquaculture

The main findings on the preferences of aquaculture farmers for risk sources and risk management strategies are briefly presented below.

a.6.1 Risk sources

One of the key risk sources identified in the literature is the risk of disease or pathogens. Even an earlier study in shrimp farming has argued that disease outbreak mortality is the greatest threat that can be affronted (Ahsan, 2011). The literature also includes significant market risks in the aquaculture industry which affect the finances of the company such as a future variation in prices, uncertainty in the market (inaccessibility or demand) and price of quality inputs.

For the future price/price variation risk, some aquaculture companies have evidenced failed experiences due to reasons such as constant lower salmon prices (Bergfjord, 2009) and the fluctuating prices of tilapia and pangasius fish (Rahman et al., 2020). Likewise, export-oriented industries like the mussel industry in Denmark have been affected by price fluctuations in the Dutch market (Ahsan and Roth, 2010). Furthermore, in Vietnam, the catfish industry suffered price fluctuations, resulting in significant losses to farmers, particularly in 2008, when farmers had to sell their products at 10% to 15% lower than the cost of production (Le and Cheong, 2009).

With respect to the risk of market uncertainty (accessibility or demand), In Bangladesh, shrimp farmers have concerns about it being heavily influenced by conditions of major importers, such as the economy, trade policies, and consumer preferences (Ahsan, 2011). This risk was also an important issue for Catfish in Vietnam, where the product was over-supplied, which prevented catfish manufacturers from purchasing every catfish, causing a loss to producers who had to continue feeding the fish, resulting in oversized products with lower quality meats, leading to lower sale prices (Le and Cheong, 2010).

In countries like Bangladesh, private hatcheries, which are the main suppliers, are not regulated in seed prices, which facilitates them to arbitrarily raise their prices, which is a major constraint for the development of shrimp aquaculture (Ahsan, 2011). Moreover, the input prices for catfish farmers in Vietnam are imperfect in the pricing mechanism, causing them to vary often and causing farmers to experience uncontrolled situations (Le and Cheong, 2009).

For operational risk sources, such as the use of illegal chemicals and medications, some countries, especially those which are highly developed, are demanding strict and rigorous standards, including the zero-tolerance for residues of prohibited medicines and chemicals, which farms from less developed countries, such as Vietnamese manufacturers of catfish, cannot always fulfil and result in losses for them, taking into account that they are not able to access to these markets (Le and Cheong, 2010).

Moreover, in the aquaculture industry, there are environmental risks such as pollution, bio-physical shocks/extreme weather events and temperature rises or falls, and social risks such as changes in future regulations (Ahsan and Roth, 2010; Darby and Incedursun, 2019). Also, some risks affect the functioning of the organization such as farmers' health/disability, workers' safety (Le Bihan et al., 2013; Theodorou, 2015) and middlemen's exploitation (Ahsan, 2011).

a.6.2 Risk management strategies

The literature identifies important risk management strategies including the supply and selection of quality fingerlings and inputs, diseases and escapes prevention, lowest possible cost of production (ceteris paribus), selection of good quality/brand feed, and the maintenance of a well-managed water environment (Ahsan and Roth, 2010; Alam and Guttormsen, 2019; Bergfjord, 2009; Joffre et al., 2019, 2018; Le and Cheong, 2009; Lebel et al., 2015; Rahman et al., 2020; Theodorou, 2015).

Establishing good relations with other farms and authorities is another important strategy of risk management, which allows sharing experience and offer mutual support, since small producers usually only have practical experience, while authorities have technical knowledge that can be useful (Lebel et al., 2016).

The company's financial health is preserved through numerous risk management strategies. Insurance is one of them, mainly reducing production risks such as diseases, escapes, and environmental shocks (Bergfjord, 2009), but its effectiveness depends on the type and scope of coverage provided (Darby and Incedursun, 2019). Moreover, financial credit reserves and off-farm employment are two risk management strategies for small farmers (Theodorou, 2015).

Finally, other risk management strategies are linked to the optimisation of an enterprise's supply chain by eliminating the impact of intermediaries (Ahsan, 2011) and the optimisation of employees' work using techniques such as best management practices and training (Joffre et al., 2018).

a.7 The levers of control by Simons (1994)

According to Simons (1994), the four Levers of Control (LOC) used by managers to maintain or modify patterns in organisational activities are diagnostic control systems, beliefs systems, boundary systems and interactive control systems. Managers who effectively apply this framework can generate creativity without sacrificing control from their employees (Simons, 1995; Speklé et al., 2017). Along with Speklé et al. (2017), the LOC provide tools to (1) help employees identify problems and/or creative opportunities, (2) encourage people to act and (3) allow employees to be creative up to certain boundaries.

a.7.1 Beliefs and boundary systems

Boundary and belief systems create dynamic tension when acting together (Simons, 1995). Belief systems are positive and stimulating while boundary systems are constraints; the action of both enables guidance and inspiration to be established as well as the safety against potential hazardous opportunism. Belief systems are structured systems that facilitate the strengthening of fundamental beliefs and values of a company (Simons, 1994). They allow managers to guide employees in their business ideas' values and directions. They also encourage employees to consider new ways of adding value to the company (Simons, 1995). Some examples of beliefs controls are company value statements, mission, vision, and corporate credos (Sheehan, 2010). On the other hand, Boundary systems are formal systems that allow managers to set limits and rules to be followed by employees (Simons, 1994). The rules on using company property, rules on confidential information sharing and employee codes of conduct are examples of boundary control systems (Sheehan, 2010).

a.7.2 Diagnostic control systems

Diagnostic control systems are formal systems that allow managers to monitor employees' results and make corrections based on those results (Simons, 1994). These systems ensure that all personnel achieve their goals in a timely and effective way (Simons, 1995). Sheehan (2010) reports that diagnostic control systems support the actions of supervisors who set goals and targets for employees in various activities, by monitoring them, and rewarding them in case they have accomplished their task. Some examples of diagnostic control systems are balanced scorecards, budgets and cash forecasts (Sheehan, 2010).

a.7.3 Interactive control systems

Managers regularly use interactive control systems to participate in the decision-making activities of their employees (Simons, 1994). Interactive control systems differ in four ways from diagnostic control systems: (1) the focus is on potentially strategic information that is constantly changing; (2) data is relevant enough for organizational operating managers at all levels to require regular and frequent attention; (3) it is easier to discuss and manage data obtained in these systems at face-to-face meetings, and (4) serve as an incentive for on-going debate on underlying data, assumptions and action plans (Simons, 1995). Widener (2007) adds that companies use these systems when high strategic risks and uncertainty are faced. Furthermore, Bisbe and Otley (2004) and Simons (1991) found that in companies experiencing a variety of risks and uncertainties interactive systems were effective.

b Objectives of the thesis

The objectives related to the topic of the investigation are:

- Analyse the main determinants that explain the frequency of consumption at home and away-from-home of FAPs by European residents (Chapter I – Sections 1 and 2).
- Measure the level of importance and satisfaction of certain consumer attitudes towards the purchase of seabream and seabass in Gran Canaria (Chapter I – Section 3).
- Understand the main insights into aquaculture companies' risk preferences and identify the most important risk sources and risk management strategies (Chapter II – Section 4).
- Determine whether risk management and risk preferences differ between full-cycle and grow-out aquaculture companies (Chapter II – Section 4).
- Determine how managers of aquaculture companies can assess the most important risk sources using Simons' levers of control framework (Chapter II – Section 5).
- Analyse the scale related to the labelling mandatory information of FAPs proposed by the EU regulation 1379/2013 according to the preference values related to 27732 EU residents and dealing with two potential interactions at the level of criteria and respondents (Chapter III – Section 6).
- Understand the acceptance of different group segments for a hypothetical ecolabel for assessing FAPs that includes additional information apart from environmental issues (animal welfare, health and safety, food quality, and social-ethical issues) (Chapter III – Section 7).

The objectives associated with the methodologies used are:

- Evaluate alternative approaches to survey response mechanisms that can lead to more robust results, through the comparison of the results of the traditional widely-used Likert-scale responses, with that obtained from best-worse scaling (BWS) methods (Chapter I – Section 3).
- Provide a different perspective of the results in absolute terms of the BWS estimates and Likert-scale ratings, using a similar approach to the common Importance-Performance Analysis (IPA) (Martilla and James, 1977), replacing the performance dimension by the satisfaction dimension, naming this as an Importance-Satisfaction Analysis (ISA) (Chapter I – Section 3).
- Develop a method based on a CFPR that identifies the interrelationship among decision-making criteria and respondents, using the GBM operator (Chapter III – Section 6).
- Propose a methodology that jointly analyses the importance of including different types of information in a hypothetical eco-label for FAPs (Chapter III – Section 7).

c Hypotheses

In the present document the following hypotheses are assessed:

- H1a: There are differences in the frequency of consumption at home of FAPs according to demographic factors such as the country of residence, age, household size and place of living (urban or rural area).
- H1b: There are differences in the frequency of consumption at home of FAPs according to economic factors such as the class of society and the economic difficulties.
- H1c: There are differences in the frequency of consumption at home of FAPs according to attitudes towards the characteristics of the product such as the main reasons or aspects for consuming/buying them and the preference for wild-caught or farmed products.
- H1d: There are differences in the frequency of consumption at home of FAPs according to psychological factors related to living conditions and satisfaction.
- H1e: There are differences in the frequency of consumption at home of FAPs according to the easiness to understand the information accompanying the products.
- H2a: There are differences in the frequency of consumption away-from-home of FAPs according to sociodemographic factors such as the country of residence, age, household size and place of living (urban or rural area).
- H2b: There are differences in the frequency of consumption away-from-home of FAPs according to economic factors such as the class of society and the economic difficulties.
- H2c: There are differences in the frequency of consumption away-from-home of FAPs according to attitudes towards the characteristics of the product such as the main reasons for buying or eating them, the preference for wild-caught or farmed products and the origin of the product (local or not and from the sea or not).
- H2d: There are differences in the frequency of consumption away-from-home of FAPs according to psychological factors related to living conditions and satisfaction.
- H3a: There are differences in the measurement of attitudes towards the purchase of seabream and seabass in Gran Canaria by consumers according to their valuation of the level of importance and level of satisfaction for the attitudes.
- H3b: The results obtained from the best-worse scaling (BWS) methods are more robust than those obtained with the traditional widely-used Likert-scale responses.
- H4a: Risks sources are rated differently according to the type of aquaculture company (full-cycle and grow-out farms).
- H4b: Risks management strategies are rated differently according to the type of aquaculture company (full-cycle and grow-out farms).
- H4c: There are differences in the attitudes towards risks according to the type of aquaculture company (full-cycle and grow-out farms).
- H5: The levers of control framework is an appropriate tool to assist aquaculture managers in risk management assessment.
- H6a: The preferences for the mandatory information of FAPs differ according to the scenario used to obtain the decision matrices following the application of a fuzzy preference relations method.

- H6b: The preferences for the mandatory information of FAPs differs according to the country of residence of the consumers.
- H6c: The preferences for the mandatory information of FAPs differs according to the age of the consumers.
- H7a: Stakeholders welcome the idea of a hypothetical EU ecolabel for FAPs that includes different types of information apart from environmental issues.
- H7b: There are differences in the preferences for different types of information apart from environmental issues in a hypothetical EU ecolabel for FAPs according to the stakeholder segment (consumers, eco-label owners, producers, retailers or suppliers, organizations).
- H7c: There are differences in the preferences for different types of information apart from environmental issues in a hypothetical EU ecolabel for FAPs according to the preference of stakeholders for the governmental intervention in the control of eco-labelling.

d Structure of the chapters

The following chapters will follow an order according to the Business Model Canvas, which is defined as a business model that describes the reasoning of how to create, deliver and capture value for an organization (Osterwalder and Pigneur, 2010). In the Business Model Canvas, there are two segments: the customer and the value proposition. The customer segment describes consumers jobs, gains and pains according to their experience in the area studied, and refers to the demand side, while the value proposition section represents the value offered to customers (Clark et al., 2012) or in other words the supply side. The integration of both in the Business Model Canvas allows aligning the demand and supply side.

Moreover, the information asymmetry between the demand and supply sides might cause agency concerns for consumers (e.g., producers acting on their own interests for the information provided of the products) taking into consideration the agency theory developed by Jensen and Meckling (1976). As a result, controls are needed to align the asymmetry of the information between the two sides. Signalling theory (Spence, 1973) proposes that the side with more information sends a signal to the side with less information, in order to enable the former to clearly specify the non-observable characteristics of the products offered, and as a consequence, reduce the asymmetry of the information between the two sides, inspiring consumers' confidence and allowing the producers to differentiate and highlight potential characteristics of their products. In terms of the aquaculture market, these signals can be provided by the labelling systems used in the products, which is another component assessed in the present thesis.

Considering the previous, the first chapter of this thesis is related to the demand side, the second chapter to the supply side and the third chapter to the labelling preferences of consumers, looking for an alignment of the information between the demand and supply sides.

Materials and methods

e Databases used

This section presents the main information of the databases used to obtain the results of the investigation.

e.1 Special Eurobarometer 475

The Special Eurobarometer 2018[1] (European Commission, 2019) aims to analyse the internal market of the EU for FAPs and provide important information to help stakeholders to formulate policies that could enhance this market. At the request of the European Commission, the surveys were carried out by the Kantar Public Brussels network. The surveys were conducted in the 28 countries of the European Union between June and July 2018. The interviews took place face to face in the home of the interviewee and the mother tongue of each respondents' country of residence. A total of 27,734 EU residents were surveyed with diverse social and demographic characteristics.

e.2 Online questionnaire assessing the preferences for seabream and seabass products in Gran Canaria

The information was obtained from online surveys on the Google Forms Platform administered between 28 April and 14 June 2020. The surveys were directed to adults on the island of Gran Canaria (Spain), who shop the food in their households and who were consumers of seabream and seabass species. To disseminate the questionnaire, the surveys were distributed by e-mail to everyone associated with the island's main public university, the University of Las Palmas de Gran Canaria. Although it was clarified in the e-mails that the survey could be shared with others outside the university context, most of the respondents were probably somehow related to the university, which is probably the main limitation of the study in order to generalize the results. Anyhow, the questionnaire and the methodology could be used in future investigations.

Initially, there were some questions concerning respondents' consumption patterns and preferences for seafood, fish, seabream and seabass. Following that, the survey presented a series of traditional rating tasks for understanding the level of importance and satisfaction for 16 different attitudes related to seabream and sea bass purchase. The included attributes were related to health and nutritional issues, safety issues, sustainable behaviour, sensory characteristics, convenience, social behaviour and price. These attributes were chosen after an extensive literature review.

After that, respondents were presented with 10 best-worst-case 1 scenarios. In each scenario, respondents were asked to choose the most and least important attributes from 4 alternatives, as well as the attributes from which they have been most satisfied and least, based on their last purchase of seabream/seabass. The four alternatives for each of those scenarios were made from the same series of 16 attributes which have been assessed for traditional rating tasks. A total of 351 respondents replied to the BWS experiment, and since each of them responded to

[1] The data can be publicly accessed in the webpage of the Leibniz Institute for the Social Sciences Data Archive for the Social Sciences (DAS): https://doi.org/10.4232/1.13212

ten different scenarios, with four different choices (most important, least important, most satisfied, least satisfied), the final sample of pseudo-individuals was 14040.

e.3 Public consultation on options for an EU ecolabel for FAPs

The database comes from a public consultation conducted between 30 April and 1 July 2015 regarding EU Ecolabel options for FAPs (European Commission, 2015a). This consultation looked to understand views on the impacts and concerns of different stakeholder groups regarding options for a Union-wide ecolabel scheme for FAPs, following a commitment that the European Commission acquired in the Common Market Organization for FAPs (CMO, Reg. EU 1379/2013). 443 individuals were surveyed, from different European countries, representing a range of different stakeholders, such as consumers, eco-label owners, producers, retailers and other organisations. To construct the database, it was considered a module that asked respondents about the level of acceptance (from 1 to 5) of various types of information in a European Union Ecolabel for FAPs.

e.4 Online questionnaire and interviews directed to European aquaculture farmers to analyse their attitudes and perceptions of risks

The questionnaires were distributed to different European aquaculture companies. They were sent via e-mail and companies were advised that all the collected information would be anonymously processed. The survey included an assessment of the different types of risks in terms of severity and probability of occurrence to identify the most important types of risks. Then, respondents must select the top three specific risks in each risk category according to their likelihood of occurrence and anticipated consequences. It also included an efficacy assessment of the various risk management strategies considered in previous literature studies. Finally, the survey asked participants to determine their risk attitudes to rate the level of agreement with various statements. There were a total of 14 responses, 8 of which were on European aquaculture grow-out companies and 7 were on full-cycle companies, which included both the hatchery and the grow-out facilities.

In addition, semi-structured interviews were conducted to a sub-sample of the respondents, to supplement the responses of the questionnaires and to understand the importance-unimportance of each risk source and management strategy. In total, there were four interviews, two involving full-cycle companies and the other two with grow-out companies.

f Methodologies used

f.1 Ordered probit models

The Ordered Probit models are an appropriate analytical framework when survey responses are ordinal (Kumar et al., 2008; Thong and Solgaard, 2017).

The probit models are rooted in the random utility modelling approach, and in them, it is assumed that the latent dependent variable Y_i depends on two elements: first, a linear combination of a vector of independent variables X_i and the parameter vector θ_i that must be estimated; and second, an error term ε_i that makes possible to elicit non-observed factors of the individual *i*. Equation 0.1 shows the latent regression model used.

$$Y_i = \sum_{k=1}^{K} \theta_i X_i^k + \varepsilon_i \qquad (0.1)$$

Moreover, as the dependent variable in the former equation is not observable, it is measured by a set of indicators y_i . that represent the different categories of the dependent variable, where μ_1, μ_2, μ_3, μ_4 and μ_5 are category threshold parameters that must be estimated subject to $\mu_1 < \mu_2 < \mu_3 < \mu_4 < \mu_5$. These category thresholds indicate the points in which there is a variation in the dependent variable due to a high change in the latent preference.

Given a distribution function for the error term, and setting $\mu_0 = -\infty$ and $\mu_J = \infty$, the probabilities for each of the outcomes can be obtained according to:

$$P(y_i = j) = P(\varepsilon_i \le \mu_j - \theta X) - P(\varepsilon_i \le \mu_{j-1} - \theta X) = F(\mu_j - \theta X) - F(\mu_{j-1} - \theta X) \qquad (0.2)$$

Where F is the assumed cumulative distribution function (cdf) for the error term, that in the case of the ordinal probit is the normal distribution.

The heteroscedastic model permits that the variance of the error term varies by allowing the standard deviation to be determined according to the following equation: $\sigma = \exp(\delta Z_i)$, where Z is a vector of variables that explain the level of variance and δ is a vector of parameters to be estimated.

The parameters of the model are estimated by maximising the log-likelihood function according to:

$$L(\theta, \delta, \mu) = \sum_{i=1}^{n\Sigma} \left(F\left(\frac{\mu_j - \theta X_i}{\exp(\delta Z_i)}\right) - F\left(\frac{\mu_{j-1} - \theta X_i}{\exp(\delta Z_i)}\right) \right) \sum_{j=1}^{J\Sigma} I(y_i = j) log \qquad (0.3)$$

Where $I(y_i = j) = 1$ when consumer *i* answers *j* and 0 otherwise. The heteroscedastic ordered probit model is estimated by maximum likelihood estimation (MLE) and provides one of the basic extensions of the traditional ordered probit models.

Also, the marginal effects are estimated and can be calculated as follows if all the variables included in the model are binary:

$$ME_j\left(X,Z\right)=\left(F\left(\frac{\mu_j-\theta\vec{X}_1}{\exp(\delta\vec{Z}_1)}\right)-F\left(\frac{\mu_{j-1}-\theta\vec{X}_1}{\exp(\delta\vec{Z}_1)}\right)\right)-\left(F\left(\frac{\mu_j-\theta\vec{X}_0}{\exp(\delta\vec{Z}_0)}\right)-F\left(\frac{\mu_{j-1}-\theta\vec{X}_0}{\exp(\delta\vec{Z}_0)}\right)\right) \quad (0.4)$$

In the vectors X and Z, the variable of interest is equal to one or zero for the dummy variables when the subindex is 1 or 0, respectively. In the case of the categorical variables, the vector X1 is substituted by its code. The marginal effects are calculated at the mean values of the sample. The practical implications of the formula are that the marginal effects of one variable in the model depend on all the model parameters, the data and the outcome of interest.

f.2 Multinomial logit models based on best-worst experiments

Best-worst (BWS) experiments are based on the random utility theory (RUT) (McFadden, 1974; Thurstone, 1927), which establishes that consumers select the alternative that offers them the highest possible utility. This utility has two components: a measurable systematic and deterministic component and an aleatory component. While the systematic utility depends on the attributes of the alternatives and the socio-economic characteristics of the individual, the random utility represents the unobserved attributes.

For estimating multinomial logit models with the results of the best-worst experiment, it was considered 8 utilities for each set of choices: the first four utility functions for parameters of importance and the second four utility parameters for satisfaction. The dataset is an unlabelled experiment that measures the importance and satisfaction for different attributes, in which the alternatives i (the subindices in eqs. 0.5 and 0.6) simply reflect the specific position of the task (1 = top, 2 = second from the top, 3 = second from the bottom, 4 = bottom). This results in measuring the importance and satisfaction. Each task offers two modelling observations, one for the best choice and the other for the worst choice. The best choices are based on the maximisation of utility, while the worst choices are based on maximizing the negative value of the utility. In this respect, for coding the attributes, it is considered (-1) for the worst-case observation and (1) for the best-case alternative.

For modelling purposes, when asked for the best options, four alternatives in the selection task are always available. When selecting the worst alternative, however, there is no longer available the best-selected option, because you cannot evaluate the same alternative as the best and worst one at the same time. This means that the availability of alternatives for the worst choices depends on the individual's previous best choices. There were three options for the worst choices are always available. The utility functions for both, importance and satisfaction of the alternative *i* are:

$$U_i^{Imp}=ASC_i+\sum_{k=1}^{15}\beta Imp_k\times Imp_{ik} \text{ with } i=1,2,3,4 \quad (0.5)$$

$$U_i^{Sat}=ASC_i+\sum_{k=1}^{15}\beta Sat_k\times Sat_{ik} \text{ with } i=1,2,3,4 \quad (0.6)$$

Considering that:

ASC_i = reflect the positional and other ordering effects

Imp_{ik} = 1 (or -1) if the attribute k is shown in alternative i for best (or worst) choices and 0 otherwise

Sat_{ik} = 1 (or -1) if the attribute k is shown in alternative i for best (or worst) choices and 0 otherwise

Four alternative specific constants (ASC_i) are used to calculate the effects of the order of each alternative, with the constant of the alternative presented in the fourth place (ASC_4) normalized to 0. Also, the multinomial logit model includes an error term, in addition to the observed utility component.

f.3 Hybrid fuzzy TOPSIS

This methodology is based on a hybrid approach with Fuzzy Set Theory (FST) and TOPSIS (Techniques for order preference by similarity of the ideal solution). TOPSIS are considered appropriate techniques for the management of different decision-making processes and are especially attractive when respondents make choices with multiple attributes (Martín et al., 2020b). Furthermore, in dealing with multi-dimensional attributes, the essence of human ambiguity judgement can be captured by fluid methods (Chang, 1996), which is a major task in using Likert linguistic scales. The hybrid fuzzy TOPSIS method proves to be more effective than other statistical methods based on averages and not dealing with the uncertainty of Likert scales, but also in providing the synthetic indicators and elasticities (Martín et al., 2019).

In the first step, the raw information of the dataset is transformed into the form of triangular fuzzy numbers (TFNs). The TFNs are three parameters (*a, b, c*). The most probable value is *b,* and the minimum and maximum values are *a* and *c*, respectively. After that, in the second step, mean TFNs are calculated for each segment of analysis, which covers diverse segmentation variables *p* and various categories *s* that correspond to each of them. Thus, the mean TFN ($\tilde{A}$) 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 part of that particular segment of analysis, as shown in equation 0.7.

$$\tilde{A} = \left(a_{s,p,q}, b_{s,p,q}, c_{s,p,q}\right) = \left(\frac{\sum_{i=1}^{n} a_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} b_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} c_{s,p,q}}{n}\right) \qquad (0.7)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

In the third step, the TFN information matrix obtained in the previous step is clarified through a defuzzification process that transforms each of the elements of the matrix into crisp values (CVs). The CVs are calculated according to equation 0.8 for simplicity and objectivity (Chen, 1996).

$$CV_{s,p,q} = \frac{a_{s,p,q} + 2 \times b_{s,p,q} + c_{s,p,q}}{4} \qquad (0.8)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

The fourth step consists 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 0.9.

$$CV_q = \left\{CV_{1,1,q},...,CV_{s,p,q}\right\} \text{ where } CV_q^+ = \max_q\left(CV_q\right) \text{ and } CV_q^- = \min_q\left(CV_q\right) \qquad (0.9)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

The fifth step is calculating the Euclidean distances of each category of *s* of the segment of analysis *p* with respect to the ideal solutions, as shown in Equation 0.10. The calculation of the synthetic indicators (Sis) is the 6th step of the method and is conducted using equation 0.11, and they simultaneously characterize the distance from the ideal and negative-ideal solutions.

$$d_{s,p}^+ = \sqrt{\sum_{q=2}^{q}(CV_q^+ - CV_{s,p,q})^2} \text{ and } d_{s,p}^- = \sqrt{\sum_{q=2}^{q}(CV_{s,p,q} - CV_q^-)^2} \qquad (0.10)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

$$SI_{s,p} = \frac{d_{s,p}^-}{d_{s,p}^+ + d_{s,p}^-} \qquad (0.11)$$

Where s:1,...,s and p:1,...,p

The seventh step consists of estimating the elasticities per segment of analysis of the SIs according to equation 0.12.

$$\eta_{s,p,q} = \frac{\Delta\% SI_{s,p}}{\Delta\% A_{s,p,q}} \qquad (0.12)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

f.4 Modified consistent fuzzy preference relation with geometric Bonferroni mean

The present methodology adapts the Consistent Preference Fuzzy Relationships (CPFRs) methods proposed by Alias et al. (2019), Alonso et al. (2008) and Herrera-Viedma et al. (2004). The Geometric Bonferroni Mean (GBM) operator was used to overcome the limitations of aggregated measures, such as the average (Xia et al., 2013). As a result, the potential interrelationships between the criteria are considered. The method is based on a fusion of the GBM and CFPRs methods, and it extends Alias et al. (2019) by applying the GBM to the weights obtained for each of the DMs. Thus, the model is denominated as the CFPR-GGBM method, where the first G stands for Grand.

The first step is to convert the information matrix obtained from the survey into linguistic evaluations obtained by surveying a la Saaty. In this case, the information matrix is based on

the answers given in a 4-point Likert scale, so when making pairwise comparisons between criteria *j* and *k* subtracting the values, the following preference relation (PR) matrix $S = s_{jk} = imp_j - imp_k$ can be obtained by each respondent. The matrix can have the following values: -3,-2,-1,0,1,2 and 3. When the value is equal to 0, it means that criteria *j* and *k* are equally important. When the value is 1, it means that the criterion *j* is moderately more important than *k*. When the value is 2, it means that the criterion *j* is strongly more important than *k*. And finally, when the value is 3, it means that the criterion *j* is very strongly more important than *k*. For the negative values, the corresponding meaning is straightforward. The transformation function that converts the above preference relation matrix in one Preference Relation (PR) a la Saaty matrix can be defined as follows: $g(-3,-2,-1,0,1,2,3) = (1/7,1/5,1/3,1,3,5,7)$. A simpler mathematical expression can be given according to:

$$S' = s'_{ij} = (1+2|s_{ij}|)^{sign(s_{ij})}, where\ signx = 1 if\ x \geq 0, 0\ otherwise \qquad (0.13)$$

In the second step, the decision matrices are obtained. For the first scenario, CFPR propositions (Herrera-Viedma et al., 2004) are used to complete the matrix, meanwhile, the second decision matrix is obtained considering all the criteria comparisons as a way to analyse the robustness of the results. Orlovsky (1978) defines *R* as an FPR on a set of criteria $A=\{a_1, a_2, \cdots, a_n\}$ if and only if $R=(r_{ij})$ is a matrix of dimension *n* that:

$$r_{ij} \geq 0, r_{ij} + r_{ji} = 1, r_{ii} = 0.5\ for\ all\ i, j = 1,2,\cdots,n \qquad (0.14)$$

Where r_{ij} represents the preference degree of the criteria a_i over the criteria a_j. The values of the matrix *R* have the following meaning over the preferences: if r_{ij} is equal to 0.5, then DM shows indifference between both criteria; if r_{ij} is greater than 0.5, then criteria *i* is preferred over criteria *j*. Similarly, if r_{ij} is lower than 0.5, then criteria *j* is preferred over criteria *i*; if r_{ij} is equal to 1, then criteria *i* is preferred to criteria *j*; and finally, if r_{ij} is equal to 0, then criteria *j* is preferred to criteria *i.*

- Proposition 1. For a reciprocal multiplicative preference relation $S = (s_{ij})$ with $s_{ij} \in [1/9, 9]$, it is possible to build a corresponding reciprocal FPR $R = (r_{ij})$ with $r_{ij} \in [0, 1]$ as follows:

$$r_{ij} = g(s_{ij}) = \frac{1}{2}(1 + \log_9 s_{ij}) \qquad (0.15)$$

In general, if $s_{ij} \in [1/n, n]$, then $log_n s_{ij}$ is used in eq. 0.15.

- Proposition 2. If *R* is a reciprocal FPR, the following expressions are equivalent:

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}, \forall i, j, k \qquad (0.16)$$

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}, \forall i < j < k \qquad (0.17)$$

$$r_{i(i+1)} + r_{(i+1)(i+2)} + \cdots r_{(i+k-1)(i+k)} + r_{(i+k)i} = \frac{k+1}{2}, \forall i, k \qquad (0.18)$$

To construct the CFPR *R* using propositions 1 and 2, the initial fuzzy preference ratios are calculated using eq. (0.15) using 7 as the base for the logarithm function. Thus, the r_{ij}*'s* are obtained for the upper principal diagonal of the CFPR matrix, i.e., for the elements $\left\{r_{12}, r_{23}, \cdots, r_{(n-1)n}\right\}$. Then, it is constructed the complete decision matrix R with the equations of Proposition 2. The second scenario is based on the CFPR *R** matrix in which all the elements are calculated with eq. (0.15).

The first matrix R is normalized whenever the values are out of the range [0,1] with the transformation function assuming that the decision matrix values belong to some interval [-c, 1+c] without loss of generality. The transformation function is defined as shown below to create an FPR *R*:

$$r_{ij} = f\left(s_{ij}\right) = \frac{s_{ij} + c}{1 + 2c} \qquad (0.19)$$

The third step is characterized by the application of the GBM operator as shown in eq. (0.20) to deal with the potential interrelationships among the criteria. Xia et al. (2013) define the $GBM(p,q,a_1,a_2,\ldots,a_n)$ for $p, q>0$ and $a_i \geq 0$ as follows:

$$GBM\left(p,q,a_1,a_2,\cdots,a_n\right) = \frac{1}{p+q}\prod_{\substack{i,j=1 \\ i\neq j}}^{n}\left(pa_i + qa_j\right)^{\frac{1}{n(n-1)}} \qquad (0.20)$$

In the fourth step, the priority weights of each criterion are obtained to see the most influential criterion. Once the FPR is obtained, it is possible to evaluate the aggregation score u_i for each criterion as follows:

$$u_i = \frac{1}{n_c}\left(\sum_{j=1}^{n_c} r_{ij}\right) \qquad (0.21)$$

Where n_c is the number of criteria. Finally, the priority weights for each criterion is computed using eq. (0.22) for each DM, and the most influential criterion for each DM is that of the maximum value.

$$w_i = \frac{u_i}{\sum_{j=1}^{n_c} u_j} \qquad (0.22)$$

Finally, in the fifth step, the rankings of the weights are analysed for both scenarios and the proposed segmentations. In this step, it is obtained again using the GGBM –Grand Geometric Bonferroni Mean, the aggregate values of the weights for each criterion of the sample and segments of interest. It is therefore possible to analyse whether data are more or less homogenously perceived by different segments of the population.

Chapter I

Consumers' determinants, preferences and attitudes towards the consumption of FAPs

1 Paper: Determinants of fishery and aquaculture products consumption at home in the EU28

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Abstract

The European Union (EU) is the world's largest market for fishery and aquaculture products (FAPs) in nominal terms. Given the importance of these products, EU authorities and policy-makers are continuously monitoring consumer preferences and attitudes, analysing whether or not the implementation of EU policies and regulations improves the market conditions. For example, the Eurobarometer (European Union, 2018a) surveyed 27732 EU residents including a specific module to analyse the fishery and aquaculture EU market. In this study, the dataset is used to estimate Ordered Probit models using effects coding and their marginal effects to identify the main determinants of the frequency of FAPs at-home consumption. Results indicate that the highest probability to consume more frequently FAPs is related to considering that one of the main reasons for buying or eating fishery and aquaculture products is because they are healthy, while the highest probability to consume less frequently FAPs is related to consumers who do not understand at all the information accompanying the products. Similarly, other important reasons for consuming FAPs more frequently are their good taste and low relative price. Also, results indicate a higher frequency of consumption of FAPs for those consumers who are over 55 years of age, are wealthy, have a wild product preference, live in a household of 3 persons or more and are very satisfied with their lives. To our best knowledge, there is not a similar approach in the current literature that considers such an extensive sample which is representative of all the countries that conformed the EU28. Results provide valuable information especially for producers and authorities in terms of marketing and policy analysis.

Keywords: Fishery and aquaculture products; European residents' consuming behaviour; Frequency of consumption at home; Heteroscedastic Ordered Probit Model; Food policy.

1.1 Introduction

The EU is the world's largest trader of fishery and aquaculture products (FAPs) in nominal terms reaching around EUR 30.3 billion in 2017 and surpassing second-ranked China by more than EUR 2.3 billion (FAO, 2021c). These high figures are a consequence of the importance of FAPs for the human diet, accounting for around 17% of the intake of animal protein for the global population (FAO, 2021c), and more specifically, because of the many benefits offered by the consumption of these products. In fact, according to FAO (2020b), fish is not only a source of protein and healthy fats but also an exceptional source of nutrients, fatty acids, iodine, vitamin D and calcium. The importance of FAPs is also due to the consumption patterns of European residents, as according to data from 2016, the EU seafood average global consumption per capita of 24.33 kg. (European Union, 2018b) was higher than the global consumption value of 20.3 kg (FAO, 2021c). Additionally, for European residents, home is the most common place to consume the FAPs with 70% of consumers eating them at home at least once a month and 41% at least once a week (European Union, 2018a).

Given the importance of FAPs, some EU regulations, framed into two different sections: Common Fisheries Policy (CFP) and Common Market Organisation (CMO), have become an indispensable instrument for the appropriate functioning of the market and industry (D'Amico et al., 2016). The CFP consists of a set of rules for the management of the fishing fleets and the market of FAPs, as well as for the conservation of fish stocks (European Union, 2018a). Meanwhile, the CMO ensures that consumers receive more and better information for FAPs sold in the European market, with the same rules applying regardless of their origin (European Commission, 2016a). The CMO is currently regulated by the 1379/2013 EU regulation, which amongst other things, establishes the mandatory labelling information for FAPs (D'Amico et al., 2016) and a list of the voluntary information that can be added to FAPs, such as information related to the environmental, ethical or social aspects of the products, production techniques and practices, and others (European Parliament, 2013).

The European Commission aims to accurately develop and implement changes to the commented regulations. Thus, it is important to know the state of the fisheries and maritime industry as well as the opinions of citizens and stakeholders (European Union, 2018a). The understanding of consumers' habits and attitudes is necessary to better address their appropriate implementation and the potential foreseen changes. For example, the success of the CMO requires consumers to be able to understand the information of labels, the necessity and benefits of eating fish and the nutritional properties of different species available in the market. The European Parliament (2013) advised the Member States to invest in marketing and educational campaigns aiming to increase FAPs consumption. The European Commission (2017) found a total of 685 FAPs promotional campaigns and projects in the period 2007-2015 in 26 EU Member States, and only two Member States (Austria and Luxembourg) have not carried out any campaigns. In our view, the campaigns should be customized to the preferences and attitudes of consumers. A better understanding of the internal market of FAPs allows operators to raise their competitiveness and to adopt new strategies or to modify their current

ones based on consumers' demands, to pursue the strengthening and growth of the internal market and, as a result, to stimulate the creation of jobs (European Union, 2018a).

Despite the importance of knowing FAPs' preferences and habits of European consumers, most of the previous econometric models are only focused on a particular geographical context (specific city, region, or country). The literature is not scant as many papers have analysed the socio-demographic and economic factors as well as other individual and attitudinal factors as the main determinants of FAPs' consumption frequency. Nevertheless, to our knowledge, the previous studies are more limited in several aspects such as the sample representativeness and the number of determinants studied. From the methodological perspective, the study is also novel as Ordered Probit models in the context of FAPs consumption are still scarce (Lee and Nam, 2019).

In our view, the success or updating of the current conditions of EU policies depends more on a better understanding of FAPs' consumption across the EU. Thus, the present study aims to fill this important gap, analysing the main determinants that explain at-home FAPs' consumption frequency in the EU through the use of an Ordered Probit model. This type of model permits to analyse the consumers' preferences in an effective way (Kumar et al., 2008; Quagrainie, 2006). Concretely, we use a representative sample of the EU to analyse one of the most extensive lists of determinants that have been used to date. The determinants used in the study are: demographic factors (country of residence, age, place of living and household-size), economic factors (difficulties in paying the bills and society class) and individual and attitudinal factors (wild-caught preference, easiness and clearness to understand FAPs' information, main reasons for buying or eating FAPs, important aspects when buying FAPs, expectations of life conditions in five years and life satisfaction).

Besides other prerogatives, it is important to identify the main determinants that affect the frequency of consumption of these products because it is well known that consumers who purchase seafood more frequently are willing to pay higher prices than those who purchase it less frequently (Quagrainie, 2006). For this reason, marginal effects will be estimated to determine which are the most important factors or attitudes that increase the probability of consuming FAPs at home at least once a week. The results provide important insights for stakeholders in the fisheries and aquaculture sector on the factors and attitudes that should be highlighted in the marketing campaigns and information accompanying the products. Additionally, the results of the marginal effects may also be valuable for researchers, academics, and authorities to propose policy lessons or to guide the scope of future investigations.

The remainder of the paper is organized as follows: Section 1.2 offers some insights from the literature, section 1.3 presents some information about the database, section 1.4 describes the methodology, section 1.5 details the results, section 1.6 discusses the results and section 1.7 offers some concluding remarks.

1.2 Literature review

The literature shows that the preference for FAPs can be studied by analysing their frequency of consumption or the choices of consumers. While both types of investigations provide information on the patterns of consumption for these products, the choice-base studies usually focus more on the general preferences and the willingness to pay estimates for these products, while the studies analysing the frequency of consumption aim to identify the factors or attitudes that enhance the repetition of the action of consuming or buying these products. The present investigation is in the context of the second type.

The literature shows different approaches that determine the main factors affecting the frequency of consumption of diverse seafood products, such as the Ordered Probit models (Almendarez-Hernández et al., 2017; Kumar et al., 2008; Lee and Nam, 2019; Myrland et al., 2000; Terin, 2019; Thong and Solgaard, 2017), the ordered logit models (Almendarez-Hernández et al., 2017; Santeramo et al., 2017), the theory of planned behaviour as a conceptual framework (Higuchi et al., 2017; Thong and Olsen, 2012; Tomić et al., 2016; Tuu et al., 2008; Verbeke and Vackier, 2005; Yousuf et al., 2019), the structural equation models (Rortveit and Olsen, 2009, 2007); some regression models such as the ordinary least square regression (Cavaliere et al., 2019), the logistic regression model (Herrmann et al., 1994), the multiple linear regression (Can et al., 2015) and the hierarchical regression models (Hall and Amberg, 2013); and other statistical analyses such as ANOVA (Almeida et al., 2015), frequency distribution (Islam et al., 2018) and Spearman's correlations (Murray et al., 2017).

Focusing on the studies that used ordered probit models, Lee and Nam (2019) studied the determinants of the frequency of live fish consumption in South Korea. They found that respondents with a low-price elasticity of demand and who consider safety to be a more important factor than the price are likely to consume live fish more frequently, whereas preference for wild-caught fish was relevant in consumers' choices, but not in their consumption frequency. Similarly, Thong and Solgaard (2017) determine how psychological and socio-demographic variables have an impact on the frequency of consumption of fish, shrimp and mussels in France. Results indicate that female, elderly, high-income consumers, living with children, living with family or partner tend to consume seafood more frequently, but there may be some differences depending on the seafood product being considered. In addition, the most important positive driver was weight control among the nine reasons assessed for the frequency of fish consumption, while convenience was the most relevant barrier. Almendarez-Hernández et al. (2017) assessed the frequency of consumption of tuna in Mexico and found that the marginal effects decreased as income increased. They also found that consumers who prefer canned tuna have a lower frequency of consumption compared to those who prefer fresh tuna; however, consumers who have been informed about the 'dolphin-safe' eco-label are more eager to consume canned tuna. Kumar et al. (2008) identified factors affecting the frequency of purchases of farmed catfish by consumers in the United States. Results indicate that fresh catfish buyers are more likely to purchase them more frequently than those who buy frozen catfish. Married couples, and Caucasians and African Americans were also more eager to buy catfish more frequently. Myrland et al. (2000) designed a recursive sequential model of the decision-making process for the consumption of seafood at home in Norway. The

methodology included a set of ordered probit models, that showed that the attributes of the product are more important perceived barriers to consumption than price beliefs. They also found that consumption increases when individuals are older, have higher education or larger household size. Moreover, Terin (2019) studied how the frequency of fish consumption of households in Turkey is related to socio-demographic factors and attitudes, and found that consumers with higher incomes, with a higher number of children in the household, and where the householders consume other aquaculture products other than fish tend to have a higher frequency of consumption. In general, all the models found on these investigations consist mostly of ordered probit models with or without interaction effects, but none of them have considered the heteroscedasticity that might be present in the effects of the variables.

In general, the studies in the literature show some differences regarding the independent variables considered, the countries included in the analysis and the species evaluated. Moreover, only a few studies analysed the frequency of consumption at home separately (Almeida et al., 2015; Herrmann et al., 1994; Myrland et al., 2000), which might be appropriate given that there are differences between the significant factors affecting at home and outside-home consumption (Almeida et al., 2015; Herrmann et al., 1994).

The factors that affect the frequency of consumption of seafood can be grouped into economic, demographic and attitudinal factors (Herrmann et al., 1994). As far as economic and demographic factors are concerned (see Table 1.1 in the section 1.8), the results obtained from the literature do not lead to a robust and clear hypothesis regarding their frequency trends. Some of the observed differences may be due to the characteristics of the sample, the species studied, and the methodology used in the investigations. Thus, there are no general trends regarding the frequency of consumption of seafood products for the gender, age, household size, the presence of young children, the education level, the income, and the marital status factors. On the other hand, most studies suggest that women, older people, people with higher education, higher incomes, married or living with a partner and a higher social class tend to have a higher frequency of consumption of seafood products.

In addition, factors related to individual conditions or attitudes towards the attributes of seafood products present a more general frequency trend pattern (see Table 1.2 in the section 1.8). Thus, the positive drivers to a higher frequency of consumption are having a positive attitude towards seafood, considering important the low calories and low fat of the products, being satisfied with the safety of the products, being an expert judging the safety of the products, preferring fresh products, caring about eco-labels and environmental issues, being a regular consumer, being involved in recreational fishing activities, executing often physical activities, frequent consumption of seafood during childhood, high knowledge of the production of seafood and consumption of other products other than fish. Meanwhile, the main barriers are the price or cost, not purchasing wild seafood for environmental concerns, and being uncomfortable when cooking or preparing seafood.

Furthermore, factors related to familiarity, health and sensory qualities are largely dependent on the species of seafood examined. For familiarity, as expected, Hall and Amberg (2013) found that consumers who are familiar with aquaculture products tend to consume them more

frequently, while Thong and Solgaard (2017) found different results about the familiarity factor for shrimp and mussels. Moreover, for the health attribute, most studies have agreed as expected that consumers who care about food-related health issues, consume FAPs more frequently. Seafood products, in general, are thought to be healthy, although Santeramo et al. (2017) found opposite results for the particular case of oysters, which consumption is explained more by being used to eat them, rather than by their healthy nature. Finally, as regards sensory qualities attributes, contrary to expectations, Santeramo et al. (2017) found that consumers who value oysters as tasty consume oysters less frequently, and the authors concluded that oysters are consumed for reasons other than their particular taste.

Other factors that have been analysed and affect the frequency of consumption of seafood products are the profession or occupation (Almendarez-Hernández et al., 2017; Can et al., 2015; Herrmann et al., 1994; Lee and Nam, 2019), the living location (Herrmann et al., 1994; Islam et al., 2018; Lee and Nam, 2019; Myrland et al., 2000; Thong and Solgaard, 2017), the ethnic group (Kumar et al., 2008), the origin of the product (Kumar et al., 2008), the packaging presentation (Kumar et al., 2008), the type of store (Kumar et al., 2008), the preference for certain species (Lee and Nam, 2019), the nationality (Yousuf et al., 2019) and the seasonal period (Can et al., 2015).

1.3 The database

The database used to estimate the models was obtained from the Special Eurobarometer 2018 (European Commission, 2019), which was the second survey on this topic and consisted of a block of questions that were asked in a similar survey conducted in 2016. The survey aimed to analyse the internal market for FAPs of the EU and to provide important information that helps stakeholders for the formulation of policies that might enhance the market.

The survey was conducted by the Kantar Public Brussels network at the request of the European Commission. The surveys were administered between June and July of 2018 in the 28 countries of the European Union. The interviews were made face to face at home and in the native language according to the country of residence. A total of 27,734 EU residents with different social and demographic characteristics were surveyed. In the section 1.8, there is a table that presents the sample description that includes the countries involved, the frequency of surveys for each country and their respective percentage over the total sample (see Table 1.3. Sample features in the section 1.9).

The dependent variable in the current study is based on the responses for the frequency of consumption at home of FAPs, while the independent variables are related to the attitudes, economic and demographic factors of respondents. The answer format for the frequency of consumption at home goes from 1 to 5, according to the frequency of consumption that varies from never (1) to at least once a week (5), respectively. The other levels are: less than once a year (2), several times a year but less than once a month (3) and at least once a month but less than once a week (4).

1.4 Methodology

The conceptual framework of the study assumes that the frequency of home consumption of FAPs is influenced by some economic and demographic consumers' characteristics and some attitudes that serve to approximate consumers' preferences toward the seafood products. Ordered Probit models were estimated to analyse the frequency of consumption at home for the mentioned products, by using it as a categorical and ordinal dependent variable. The Ordered Probit models are an appropriate analytical framework when survey responses are ordinal (Kumar et al., 2008; Thong and Solgaard, 2017).

The estimated probit models are rooted in the random utility modelling approach, and in them, it is assumed that the latent dependent variable Y_i (home consumption frequency) depends on two elements: first, a linear combination of a vector of independent variables X_i and the parameter vector θ_i that must be estimated; and second, an error term ε_i that makes possible to elicit non-observed factors of the individual *i*. Equation 1.1 shows the latent regression model used.

$$Y_i = \sum_{k=1}^{K} \theta_i X_i^k + \varepsilon_i \qquad (1.1)$$

Moreover, as the dependent variable in the former equation is not observable, it is measured by a set of indicators y_i that represent the different categories of the dependent variable (Equation 1.2), where μ_1, μ_2, μ_3, μ_4 and μ_5 are category threshold parameters that must be estimated subject to $\mu_1 < \mu_2 < \mu_3 < \mu_4 < \mu_5$. These category thresholds indicate the points in which there is a variation in the level of consumption due to a high change in the latent preference.

$$\begin{aligned}
&\textit{Never: } y_i = 1 \textit{ if } Y_i \le \mu_1 \\
&\textit{Less than one year: } y_i = 2 \textit{ if } \mu_1 < Y_i \le \mu_2 \\
&\textit{Several times a year but less than once a month: } y_i = 3 \textit{ if } \mu_2 < Y_i \le \mu_3 \\
&\textit{At least once a month but less than once a week: } y_i = 4 \textit{ if } \mu_3 < Y_i \le \mu_4 \\
&\textit{At least once a week: } y_i = 5 \textit{ if } \mu_4 < Y_i
\end{aligned} \qquad (1.2)$$

Given a distribution function for the error term, and setting $\mu_0 = -\infty$ and $\mu_J = \infty$, the probabilities for each of the outcomes can be obtained according to:

$$P(y_i = j) = P(\varepsilon_i \le \mu_j - \theta X) - P(\varepsilon_i \le \mu_{j-1} - \theta X) = F(\mu_j - \theta X) - F(\mu_{j-1} - \theta X) \qquad (1.3)$$

Where F is the assumed cumulative distribution function (cdf) for the error term, that in the case of the ordinal probit is the normal distribution.

The heteroscedastic model permits that the variance of the error term varies by allowing the standard deviation to be determined according to the following equation: $\sigma = \exp(\delta Z_i)$, where Z is a vector of variables that explain the level of variance and δ is a vector of parameters to be estimated.

The parameters of the model are estimated by maximising the log-likelihood function according to:

$$L(\theta,\delta,\mu) = \sum_{i=1}^{n\Sigma}\left(F\left(\frac{\mu_j-\theta X_i}{\exp(\delta Z_i)}\right)-F\left(\frac{\mu_{j-1}-\theta X_i}{\exp(\delta Z_i)}\right)\right)\sum_{j=1}^{J\Sigma} I(y_i = j)\,log \qquad (1.4)$$

Where $I(y_i = j) = 1$ when consumer *i* answers *j* and 0 otherwise. The heteroscedastic ordered probit model is estimated by maximum likelihood estimation (MLE) and provides one of the basic extensions of the traditional ordered probit models that have been previously used in the context of fish consumption (Almendarez-Hernández et al., 2017; Kumar et al., 2008; Lee and Nam, 2019; Myrland et al., 2000; Terin, 2019; Thong and Solgaard, 2017). The basic idea of the traditional ordered probit model relies on the use of an unobserved latent variable through a mechanism based on a set of thresholds (Greene and Hensher, 2010; Winkelmann and Boes, 2009). However, both methods do not permit to analyse unobserved heterogeneity as one strict assumption is that the estimated parameters are considered fixed. The main limitations arise from considering that there exists a homogeneous process that generates the outcomes for all the observations (Fountas et al., 2020).

A number of model extensions that account for unobserved heterogeneity have been proposed in other research fields mainly in accident analysis. For example, the threshold parameters can depend on a set of explanatory variables (Avsar et al., 2017; Fountas and Anastasopoulos, 2018, 2017; Pudney and Shields, 2000); the coefficients can vary with the outcomes through fixed effects (Avsar et al., 2017; Cubas-Díaz and Martínez Sedano, 2018; Pfarr et al., 2010); the coefficients can vary with the observations through the use of random parameters (Behnood and Mannering, 2017; Fountas and Anastasopoulos, 2017); the observations can be differentiated by the use of a latent class model (Bago d'Uva, 2005; Fountas et al., 2018; Greene et al., 2008; Stone et al., 2019); the outcomes can be differentiated by the use of zero-inflated ordered probit models that accounts for some unobserved differentiation in one of the outcomes such as no-consumption vs. consumption or accidents with no injuries vs. accidents with injuries (Fountas et al., 2020; Jiang et al., 2017).

The independent explanatory variables considered in the models include dummies related to the country, age, place of living, household size, social class, wild product preference, attitudes regarding the main reasons for buying or eating FAPs, the most important aspects when buying FAPs, information regarding how easy and clear is to understand the information of the products, the difficulties of paying the bills, and life satisfaction and expectations. A table in the section 1.9 shows the questions of the survey that were used to obtain the information of the dependent and independent variables (see Table 1.4 in the section 1.9).

It is also important to note that, although there may be some similarities between the variables related to the main reasons for buying or eating FAPs and those related to the most important aspects of buying FAPs, there is a clear difference as the first category refers to both buying and eating behaviour while the second category refers only to buying behaviour.

For the present study, three ordered probit models were estimated: a homoscedastic model and two heteroscedastic models. Also, the marginal effects of the different consumption patterns at home were estimated. The marginal effects determine how much the probability of fish consumption at home outcome will be affected by a change in the value of the independent variables included in the model. In our study, the marginal effects can be calculated as follows as all the variables included in the model are binary:

$$ME_j\left(X,Z\right)=\left(F\left(\frac{\mu_j-\theta\vec{X}_1}{\exp(\delta\vec{Z}_1)}\right)-F\left(\frac{\mu_{j-1}-\theta\vec{X}_1}{\exp(\delta\vec{Z}_1)}\right)\right)-\left(F\left(\frac{\mu_j-\theta\vec{X}_0}{\exp(\delta\vec{Z}_0)}\right)-F\left(\frac{\mu_{j-1}-\theta\vec{X}_0}{\exp(\delta\vec{Z}_0)}\right)\right) \quad (1.5)$$

In the vectors X and Z, the variable of interest is equal to one or zero for the dummy variables when the subindex is 1 or 0, respectively. In the case of the categorical variables, the vector X_1 is substituted by its code. The marginal effects are calculated at the mean values of the sample. The practical implications of the formula are that the marginal effects of one variable in the model depend on all the model parameters, the data and the outcome of interest.

1.5 Results

Initially, a homoscedastic Ordered Probit model was estimated using effects coding for all the categorical variables included in the model (see Table 1.5 in the section 1.9). Effects coding normalization is not as popular as dummy coding normalization, but it presents a number of advantages (Hensher et al., 2005) that are relevant in the study. First, it avoids the always tricky selection of the reference base of the dummy coding normalization. Second, the marginal effects for each of the outcomes and levels of the categorical variables are referred to the average of all the levels of each variable and this is usually a better approach than an ex-ante selection of a specific category.

Results showed a significant and a higher frequency of consumption of FAPs for those consumers who: are older than 55 years, are part of the upper-middle class of society, have a wild product preference, live in a household of 3 persons or more, that are very satisfied with their lives and never or rarely have difficulties paying the bills. Similarly, there is a higher frequency of consumption for consumers who select as important any of the reasons listed for buying the products (except for those who consider that they are products for special occasions), as well as for those who contemplate as relevant any of the important aspects mentioned related to the product (except for the cost). In contrast, it was found that there is a lower frequency of consumption of FAPs for those consumers who: do not understand at all the information accompanying the products, are between the ages of 15 and 54, live in cities or large urban areas, are not satisfied with their lives and expect no changes in their living conditions for the next five years.

After that, a heteroscedastic Ordered Probit model using effects coding (see Table 1.5 in the section 1.9 for the detailed results) was estimated considering the same parameters, and it was found that, in many cases, the standard deviations of the factors could be explained by some of the factors included in the homoscedastic model. Thus, the homoscedasticity assumed in the homoscedastic model might lead to biased results for the obtained coefficients of some of the parameters. Furthermore, the heteroscedastic model showed a better adjustment than the homoscedastic model according to the Likelihood-ratio test. A more parsimonious heteroscedastic model was estimated considering just the parameters and standard deviations that were significant to a minimum significance level of 0.1, while the rest were fixed to 0. Nevertheless, the likelihood-ratio indicated that the fit of the model was lower than the previous model, so the first heteroscedastic ordered probit model was chosen to describe the results. Concretely, the analysis is focused on the marginal effects for the consumption frequency of at least once a week.

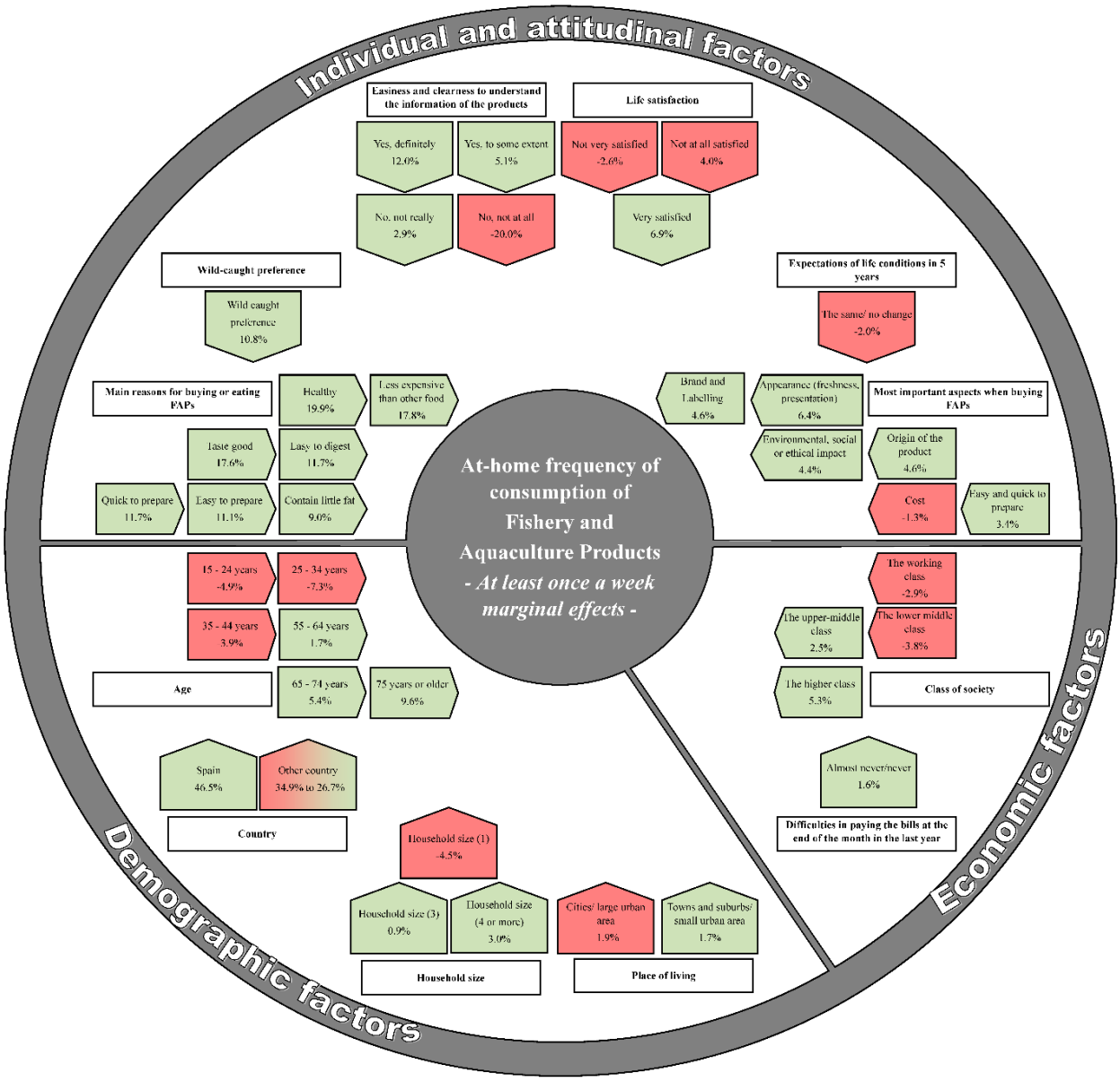
The marginal effects from the heteroscedastic model indicate that the frequency of consumption at home of FAPs differs across countries in the EU28. The largest effects are observed in Spain in comparison with Hungary which presents the lowest effects. Regarding the results on the main reasons for buying or eating fishery and aquaculture products, we obtain that the highest positive impact on the frequency of consumption is related to considering that fish products are healthy, in contrast with other reasons such as the cost or the origin of the product. Another interesting issue to remark is that the most negative impact is related to not understanding at all the information accompanying the products. The marginal effects for the consumption of FAPs at home at least once a week are illustrated in Figure 1.1 for the significant factors, in which the results are summarized succinctly according to the demographic factors (country of residence, age, place of living and household-size), the economic factors (difficulties in paying the bills and society class) and, individual and attitudinal factors (wild-caught preference, easiness and clearness to understand FAPs' information, main reasons for buying or eating FAPs, important aspects when buying FAPs, expectations of life conditions in five years and life satisfaction).

Results also show that attitudes of consumers towards the main reasons for buying or eating them are also very important determinants. Consumers who think that one of the main reasons for buying or eating FAPs is that they are less expensive than other foods, taste good, are easy to digest, are quick and easy to prepare or that they contain little fat, tend to consume them at home more frequently. In addition, less important factors to consume FAPs more frequently at home are related to those who believe that the most important aspect for buying FAPs refers to the product's appearance, the brand or quality labels, the origin of the product, the environmental, social or ethical impacts, or their easiness and quickness to prepare, also tend to consume the products more frequently. Interestingly, the cost result can be partly explained because it was only significant for the standard deviation, so, in general, it can be concluded that it is not relevant for the average consumer, but it might be important to some particular segments of the population.

The preference between wild and farmed products was found to be significant for the frequency of consumption of FAPs. The consumers who showed a clear preference for wild

products were more eager to consume them more frequently. Besides, results indicate that the older generation of residents, especially those over 55 years old, are more eager to consume FAPs more frequently at home, as well as those living together with more people and areas such as towns and suburbs or in small urban areas. Moreover, the results show a tendency for higher consumption rates for consumers who are part of higher social classes, while results also indicate that those who rarely or never had difficulties to pay their bills have a higher frequency of consumption of FAPs at home. It was also found that consumers who are not satisfied with their lives are less likely to eat FAPs at least once a week at home. Moreover, regarding the life condition expectations in five years, the results showed that those consumers who believe that their current living conditions will not change consume fish products less frequently.

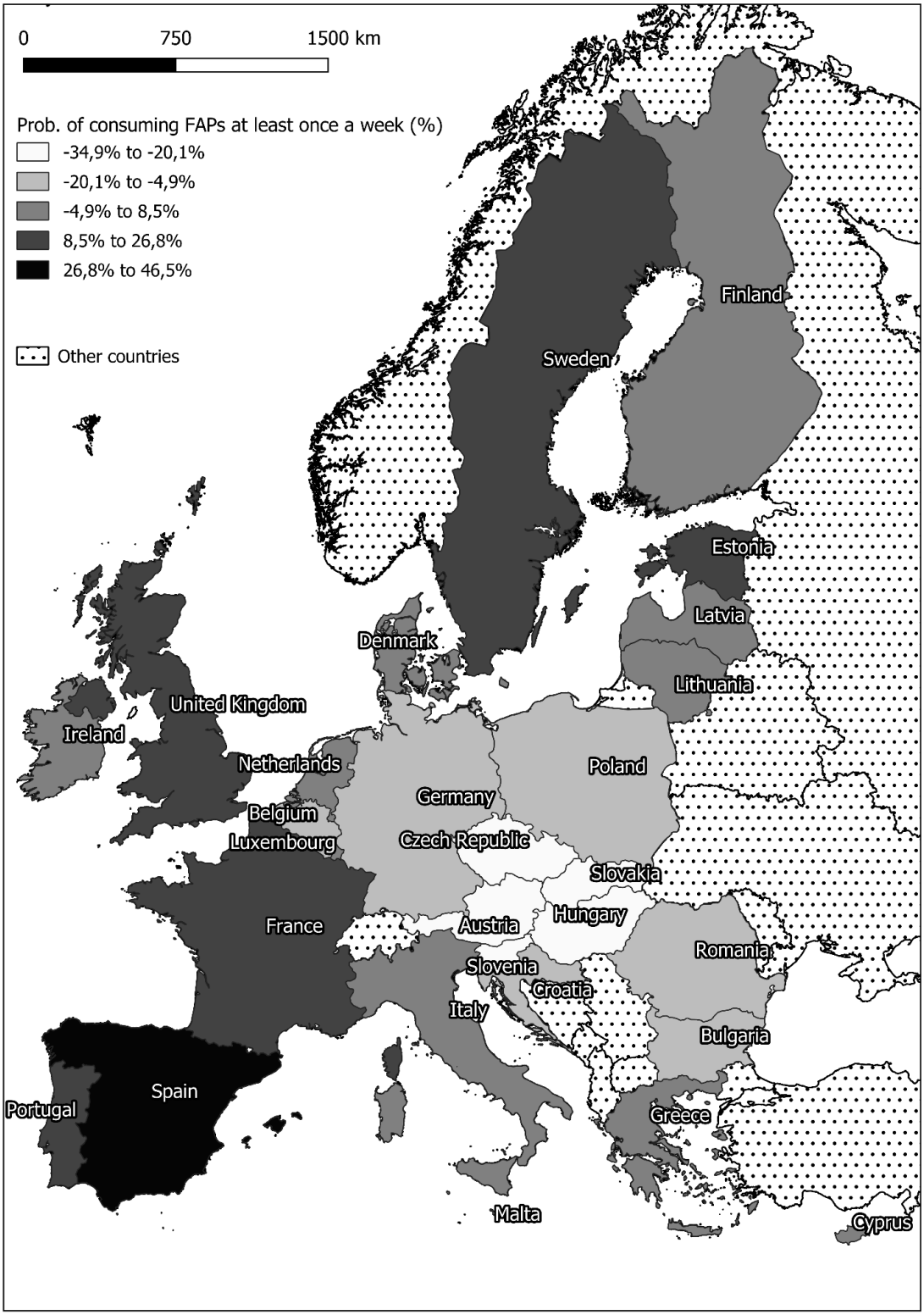
Figure 1.1. Marginal effects for the consumption of FAPs at home at least once a week



Analysing the probabilities to eat FAPs at least once a week at home for the countries according to their spatial distribution (see Figure 1.2), it can be seen that countries which do not have a

coastline or a very small one such as the Czech Republic, Slovakia, Hungary, Austria and Slovenia have the lowest probabilities. Similarly, the countries on the western side of Europe as well as Sweden, Estonia and the United Kingdom have a higher probability of consuming FAPs more frequently than those on the eastern side of Europe.

Figure 1.2. Probabilities to eat FAPs at least once a week at home for the countries



We also present the 95% confidence intervals for the marginal effects' values of each one of the analysed parameters (the country's specific constants, the attitudes, the easiness to understand the information that accompanies the products and the age). Thus, it is possible to evaluate at first glance different pairwise comparisons. For example, the analysis of Figure 1.3 indicated that the higher marginal effects mean values for the countries are observed in Spain, Portugal, Great Britain and Sweden. In general, the order of the countries according to the values of the parameters shows a similar tendency to their order according to the percentage of the population consuming FAPs at least once a week (European Union, 2018a), except for some specific cases.

Similarly, as shown in Figure 1.4, the marginal effects' values for the attitudes towards eating or buying FAPs indicated that the most important reasons to eat or buy them were their healthiness, low relative cost and good taste, while the least important aspect was their specific cost. The marginal effects' values related to the levels of understanding the information accompanying the products are presented in Figure 1.5, which exhibits that there is a high difference between the various levels of understanding the information accompanying the products and those who do not understand it at all. Finally, Figure 1.6 shows the marginal effects' values of the age factor, which expose clearly that there is a tendency of higher consumption of FAPs for older consumers.

Figure 1.3. Confidence intervals for the marginal effects of consuming fish at least once a week by country

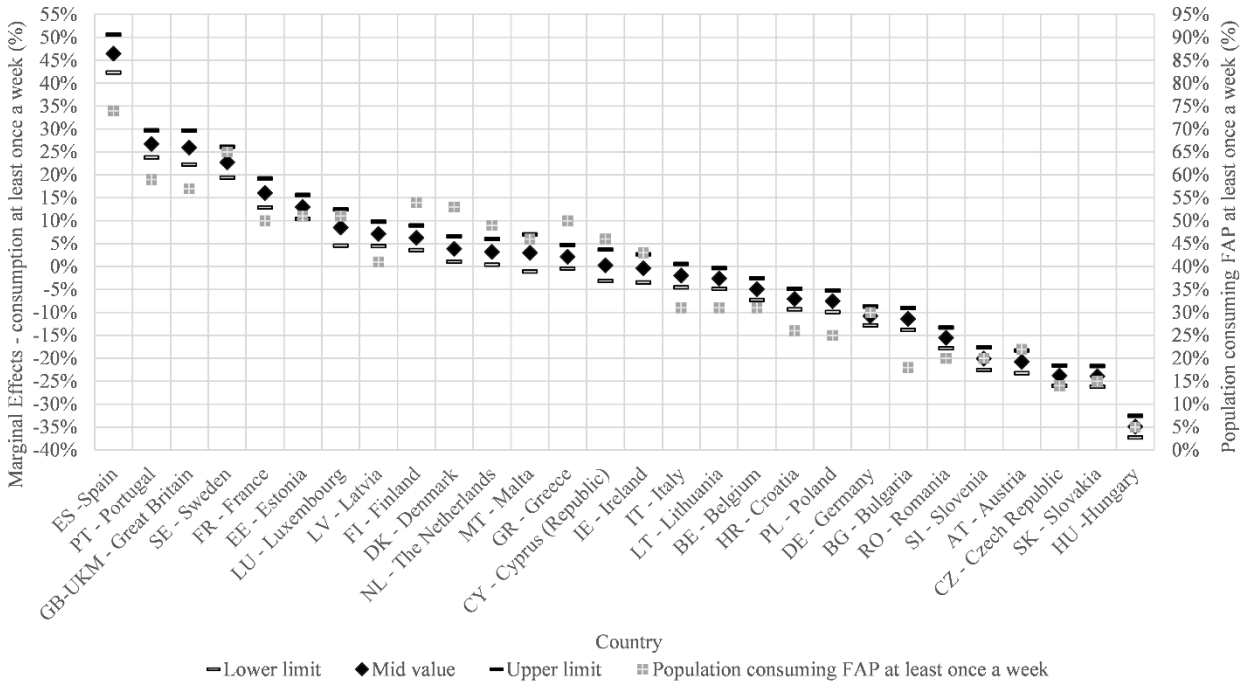


Figure 1.4. Confidence intervals for the marginal effects of consuming fish at least once a week by the attitudes (reasons to buy or eat fish and aspects to buy fish)

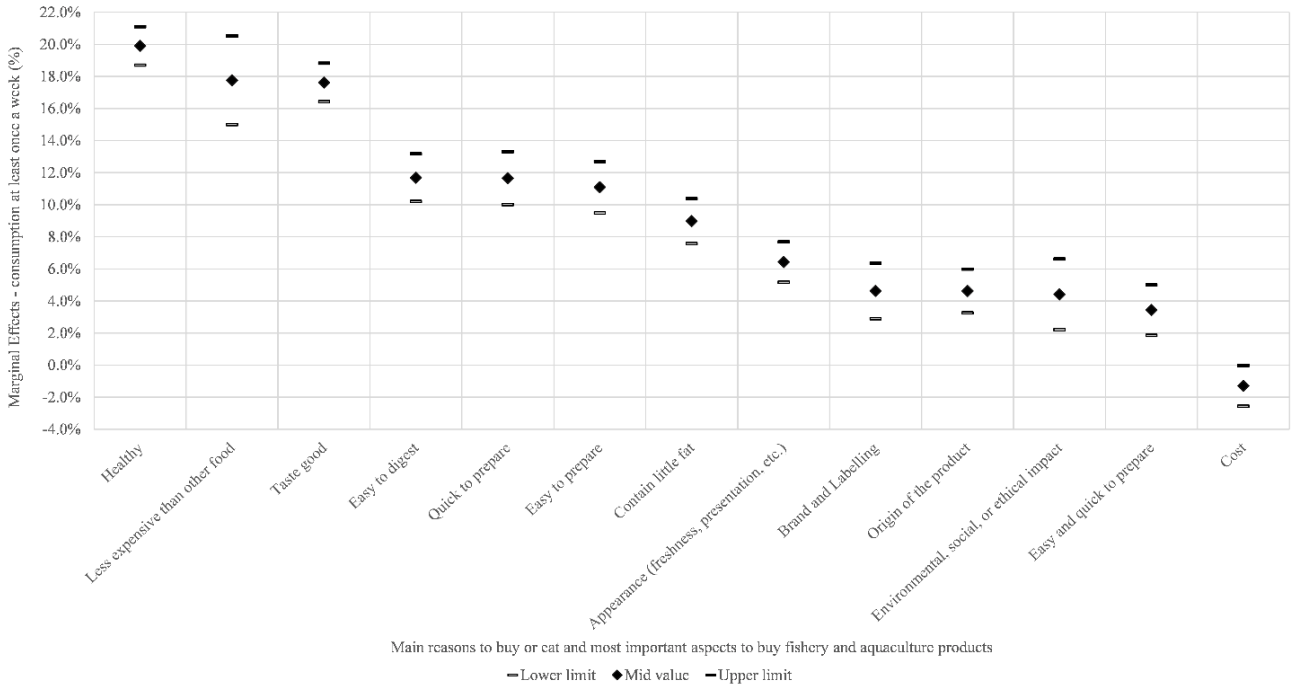


Figure 1.5. Confidence intervals for the marginal effects of consuming fish at least once a week by the easiness to understand the information that accompanies fish products

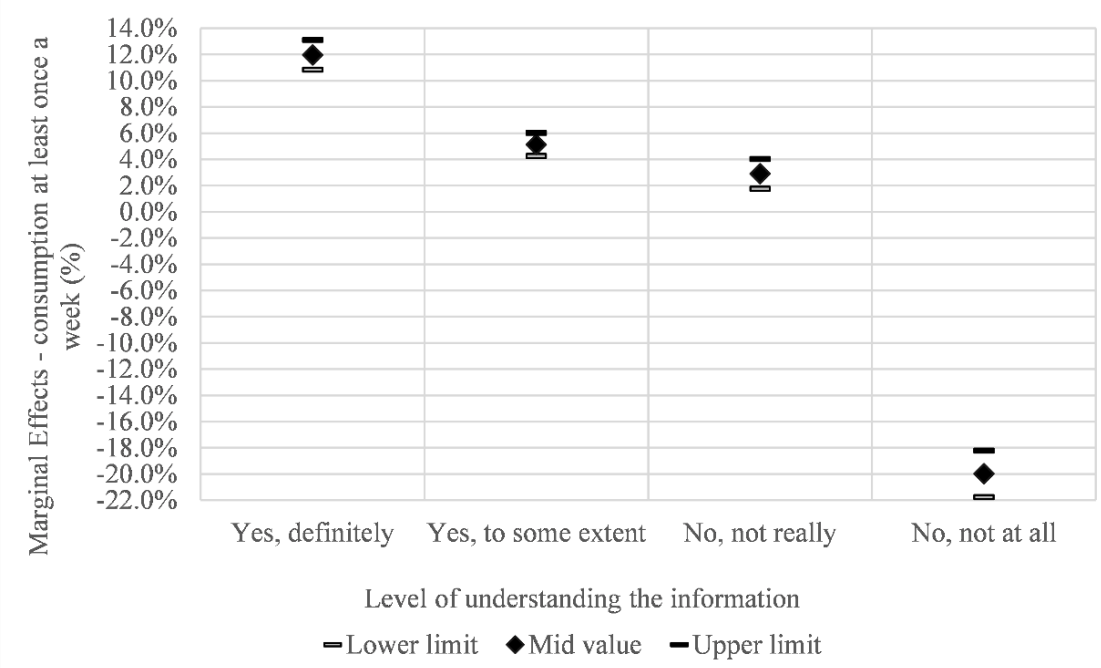
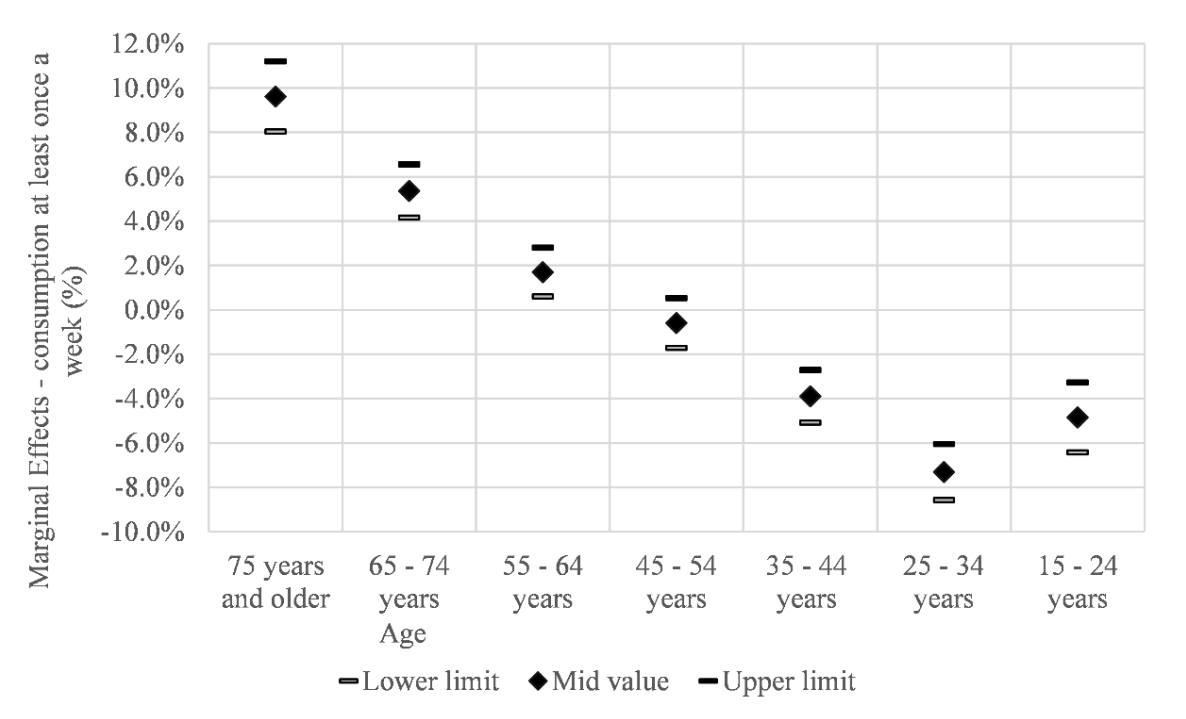


Figure 1.6. Confidence intervals for the marginal effects of consuming fish at least once a week by age



1.6 Discussion

Model results indicate that consumers who do not understand at all the information accompanying the products have a lower probability of around 20% to consume FAPs at least once a week than the average consumer. Therefore, the possibility of increasing the consumption of these products in the EU28 by simply providing clearer and easier to understand information can be considered an adequate policy to implement, especially, keeping in mind, that around 3% of respondents from the Eurobarometer survey indicated that the information accompanying FAPs was not at all clear or easy to understand (European Union, 2018). This strategy is also supported by several studies in the literature, which conclude that providing quality information to consumers enhances product attributes (Bronnmann and Hoffmann, 2018; Kumar, 2018).

Also, it was found that when consumers considered that the main reasons for buying FAPs are that they are healthy, less expensive than other foods and taste good, they have a higher probability of consuming FAPs at least once a week of 19.9%, 17.8% and 17.6%, respectively. The results confirm the previous findings by Can et al. (2015), Murray et al. (2017) and Thong and Solgaard (2017), in which the authors found that there is a higher frequency of consumption for consumers who are concerned with health issues. Other studies have shown that consumers are willing to pay premiums for health-related labels on seafood products highlighting the content of Omega 3 (Banovic et al., 2019; Bi et al., 2016; Fernández-Polanco et al., 2013), the high content of protein (Banovic et al., 2019) or how the product improves heart (Banovic et al., 2019; Lim et al., 2018) and brain function (Banovic et al., 2019). Moreover, Thong and Solgaard (2017) also found that more frequent FAPs consumers were also characterized by

those who considered the sensory qualities of FAPs to be important, such as the smell, texture, and taste.

In addition, our results indicate that other reasons that increase the probability of consuming FAPs at least once a week by around 11%, are the consideration of the products as being easy to digest and easy or quick to prepare. This finding is consistent with Murray et al. (2017) and Thong and Solgaard (2017). In both papers, the authors found that there is a lower frequency of consumption for consumers who are uncomfortable cooking or preparing these products. For this reason, ready-to-cook FAP's products can be considered an adequate policy that could promote the consumption of FAPs in the EU (Husein et al., 2020). Stead et al. (2004) warned that there are no simple solutions to those who are identified as feeling uncomfortable cooking FAPs, as the lack of confidence could be better aligned with unfamiliarity than with lack of cooking skills.

Other important individual and attitudinal determinants related to increasing the probability to consume FAPs at least once a week are: contain little fat (9.0%), appearance –freshness and presentation- (6.4%), the brand and labelling (4.6%), the origin of the product (4.6%) and the environmental, social or ethical impacts (4.4%). With regard to labels and environmental impacts, Almendarez-Hernández et al. (2017) and Santeramo et al. (2017) found that there is a higher frequency of consumption for consumers who care about eco-labels and environmental issues. In fact, some studies suggest that consumers are willing to pay premiums for products labelled as certified according to the standards of Aquaculture Stewardship Council (Banovic et al., 2019; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Hinkes and Schulze-Ehlers, 2018), Marine Stewardship Council (Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Chen et al., 2015; Wakamatsu and Miyata, 2017) or Naturland (Hinkes and Schulze-Ehlers, 2018), or labelled as produced with a more sustainable alternative process such as Integrated Multitrophic Aquaculture or Closed Containment Aquaculture (Yip et al., 2017). Concerning the appearance (freshness, presentation, etc), Almendarez-Hernández et al. (2017), Can et al. (2015), Hall and Amberg (2013), Kumar et al. (2008) and Yousuf et al. (2019) found similar results for fresh products, with higher consumer consumption rates than other presentations. Other studies have stated that consumers are willing to pay more for fresh seafood presentations than for other frozen presentations (Ankamah-Yeboah et al., 2019, 2018; Bronnmann and Asche, 2017; Davidson et al., 2012), while specifically for farmed salmon, consumers are willing to pay more for redder colour options, even after knowing that the red colour is artificially added (Alfnes et al., 2006; Olesen et al., 2010, 2006; Steine et al., 2005). Moreover, other studies have found that fillet presentation is preferred over whole fish (Ankamah-Yeboah et al., 2019, 2018) and steak (Thong et al., 2015) presentations.

In addition, according to the literature, the origin of the product is also an important determinant for consumers' decisions on seafood, with consumers having a higher willingness to pay for domestic or local products than for imported products (Ankamah-Yeboah et al., 2019, 2018; Ariji, 2010; Davidson et al., 2012; Fernández-Polanco et al., 2013; Hinkes and Schulze-Ehlers, 2018; Lim et al., 2018; Mauracher et al., 2013; Rudd et al., 2011; Stefani et al., 2012; Thong et al., 2015; Uchida et al., 2014; van Osch et al., 2019, 2017; Witkin et al., 2015).

Furthermore, with regard to environmental, social and ethical impacts, according to Schlag and Ystgaard (2013), European consumers are very concerned about the environmental impact of both wild and farmed fish. For example, Bronnmann and Hoffmann (2018) found that the environmental conditions of seafood products have an impact on consumers' choices and that consumers' preference for wild products was partially related to the negative environmental impact of farmed products. In fact, some studies have found that consumers are willing to pay premiums for environmentally friendly products (Fonner and Sylvia, 2015; Hynes et al., 2019; Lim et al., 2018; Olesen et al., 2010, 2006; Rudd et al., 2011). On the other hand, lower importance is given to social and ethical issues. For example, in Germany, Hinkes and Schulze-Ehlers (2018) found that although consumers are willing to pay premiums for generic fair trade labels, they are willing to pay more for other certifications that focus more on environmental aspects such as the certifications by the Aquaculture Stewardship Council and Naturland.

All of these findings can be used by different stakeholders, mainly retailers, producers and policy-makers, to promote FAPs' consumption in the EU highlighting the healthiness and taste of the products, the cheaper protein ingest in comparison with other foods and the ease of digestion. The retailers and the food industry should provide products that are easy and quick to prepare, as this strategy is not currently so common on the market in comparison with other food categories. Other less important determinants that could be improved are the appearance of the products, as well as the provision of clearer information regarding the origin, quality labels, and environmental, social, and ethical impacts. It is important to note that the information about the quality of the products, environmental, social, and ethical impacts may be added as voluntary labels as long as they comply with article 39 of the 1379/2013 EU regulation.

Moreover, regarding the distinction between farmed and wild products, consumers who prefer wild-caught products have a higher probability of 10.8% to eat them at least once a week. As a matter of fact, many investigations have shown that consumers are willing to pay more for wild-caught fish over farmed fish (Ariji, 2010; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Darko et al., 2016; Davidson et al., 2012; Fernández-Polanco et al., 2013; Roheim et al., 2012; Thong et al., 2015; Uchida et al., 2014). This finding reaffirms how important is the inclusion of the production method (wild-caught or farmed) as mandatory information for FAPs in the 1379/2013 EU regulation. Besides, this preference for wild-caught products is in line with the investigation of Murray et al. (2017) and exhibits a handicap that aquaculture producers and authorities need to correct by designing planned programs that can change the negative image of aquaculture products (Bronnmann and Hoffmann, 2018). In fact, several studies indicate that consumers describe farmed fish as less healthy and of lower quality when compared to wild fish (Claret et al., 2014; Verbeke et al., 2007b). On the other hand, some studies have found that the key elements that conditioned the image and acceptance of the reared fish were the comparatively low costs, the perception of being an artificial product and the lack of information regarding sustainable breeding techniques (Altintzoglou et al., 2010; Claret et al., 2014; Vanhonacker et al., 2011).

Consumers between 65 and 74 years old (baby-boomers' generation) or over 75 years old have an increased probability of at least 5.4% and 9.6%, respectively to consume FAPs at home at

least once a week. Given that young people have a lower frequency of consumption at home for these products, strategies such as product differentiation, online shopping of ready-to-eat or ready-to-cook FAPs may increase their interests. Some studies in the literature found similarly a higher frequency of consumption for older consumers (Herrmann et al., 1994; Murray et al., 2017; Myrland et al., 2000; Thong and Solgaard, 2017).

Results also show that consumers with a household size of 3 persons or more are more likely to consume FAPs more frequently. The same result was also found by Islam et al. (2018), Myrland et al. (2000) and Yousuf et al. (2019). Our results also show that there is a higher frequency of FAPs consumption for those who have a better financial situation (social class equal or higher than the upper-middle class, and rarely or never have difficulties to pay their bills). This result is due to the fact that FAPs are normal goods and is consistent with the investigations of Can et al. (2015), Cavaliere et al. (2019), Herrmann et al. (1994), Lee and Nam (2019), Thong and Solgaard (2017) and Yousuf et al. (2019).

1.7 Conclusions

The results provide valuable information for different stakeholders such as fisheries, fish farms managers, retailers, food industry and policy-makers, which can be used for production improvement, marketing, and policy analysis. The use of an adequate representative database enhances the robustness and credibility of the results.

The greatest negative marginal effect on the frequency of home consumption of FAPs correspond to not understanding at all the information accompanying the products. Despite this, further analysis is required to confirm if this result is rather due to not actually paying attention to the mandatory information provided by the labels, instead of not really understanding it. For example, some consumers may have never read the labels, either because they could have good knowledge of FAPs based on childhood habits or because they could trust the suggestions made by local fishmongers. Additional studies are therefore needed to understand how information can be provided in a more attractive, clearer and easier way and to identify the information needed by consumers, to analyse and confirm the effectiveness of the current mandatory information set out in Article 39 of the EU Regulation 1379/2013.

The findings also highlight the importance of certain attitudes that increase the consumption frequency at the home for FAPs. These attitudes suggest that one of the main reasons for buying or eating FAPs is that they are healthy, less expensive than other foods, taste good, easy to digest, quick and easy to prepare and contain little fat. Similarly, other attitudes related important aspects for buying fish products such as the easiness and quickness to prepare, the product's origin, the product's appearance, the brand or quality labels, and the environmental, social or ethical impacts, also increase the consumption frequency but are less important than the previous ones. Results also indicate that FAPs are more frequently consumed by those who: prefer wild-caught products; are older than 55 years old; live in larger households; have a better financial situation, are very satisfied with their lives and live in towns and suburbs or small urban areas. It is also important to note that since the attitude towards the importance of the cost was not significant in general, but only for certain groups, producers should risk on looking

for higher quality products that might be more attractive to some consumers despite their higher costs. However, before this, studies that evaluate the willingness to pay for these new products should be performed to understand the products' market feasibility and the population that might be interested in the product.

The study is not exempt from limitations. As mentioned in the methodology section, the heteroscedastic ordered probit model could be extended to account for unobserved heterogeneity. For example, the zero-inflated ordered probit model with its two-steps structure of a binary probit component and an ordered probit component could be proposed to analyse the two underlying states (no fish consumption vs. fish consumption). It is not unrealistic to suppose that these two states could greatly differ between countries. This model has been successfully applied in the analysis of low and severe accidents by Fountas et al. (2020). In addition, the systematic variation could also be analysed using sub-samples of the consumer population (grouped effects). For example, the effects of countries or other systematic geographical effects are likely to occur because consumers can share some cultural background regarding fish consumption. To that end, a grouped latent class ordered probit model with class-probability functions can be used to study the determinants that affect fish consumption at home in the EU. This type of model has been used by Fountas et al. (2018) to compare two latent class models (one based on segments and other based on accidents) that analyse the vehicle accident-injury severities in the state of Washington. Nevertheless, a word of caution for the search of more sophisticated models that better accommodate the unobserved heterogeneity is needed here as the payoff is usually manifested in terms of the difficulties in interpreting the parameters. Thus, a better model fit is usually accompanied by an arduous task of interpreting the results into something meaningful to describe the behaviour of fish consumption at home.

1.8 Appendix

Table 1.1 shows the frequency trends of the economic and demographic factors found in the literature review.

Table 1.1. Economic and demographic factors

Factor	Frequency trend	Supporting studies
Gender	Higher frequency of consumption for women	Can et al., 2015; Cavaliere et al., 2019; Thong and Solgaard, 2017
	Higher frequency of consumption for men	Islam et al., 2018
Age	Higher frequency of consumption for older people	Herrmann et al., 1994; Murray et al., 2017; Myrland et al., 2000; Thong and Solgaard, 2017
	Higher frequency of consumption for younger people	Can et al., 2015; Cavaliere et al., 2019
Household size	Higher frequency of consumption for a larger household size	Myrland et al., 2000; Yousuf et al., 2019
	Higher frequency of consumption for a shorter household size	Islam et al., 2018; Thong and Solgaard, 2017
Presence of young children	Higher frequency of consumption	Myrland et al., 2000; Terin, 2019; Thong and Solgaard, 2017
	Lower frequency of consumption	Herrmann et al., 1994
Education level	Higher frequency of consumption for a higher education level	Can et al., 2015; Cavaliere et al., 2019; Islam et al., 2018; Myrland et al., 2000
	Higher frequency of consumption for a lower education level	Yousuf et al., 2019
Income	Higher frequency of consumption for a higher income	Can et al., 2015; Cavaliere et al., 2019; Herrmann et al., 1994; Lee and Nam, 2019; Terin, 2019; Thong and Solgaard, 2017; Yousuf et al., 2019
	Higher frequency of consumption for a lower income	Almendarez-Hernández et al., 2017
Married or living with partner or family	Higher frequency of consumption for being married or living with a partner or family	Cavaliere et al., 2019; Kumar et al., 2008; Thong and Solgaard, 2017
	Higher frequency of consumption for being single	Can et al., 2015
Social class	Higher frequency of consumption for a higher social class	Islam et al., 2018
Household head	Higher frequency of consumption in the respondent of the survey is the head of the household	Terin, 2019

Table 1.2 shows the frequency trends of the individual and attitudinal factors found in the literature review executed.

Table 1.2. Individual and attitudinal factors and product attributes

Factor	Frequency trend	Supporting studies
Attitude or favourability toward seafood products	Higher frequency of consumption for a positive attitude or favourability toward seafood products	Kumar et al., 2008; Lee and Nam, 2019
Product presentation	Higher frequency of consumption for consumers who prefer fresh products over other presentations	Almendarez-Hernández et al., 2017; Can et al., 2015; Kumar et al., 2008; Yousuf et al., 2019
Freshness	Higher frequency of consumption for a higher freshness of the product	Hall and Amberg, 2013; Kumar et al., 2008
Ecolabels and environmental issues	Higher frequency of consumption for consumers who care about eco-labels and environmental issues	Almendarez-Hernández et al., 2017; Santeramo et al., 2017
Habitual consumers or being used to eating the product	Higher frequency of consumption for habitual consumers or who are used to eat some seafood products	Santeramo et al., 2017; Yousuf et al., 2019
Weight control (low calories and low fat)	Higher frequency of consumption for consumers that value as important that the seafood products have low calories and fat	Thong and Solgaard, 2017
Safety	Higher frequency of consumption for consumers who are satisfied with the safety of the product	Lee and Nam, 2019
	Higher frequency of consumption for consumers who care about the safety of oysters and are experts on judging its safety	Santeramo et al., 2017
Recreational fish participation	Higher frequency of consumption for consumers who are involved in recreational fish activities	Herrmann et al., 1994
Lifestyle-related to the level of physical activity	Higher frequency of consumption for consumers who execute physical activities more often	Myrland et al., 2000
Childhood consumption	Higher frequency of consumption as adults for consumers who consume seafood frequently when they were children	Murray et al., 2017
Subjective knowledge related to seafood production	Higher frequency of consumption at home for more knowledgeable consumers	Almeida et al., 2015
Price or cost	Lower frequency of consumption for a higher price or cost	Hall and Amberg, 2013; Lee and Nam, 2019; Terin, 2019; Thong and Solgaard, 2017
Inconvenience	Lower frequency of consumption for consumers who are uncomfortable cooking or preparing seafood	Murray et al., 2017; Thong and Solgaard, 2017

Factor	Frequency trend	Supporting studies
Wild vs. farmed seafood distinction	Lower frequency of consumption for consumers who do not purchase wild seafood	Murray et al., 2017
Familiarity	Higher frequency of consumption for consumers who are familiar with aquaculture products	Hall and Amberg, 2013
	Lower frequency of consumption of shrimp and mussel for consumers who give importance to the familiarity of the food	Thong and Solgaard, 2017
Health	Higher frequency of consumption for consumers who care about health issues of the product	Can et al., 2015; Murray et al., 2017; Thong and Solgaard, 2017
	Lower frequency of consumption for consumers who care about health issues of the product	Santeramo et al., 2017
Sensory qualities (smell, texture, taste)	Higher frequency of consumption for consumers who consider important the sensory quality of the product	Thong and Solgaard, 2017
	Lower frequency of consumption for consumers who value oysters as tasty	Santeramo et al., 2017
Other seafood consumption	Higher frequency of consumption for consumers that eat other aquaculture products apart from fish	Terin, 2019

1.9 Electronic appendix

Table 1.3 includes the sample features of the Eurobarometer survey.

Table 1.3. Sample features

Country	Frequency	Percentage (%)
AT - Austria	1044	3.8
BE - Belgium	1055	3.8
BG - Bulgaria	1031	3.7
CY - Cyprus (Republic)	503	1.8
CZ - Czech Republic	1023	3.7
DE - Germany	1550	5.6
DK - Denmark	1020	3.7
EE - Estonia	1004	3.6
ES -Spain	1035	3.7
FI - Finland	1017	3.7
FR - France	1006	3.6
GB-UKM - Great Britain	1043	3.8
GR - Greece	1016	3.7
HR - Croatia	1031	3.7
HU - Hungary	1064	3.8
IE - Ireland	1011	3.6
IT - Italy	1025	3.7
LT - Lithuania	1015	3.7
LU - Luxembourg	506	1.8
LV - Latvia	1007	3.6
MT - Malta	502	1.8
NL - The Netherlands	1006	3.6
PL - Poland	1033	3.7
PT - Portugal	1082	3.9
RO - Romania	1021	3.7
SE - Sweden	996	3.6
SI - Slovenia	1015	3.7
SK - Slovakia	1071	3.9
Total	27732	100

Table 1.4 shows the questions of the Eurobarometer survey that were used to obtain the information of the independent variables included in the Probit models. These questions do not include personal characteristics or situations of the respondents that were asked separately. For example, the country, age, household size, class of society, life satisfaction, place of living, expectations of life conditions in 5 years and difficulties in paying the bills at the end of the month in the last year.

Table 1.4. Questions of the Eurobarometer survey related to the explanatory variables

Variable	Questions	Number of answers	Possible answers
Dependent variable			
Frequency of consumption at home	How frequently do you eat fishery or aquaculture at home?	Only 1	Never
			Less than once a year
			Several times a year but less than once a month
			At least once a month but less than once a week
			At least once a week
Independent variables			
Wild products preference	Fishery and aquaculture products can be wild or farmed. Would you say that…	Only 1	You prefer wild products
			You prefer farmed products
			You have no preference
			You do not know if the products you buy or eat are wild or farmed
			It depends on the type of product
			Do not know
Main reasons for buying or eating FAPs	In your opinion, what are the main reasons for buying or eating fishery and aquaculture products?	Max. 3	They are healthy
			They taste good
			They are products for special occasions
			They contain little fat
			They are quick to prepare
			They are easy to prepare
			They are easy to digest
			They are less expensive than other food
			Another reason (SPONTANEOUS)
			No specific reason (SPONTANEOUS)
			Do not know
Most important aspects when buying FAPs	When you buy fishery and aquaculture products, which of the following aspects are the most important for you?	Max. 3	How easy and quick it is to prepare
			The origin of the product
			The product's appearance (freshness, presentation, etc.)
			The cost of the product
			The brand or quality labels (e.g., PGI, PDO)
			The environmental, social, or ethical impact
			Other (SPONTANEOUS)
			None (SPONTANEOUS)
			Do not know
How easy and clear to understand the information of the products	Do you think the information accompanying fish or aquaculture products you buy is clear and easy to understand?	Only 1	Yes, definitely
			Yes, to some extent
			No, not really
			No, not at all
			Do not know

Table 1.5 shows the results of the homoscedastic model and the heteroscedastic model. All the estimated parameters for each level of the categorical variables can be interpreted with respect to the average of all the levels. The parameters that are in bold letters achieve a minimum level of significance of 0.05, while those in italic represent a minimum level of significance of 0.1. At the end of the table, it can be found the Likelihood-ratio test that compares the models in order to see which one is statistically superior.

Table 1.5. Homoscedastic model and Heteroscedastic model

Variable		Homoscedastic model				Heteroscedastic model							
		Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Country	HU -Hungary	**-0.8657**	0.0345	-25.1205	0.000	**-0.9277**	0.0377	-24.6148	0.000	**-0.1998**	0.0289	-6.9252	0.000
	FR - France	**0.2613**	0.0370	7.0676	0.000	**0.3592**	0.0533	6.7442	0.000	**0.2286**	0.0402	5.6822	0.000
	BE - Belgium	**-0.0877**	0.0342	-2.5673	0.010	**-0.1286**	0.0349	-3.6843	0.000	-0.0296	0.0316	-0.9396	0.347
	NL - The Netherlands	0.0526	0.0381	1.3829	0.167	0.0748	0.0456	1.6408	0.101	0.0404	0.0405	0.9980	0.318
	DE - Germany	**-0.2630**	0.0290	-9.0587	0.000	**-0.2899**	0.0306	-9.4741	0.000	*-0.0531*	0.0273	-1.9439	0.052
	IT - Italy	-0.0169	0.0356	-0.4735	0.636	-0.0589	0.0370	-1.5899	0.112	0.0022	0.0342	0.0632	0.950
	LU - Luxembourg	**0.1661**	0.0516	3.2179	0.001	**0.2011**	0.0647	3.1099	0.002	*0.0992*	0.0549	1.8090	0.070
	DK - Denmark	**0.1366**	0.0388	3.5249	0.000	**0.1246**	0.0465	2.6830	0.007	-0.0225	0.0406	-0.5547	0.579
	IE - Ireland	**-0.0935**	0.0372	-2.5137	0.012	-0.0731	0.0470	-1.5533	0.120	**0.1227**	0.0428	2.8669	0.004
	GB-UKM - Great Britain	**0.4180**	0.0386	10.8303	0.000	**0.6128**	0.0658	9.3186	0.000	**0.3020**	0.0493	6.1325	0.000
	GR - Greece	**0.1086**	0.0384	2.8277	0.005	**0.0813**	0.0407	1.9960	0.046	-0.0358	0.0387	-0.9255	0.355
	ES -Spain	**1.0377**	0.0424	24.4659	0.000	**1.2431**	0.0832	14.9341	0.000	**0.2491**	0.0534	4.6621	0.000
	PT - Portugal	**0.6937**	0.0380	18.2660	0.000	**0.7213**	0.0537	13.4336	0.000	**0.1336**	0.0405	3.2959	0.001
	FI - Finland	**0.1825**	0.0384	4.7486	0.000	**0.1829**	0.0460	3.9760	0.000	0.0060	0.0408	0.1463	0.884
	SE - Sweden	**0.5449**	0.0419	13.0020	0.000	**0.6139**	0.0630	9.7415	0.000	**0.1110**	0.0485	2.2875	0.022
	AT - Austria	**-0.5093**	0.0351	-14.4928	0.000	**-0.5475**	0.0362	-15.1273	0.000	**-0.1268**	0.0328	-3.8591	0.000
	CY - Cyprus (Republic)	0.0447	0.0506	0.8838	0.377	0.0184	0.0535	0.3436	0.731	-0.0196	0.0503	-0.3902	0.696
	CZ - Czech Republic	**-0.5393**	0.0344	-15.6644	0.000	**-0.5889**	0.0324	-18.1725	0.000	**-0.2196**	0.0299	-7.3488	0.000
	EE - Estonia	**0.3653**	0.0374	9.7572	0.000	**0.3597**	0.0446	8.0688	0.000	0.0467	0.0388	1.2055	0.228
	LV - Latvia	**0.1722**	0.0357	4.8228	0.000	**0.1574**	0.0415	3.7934	0.000	**0.1044**	0.0348	3.0021	0.003
	LT - Lithuania	0.0303	0.0350	0.8648	0.387	-0.0215	0.0328	-0.6551	0.512	**-0.1078**	0.0322	-3.3419	0.001
	MT - Malta	0.0361	0.0517	0.6993	0.484	0.0513	0.0638	0.8029	0.422	0.0732	0.0573	1.2778	0.201
	PL - Poland	**-0.1383**	0.0343	-4.0319	0.000	**-0.1893**	0.0334	-5.6701	0.000	**-0.0656**	0.0309	-2.1198	0.034
	SK - Slovakia	**-0.5638**	0.0343	-16.4267	0.000	**-0.5999**	0.0332	-18.0562	0.000	**-0.2087**	0.0307	-6.7987	0.000
	SI - Slovenia	**-0.5151**	0.0347	-14.8281	0.000	**-0.5443**	0.0363	-15.0119	0.000	**-0.0928**	0.0313	-2.9632	0.003
	BG - Bulgaria	**-0.2467**	0.0349	-7.0763	0.000	**-0.2967**	0.0342	-8.6838	0.000	**-0.0787**	0.0307	-2.5674	0.010
	RO - Romania	**-0.3242**	0.0345	-9.4108	0.000	**-0.3853**	0.0325	-11.8517	0.000	**-0.1433**	0.0307	-4.6660	0.000
	HR - Croatia	**-0.0875**	0.0344	-2.5479	0.011	**-0.1502**	0.0319	-4.7099	0.000	**-0.1153**	0.0312	-3.6904	0.000
Age	15 - 24 years	**-0.1330**	0.0217	-6.1369	0.000	**-0.1409**	0.0227	-6.2100	0.000	-0.0038	0.0201	-0.1915	0.848
	25 - 34 years	**-0.2069**	0.0182	-11.3722	0.000	**-0.1988**	0.0188	-10.5949	0.000	**-0.0334**	0.0167	-1.9986	0.046
	35 - 44 years	**-0.1087**	0.0173	-6.2918	0.000	**-0.1041**	0.0175	-5.9531	0.000	-0.0215	0.0160	-1.3508	0.177
	45 - 54 years	**-0.0365**	0.0163	-2.2405	0.025	-0.0201	0.0166	-1.2095	0.226	0.0047	0.0152	0.3119	0.755
	55 - 64 years	**0.0522**	0.0161	3.2422	0.001	**0.0509**	0.0165	3.0866	0.002	-0.0020	0.0153	-0.1320	0.895
	65 - 74 years	**0.1693**	0.0173	9.7844	0.000	**0.1525**	0.0186	8.2005	0.000	0.0108	0.0166	0.6505	0.515
	75 years or older	**0.2636**	0.0221	11.9051	0.000	**0.2604**	0.0252	10.3347	0.000	**0.0452**	0.0216	2.0994	0.036

Variable		Homoscedastic model				Heteroscedastic model							
		Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Wild	Wild products preference	**0.2661**	0.0163	16.3703	0.000	**0.2784**	0.0200	13.9318	0.000	**0.0832**	0.0155	5.3532	0.000
Reasons	Healthy	**0.6703**	0.0168	39.8640	0.000	**0.5984**	0.0233	25.7311	0.000	**0.0337**	0.0161	2.1007	0.036
	Taste good	**0.5634**	0.0156	36.1382	0.000	**0.5139**	0.0214	24.0362	0.000	0.0235	0.0146	1.6043	0.109
	Are products for special occasions	0.0364	0.0284	1.2821	0.200	0.0082	0.0272	0.2997	0.764	-0.0273	0.0246	-1.1117	0.266
	Contain little fat	**0.2662**	0.0173	15.3919	0.000	**0.2539**	0.0190	13.3832	0.000	0.0100	0.0162	0.6162	0.538
	Quick to prepare	**0.3265**	0.0209	15.6117	0.000	**0.3164**	0.0231	13.6893	0.000	**0.0446**	0.0195	2.2922	0.022
	Easy to prepare	**0.3390**	0.0200	16.9298	0.000	**0.3106**	0.0220	14.1227	0.000	0.0101	0.0187	0.5385	0.590
	Easy to digest	**0.3400**	0.0192	17.7244	0.000	**0.3172**	0.0210	15.1279	0.000	**0.0450**	0.0179	2.5162	0.012
	Less expensive than other food	**0.5055**	0.0368	13.7508	0.000	**0.4820**	0.0417	11.5538	0.000	**0.0871**	0.0334	2.6077	0.009
Important aspects	Easy and quick to prepare	**0.0888**	0.0196	4.5388	0.000	**0.0855**	0.0204	4.1924	0.000	**0.0318**	0.0182	1.7485	0.080
	Origin of the product	**0.1263**	0.0169	7.4841	0.000	**0.1270**	0.0177	7.1842	0.000	0.0165	0.0157	1.0537	0.292
	Appearance (freshness, presentation, etc.)	**0.2168**	0.0165	13.1573	0.000	**0.1926**	0.0174	11.0893	0.000	-0.0069	0.0152	-0.4578	0.647
	Cost	0.0160	0.0164	0.9742	0.330	-0.0143	0.0168	-0.8538	0.393	**-0.0467**	0.0149	-3.1304	0.002
	Brand and Labelling	**0.1297**	0.0205	6.3131	0.000	**0.1311**	0.0218	6.0072	0.000	0.0066	0.0195	0.3377	0.736
	Environmental, social, or ethical impact	**0.1364**	0.0247	5.5116	0.000	**0.1230**	0.0277	4.4435	0.000	0.0102	0.0237	0.4313	0.666
Understanding information	Yes, definitely	**0.3162**	0.0152	20.7401	0.000	**0.3647**	0.0203	17.9387	0.000	-0.0243	0.0153	-1.5870	0.113
	Yes, to some extent	**0.1457**	0.0114	12.7337	0.000	**0.1853**	0.0140	13.1970	0.000	**-0.0683**	0.0113	-6.0270	0.000
	No, not really	**0.1142**	0.0163	7.0105	0.000	**0.1377**	0.0171	8.0316	0.000	**-0.1045**	0.0155	-6.7552	0.000
	No, not at all	**-0.5761**	0.0167	-34.5676	0.000	**-0.6877**	0.0311	-22.1232	0.000	**0.1971**	0.0194	10.1839	0.000
Household size	Household size (1)	**-0.1344**	0.0139	-9.6582	0.000	**-0.1295**	0.0145	-8.9165	0.000	-0.0071	0.0131	-0.5427	0.587
	Household size (2)	0.0011	0.0117	0.0920	0.927	0.0059	0.0120	0.4894	0.625	**0.0222**	0.0110	2.0223	0.043
	Household size (3)	**0.0419**	0.0144	2.9132	0.004	**0.0408**	0.0142	2.8738	0.004	**-0.0263**	0.0134	-1.9645	0.049
	Household size (4 or more)	**0.0914**	0.0133	6.8839	0.000	**0.0827**	0.0136	6.0720	0.000	0.0112	0.0123	0.9095	0.363
Economic difficulties	Most of the time	**-0.0461**	0.0182	-2.5390	0.011	**-0.0477**	0.0189	-2.5273	0.011	**0.0396**	0.0166	2.3883	0.017
	From time to time	-0.0146	0.0126	-1.1625	0.245	-0.0089	0.0127	-0.6999	0.484	*-0.0206*	0.0115	-1.7979	0.072
	Almost never/never	**0.0607**	0.0129	4.7094	0.000	**0.0565**	0.0132	4.2685	0.000	-0.0190	0.0117	-1.6210	0.105
Social class	The working class	**-0.0735**	0.0206	-3.5741	0.000	**-0.0744**	0.0228	-3.2600	0.001	-0.0210	0.0198	-1.0584	0.290
	The lower middle class	**-0.0519**	0.0224	-2.3115	0.021	**-0.0806**	0.0240	-3.3586	0.001	**-0.0608**	0.0212	-2.8711	0.004
	The middle class	0.0059	0.0184	0.3224	0.747	0.0006	0.0209	0.0298	0.976	-0.0253	0.0177	-1.4257	0.154
	The upper middle class	**0.0621**	0.0284	2.1866	0.029	**0.0651**	0.0327	1.9880	0.047	0.0168	0.0282	0.5959	0.551
	The higher class	0.0791	0.0706	1.1205	0.263	0.1188	0.0841	1.4124	0.158	0.0729	0.0693	1.0526	0.293
	NA	-0.0218	0.0314	-0.6940	0.488	-0.0295	0.0343	-0.8590	0.390	0.0172	0.0296	0.5816	0.561

Variable		Homoscedastic model				Heteroscedastic model							
		Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Life satisfaction	Very satisfied	**0.1492**	0.0177	8.4261	0.000	**0.1698**	0.0191	8.8658	0.000	**0.0653**	0.0168	3.8789	0.000
	Fairly satisfied	-0.0013	0.0135	-0.0969	0.923	-0.0068	0.0135	-0.5061	0.613	-0.0007	0.0123	-0.0592	0.953
	Not very satisfied	**-0.0650**	0.0175	-3.7197	0.000	**-0.0717**	0.0173	-4.1381	0.000	-0.0118	0.0158	-0.7429	0.458
	Not at all satisfied	**-0.0829**	0.0284	-2.9220	0.003	**-0.0912**	0.0279	-3.2745	0.001	**-0.0528**	0.0254	-2.0788	0.038
Expectations	Better	-0.0104	0.0137	-0.7607	0.447	-0.0062	0.0140	-0.4456	0.656	0.0061	0.0127	0.4794	0.632
	Worse	0.0171	0.0155	1.1036	0.270	0.0152	0.0159	0.9575	0.338	0.0206	0.0144	1.4360	0.151
	The same/ no change	**-0.0547**	0.0119	-4.6041	0.000	**-0.0521**	0.0121	-4.2880	0.000	-0.0153	0.0110	-1.3860	0.166
	NA	**0.0480**	0.0211	2.2742	0.023	**0.0431**	0.0217	1.9841	0.047	-0.0114	0.0197	-0.5789	0.563
Place	Rural area	**0.0222**	0.0105	2.1169	0.034	0.0151	0.0105	1.4467	0.148	**-0.0204**	0.0098	-2.0845	0.037
	Towns and suburbs/ small urban area	**0.0313**	0.0102	3.0788	0.002	**0.0346**	0.0106	3.2744	0.001	**0.0308**	0.0095	3.2364	0.001
	Cities/ large urban area	**-0.0535**	0.0100	-5.3568	0.000	**-0.0497**	0.0103	-4.8199	0.000	-0.0104	0.0094	-1.1149	0.265
Threshold parameters													
Thresholds		Estimate	Std. err.	t-stat	p-val.	Estimate	Std. err.	t-stat	p-val.				
μ_1		**-0.7142**	0.0280	-25.5227	0.000	**-0.9355**	0.0388	-24.0977	0.00				
μ_2		**-0.2799**	0.0277	-10.0920	0.000	**-0.4455**	0.0324	-13.7406	0.00				
μ_3		**0.6489**	0.0280	23.2008	0.000	**0.5148**	0.0344	14.9528	0.00				
μ_4		**1.7680**	0.0287	61.6562	0.000	**1.6395**	0.0555	29.5547	0.00				
Model adjustment													
Initial Log-Likelihood		-38793.06				-38793.06							
Final Log-Likelihood		-29439.70				-29077.65							
McFadden's R2		0.2411				0.2504							
AIC		59025.41				58439.3							
Likelihood-ratio test - Homoscedastic model vs. Heteroscedastic model													
Degrees of freedom		69											
LRT		724.1											
P-value		0.00											
Statistically superior model:		Heteroscedastic model 1											
LRT = chi-square test statistic for the likelihood-ratio test: -2(LogLmodel1-LogLmodel2)													
Degrees of freedom = degrees of freedom for the χ^2 test statistic defined as the difference													

Similarly, Table 1.6 shows the significant marginal effects of consuming FAPs at least once a week (y=5) based on the results of the heteroscedastic model. All the values for each level of the categorical variables can be interpreted with respect to the average of all the levels.

Table 1.6. Marginal effects of Heteroscedastic model: Frequency of consumption at least once a week (y=5)

Variable		Marginal effects of Heteroscedastic model: Frequency of consumption at least once a week (y=5)			
		Value	Std. err.	t-stat	p-val.
Country	HU -Hungary	**-0.3492**	0.0120	-29.0389	0.000
	FR - France	**0.1610**	0.0162	9.9440	0.000
	BE - Belgium	**-0.0487**	0.0121	-4.0318	0.000
	NL - The Netherlands	**0.0323**	0.0142	2.2738	0.023
	DE - Germany	**-0.1076**	0.0105	-10.2357	0.000
	IT - Italy	-0.0196	0.0130	-1.5073	0.132
	LU - Luxembourg	**0.0853**	0.0201	4.2479	0.000
	DK - Denmark	**0.0385**	0.0141	2.7282	0.006
	IE - Ireland	-0.0039	0.0155	-0.2495	0.803
	GB-UKM - Great Britain	**0.2597**	0.0188	13.7961	0.000
	GR - Greece	0.0215	0.0131	1.6376	0.102
	ES -Spain	**0.4648**	0.0212	21.9495	0.000
	PT - Portugal	**0.2678**	0.0150	17.8399	0.000
	FI - Finland	**0.0631**	0.0137	4.6141	0.000
	SE - Sweden	**0.2275**	0.0171	13.2704	0.000
	AT - Austria	**-0.2076**	0.0126	-16.4512	0.000
	CY - Cyprus (Republic)	0.0029	0.0174	0.1663	0.868
	CZ - Czech Republic	**-0.2375**	0.0112	-21.1512	0.000
	EE - Estonia	**0.1302**	0.0135	9.6623	0.000
	LV - Latvia	**0.0713**	0.0136	5.2308	0.000
	LT - Lithuania	**-0.0257**	0.0115	-2.2335	0.026
	MT - Malta	0.0299	0.0207	1.4432	0.149
	PL - Poland	**-0.0755**	0.0119	-6.3332	0.000
	SK - Slovakia	**-0.2394**	0.0115	-20.7613	0.000
	SI - Slovenia	**-0.2007**	0.0126	-15.9805	0.000
	BG - Bulgaria	**-0.1142**	0.0122	-9.3359	0.000
	RO - Romania	**-0.1554**	0.0115	-13.4619	0.000
	HR - Croatia	**-0.0707**	0.0113	-6.2337	0.000
Age	15 - 24 years	**-0.0485**	0.0080	-6.0496	0.000
	25 - 34 years	**-0.0732**	0.0065	-11.3402	0.000
	35 - 44 years	**-0.0390**	0.0060	-6.4630	0.000
	45 - 54 years	-0.0060	0.0057	-1.0514	0.293
	55 - 64 years	**0.0170**	0.0056	3.0184	0.003
	65 - 74 years	**0.0536**	0.0061	8.7613	0.000
	75 years or older	**0.0962**	0.0081	11.8877	0.000
Wild	Wild products preference	**0.1079**	0.0071	15.2075	0.000
Reasons	Healthy	**0.1990**	0.0061	32.4381	0.000
	Taste good	**0.1762**	0.0061	28.7483	0.000
	Are products for special occasions	-0.0019	0.0108	-0.1740	0.862
	Contain little fat	**0.0898**	0.0071	12.5791	0.000
	Quick to prepare	**0.1166**	0.0084	13.8343	0.000
	Easy to prepare	**0.1109**	0.0082	13.5409	0.000
	Easy to digest	**0.1168**	0.0076	15.4132	0.000
	Less expensive than other food	**0.1776**	0.0141	12.6058	0.000
Important aspects	Easy and quick to prepare	**0.0343**	0.0080	4.2675	0.000
	Origin of the product	**0.0462**	0.0070	6.6248	0.000
	Appearance (freshness, presentation, etc.)	**0.0642**	0.0064	10.0080	0.000
	Cost	**-0.0129**	0.0065	-1.9930	0.046
	Brand and Labelling	**0.0463**	0.0088	5.2553	0.000
	Environmental, social, or ethical impact	**0.0441**	0.0112	3.9243	0.000
	Yes, definitely	**0.1197**	0.0057	20.8230	0.000

Variable		Marginal effects of Heteroscedastic model: Frequency of consumption at least once a week (y=5)			
		Value	Std. err.	t-stat	p-val.
Understanding information	Yes, to some extent	**0.0513**	0.0045	11.4250	0.000
	No, not really	**0.0289**	0.0058	5.0250	0.000
	No, not at all	**-0.1999**	0.0091	-22.0542	0.000
Household size	Household size (1)	**-0.0452**	0.0050	-9.1133	0.000
	Household size (2)	0.0058	0.0041	1.4086	0.159
	Household size (3)	*0.0094*	0.0050	1.8890	0.059
	Household size (4 or more)	**0.0300**	0.0047	6.3959	0.000
Economic difficulties	Most of the time	-0.0094	0.0068	-1.3864	0.166
	From time to time	-0.0065	0.0045	-1.4413	0.150
	Almost never/never	**0.0160**	0.0047	3.4006	0.001
Social class	The working class	**-0.0289**	0.0077	-3.7397	0.000
	The lower middle class	**-0.0378**	0.0082	-4.6311	0.000
	The middle class	-0.0041	0.0069	-0.5975	0.550
	The upper middle class	**0.0250**	0.0106	2.3667	0.018
	The higher class	*0.0528*	0.0272	1.9408	0.052
	NA	-0.0071	0.0120	-0.5890	0.556
Life satisfaction	Very satisfied	**0.0688**	0.0065	10.6305	0.000
	Fairly satisfied	-0.0024	0.0049	-0.4992	0.618
	Not very satisfied	**-0.0264**	0.0062	-4.2746	0.000
	Not at all satisfied	**-0.0400**	0.0104	-3.8545	0.000
Expectations	Better	-0.0011	0.0049	-0.2216	0.825
	Worse	0.0087	0.0056	1.5624	0.118
	The same/ no change	**-0.0203**	0.0042	-4.8318	0.000
	NA	*0.0127*	0.0076	1.6740	0.094
Place	Rural area	0.0017	0.0037	0.4505	0.652
	Towns and suburbs/ small urban area	**0.0170**	0.0036	4.6833	0.000
	Cities/ large urban area	**-0.0187**	0.0036	-5.2583	0.000

2 Paper: Analysis of the main determinants of away-from-home consumption of fishery and aquaculture products in the EU28

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Abstract

The European Union (EU) is the largest market in nominal terms for fishery and aquaculture products (FAPs), partly due to the away-from-home consumption of these products in restaurants and food outlets. In view of this, it is necessary to identify the main determinants of the away-from-home consumption patterns in order to propose strategies that could increase the consumption of FAPs. Following this, ordered probit models were estimated alongside their marginal effects to identify the most relevant factors determining the frequency of away-from-home consumption of FAPs in the EU28, using a representative sample of 27732 EU residents. We found that those in the highest classes of society are most likely to consume FAPs away-from-home more frequently. Also, the most important reasons for consuming FAPs more frequently away-from-home are that they are less expensive than other foods, taste good, and are healthy and easy to digest. In addition, among the different nationalities, British consumers are more likely to consume FAPs away-from-home. We also found that there is a higher frequency of away-from-home consumption of FAPs for consumers between the ages of 25 and 54, who do not live in rural areas, who prefer wild-caught and local and marine products, and that are very satisfied with their lives. The study contributes to the literature with the analysis of FAPs away-from-home consumption by using a large representative sample of EU28 consumers. The study is also relevant with respect to the extensive list of determinants that include factors related to the attitudes of respondents to FAPs and socio-demographic characteristics.

Keywords: Heteroscedastic Ordered Probit model; Marginal effects; Fishery and aquaculture products; Residents' away-from-home consumption behavior; Frequency of consumption.

2.1 Introduction

Fishery and Aquaculture products (FAPs) consumption is an important component of the human diet, as it accounts for around 17% of the intake of animal protein in the global population (FAO, 2021c). Consumption of FAPs offers health benefits, due to the presence of high biological value proteins, unsaturated fatty acids, vitamins and minerals (Sidhu, 2003), while it has also been associated with a low risk of heart disease (Zarrazquin et al., 2014). In addition, Maciel et al. (2016, 2019) found that regular fish consumers had a better perception of the quality of life and were more physically active; suggesting that they were healthier people.

The average consumption of seafood by European residents is 24,33 kg per capita (European Union, 2018b), which is considerably higher than the 20,3 kg per capita of global consumption (FAO, 2021c). This is not surprising given that the European Union (EU) is the largest trader in nominal terms of FAPs in the world (FAO, 2021c). Part of the consumption is spent away-from-home, in places such as restaurants and food outlets, where 32% of European residents consume FAPs at least once a month and 11% at least once a week (European Union, 2018a).

Considering that consumers who purchase seafood more regularly are more likely to pay higher prices for seafood than those who purchase them less (Quagrainie, 2006), it is important to better understand the patterns of consumption of FAPs in the EU. According to our best knowledge, besides the numerous studies that analyse the preferences of consumers and frequency of consumption of FAPs, only a small part of them focuses on the identification of particular determinants of away-from-home consumption. The limited number of studies (Almeida et al., 2015; Baptista et al., 2020; Herrmann et al., 1994; Hori et al., 2020) usually involves a particular country, region and/or fish species, and the set of determinants is also limited in number and scope. Thus, the obtained results are not easily generalizable and the value for policies that could involve supranational entities such as the EU is also narrow.

The present investigation analyses the main determinants that explain the frequency of away-from-home consumption of FAPs by European residents using for the first time a heteroscedastic ordered probit model. Ordered Probit models are a proper analytical framework when the responses of a survey are ordinal (Kumar et al., 2008; Thong and Solgaard, 2017). In addition, the heteroscedastic model does not assume that error variances are constant or homoscedastic across observations, and the issue of biased parameter estimates as well as miss-specified standard errors is consistently handled. Our research extends the previous literature in two important aspects: (1) we use a large representative sample of consumers of the EU28, and (2) the list of determinants is very extensive and includes factors related to the attitudes of respondents to seafood and socio-demographic characteristics. We estimate the marginal effects of the different determinants to obtain the key factors that are likely to increase the likelihood of consuming FAPs away-from-home more frequently. The findings provide very important insights that are especially relevant for restaurant owners and the rest of the stakeholders of the supply chain in order to design and implement commercial strategies that enhance the FAPs logistic value. In addition, the results of the marginal effects may also be useful in drawing policy lessons or in guiding the extent of future investigations for researchers and authorities.

The rest of the paper presents the literature review (section 2.2), the data and methodology used for the analysis (section 2.3), the results (section 2.4), the discussion (section 2.5), and the conclusions (section 2.6).

2.2 Literature review and hypotheses

Higher demand for away-from-home food consumption in recent decades, especially in developed countries, has been attributed to different aspects, such as increased incomes (Binkley, 2006; Gäl et al., 2007; Ham et al., 2004; Ma et al., 2006) and increased pursuit of convenience through time savings (Binkley, 2006; Gäl et al., 2007; Mutlu and Gracia, 2004). Increased participation of women in the labour market has also favoured a tendency to spend more on leisure activities (Binkley, 2006; Gäl et al., 2007; Mutlu and Gracia, 2004). In addition, the growth in urbanization gives families greater access to restaurants that facilitates away-from-home food consumption (Ma et al., 2006; Mutlu and Gracia, 2004). According to Rezende & Avelar (2012), a variety of practices are related to the consumption of food away-from-home, such as the consumption of food products in food-specialised establishments, such as restaurants and snack bars, or in places where food is part of the service offered, such as hotel and in-flight meals, as well as the consumption of non-commercial substitutes, such as family meals.

There is a large number of studies assessing the consumption of fish and seafood. In general, according to Carlucci et al. (2015), the main drivers for fish consumption are the sensory liking (taste, smell and texture) of fish, perceived health benefits and fish-eating habits, while the main barriers are the sensory disliking of fish, health risk concerns, high price perception, lack of convenience, lack of availability of the preferred products, and lack of knowledge in selecting and preparing the product. Moreover, Olsen (2004) argues that the consumption of seafood varies considerably across individuals, families, cultures and countries. In addition, the species consumed may be associated with cultural traditions that are also changing over time (Apostolidis and Stergiou, 2012).

The consumption of FAPs is usually studied in the literature by analysing the choices of consumers or the frequency of consumption. Regarding the determinants of the frequency of consumption of seafood products, different quantitative approaches have been used according to the literature reviewed (see Appendix A). The most common methods used range from basic statistical analysis such as ANOVA or descriptive analysis to multinomial regressions and more sophisticated methods such as Probit and logit models.

The independent variables used for these models are usually related to socioeconomic variables and factors related to consumer attitudes towards seafood. As far as socioeconomic variables are concerned, the studies consulted have shown that there are no absolute trends for this type of attributes, as it depends on the characteristics of the sample within the context of the study or aspects related to the products, such as the species. However, the majority of the investigations indicate that female (Can et al., 2015; Cavaliere et al., 2019; Thong and Solgaard, 2017), elderly people (Herrmann et al., 1994; Murray et al., 2017; Myrland et al., 2000; Thong and Solgaard, 2017), highly educated people (Can et al., 2015; Cavaliere et al., 2019; Islam

et al., 2018; Myrland et al., 2000), people with higher incomes (Can et al., 2015; Cavaliere et al., 2019; Herrmann et al., 1994; Lee and Nam, 2019; Thong and Solgaard, 2017; Yousuf et al., 2019) and living with a partner (Cavaliere et al., 2019; Kumar et al., 2008; Thong and Solgaard, 2017), usually have a higher frequency of consumption of different seafood products.

Moreover, other factors are related to the lifestyle of the respondent. It has been found that consumers tend to consume seafood products more frequently when: they are used to eat seafood products (Yousuf et al., 2019); they frequently consumed seafood when they were young (Murray et al., 2017); they engage in regular physical activity (Myrland et al., 2000); and they engage in recreational fishing activities (Herrmann et al., 1994).

As shown in Table 2.3 (Section 2.7.1), most of the studies analysed the general frequency of consumption, and only a limited number carried out separate analyses for home consumption or away-from-home consumption, or both. This is an important point to consider given that some studies have found that the main determinants of home and away-from-home FAPs consumption differ (Almeida et al., 2015; Herrmann et al., 1994). In addition, Almeida et al. (2015) concluded that the self-reported frequency of consumption of seafood differs from the frequency of consumption calculated as the sum of the frequency of consumption of seafood on different occasions (at-home or away-from-home, at lunch or dinner), being the self-reported frequency of consumption of around 3 times a week, while the estimated consumption from summing up the various occasions is approximately 5 times a week. The difference might be due to the fact that the respondents could be more accurate when their consumption response is based on occasions, as it might be easier for them to take into account the seafood consumed as a supplement, such as an intake included in a sandwich, rather than just considering the seafood consumed as a main meal dish. The authors, therefore, concluded that it would be better to ask for more detailed information on consumption as the general answer tends to underestimate the frequency of consumption.

Focusing now on the studies that have assessed the frequency of away-from-home consumption separately, Almeida et al. (2015) found that the frequency of at-home consumption was far higher than the frequency of away-from-home consumption. The authors also found that consumers with a higher knowledge of seafood (in terms of the amount of information they know about the characteristics, the preparation and the assessment of the quality of fish and other seafood) had a higher frequency of consumption of seafood and were more interested in information on seafood products. In another study, Hori et al. (2020) found that eco-friendliness was a significant positive reason for the more frequent consumption of seafood away-from-home, while freshness, price, quality and taste and the expiry date were significant reasons for not consuming seafood more frequently away-from-home. The country of origin and food safety were not significantly linked to the frequency of away-from-home consumption.

2.2.1 Attitudinal factors

Attitudinal factors present a general pattern of preference. Several studies have shown that there is a higher frequency of consumption for consumers who: prefer fresh products over

other presentations (Almendarez-Hernández et al., 2017; Can et al., 2015; Kumar et al., 2008; Yousuf et al., 2019); have a positive attitude towards seafood products (Kumar et al., 2008; Lee and Nam, 2019); care about eco-labels and the environment (Almendarez-Hernández et al., 2017); care about health issues of the products (Can et al., 2015; Murray et al., 2017; Thong and Solgaard, 2017); and consider important that the seafood products have low calories and fat (Thong and Solgaard, 2017). On the other hand, certain attitudes that favour a lower frequency of consumption of seafood products are: being uncomfortable cooking or preparing seafood (Murray et al., 2017; Thong and Solgaard, 2017); not purchasing wild seafood (Murray et al., 2017); or finding the products with higher prices (Hall and Amberg, 2013; Lee and Nam, 2019; Thong and Solgaard, 2017). Based on the previous findings, we have proposed the following first hypothesis:

H1: Attitudinal factors towards the characteristics of FAPs are important determinants of the frequency of away-from-home consumption of FAPs.

2.2.2 Psychological factors

Other factors are related to life conditions and life satisfaction. For general fish consumption, Maciel et al. (2016, 2019) found that those who consume fish often had a better perception of the quality of life and were more physically active. They concluded that they were healthier people. As a result, we can establish the following hypothesis:

H2: Psychological factors are relevant determinants of the frequency of away-from-home consumption of FAPs.

2.2.3 Sociodemographic and economic factors

Sociodemographic and economic factors are also important determinants of away-from-home consumption. Baptista et al. (2020) found that consumers who were born between 1961 and 1997, who have high incomes, postgraduate education and families without children are more likely to eat seafood products in restaurants than to eat them at-home. Herrmann et al. (1994) found that consumers associated with frequent purchases at restaurants are likely to be those with the highest income, white-collar occupations, recreational fishing activities and living in households with children aged 10 or under. They also determined that the attitudinal variables show less correlation with the frequency of purchases at restaurants than with the frequency of at-home consumption. Based on the previous investigations, we have established the following two hypotheses:

H3: There are differences in the frequency of away-from-home consumption of FAPs depending on sociodemographic factors.

H4: There are differences in the frequency of away-from-home consumption of FAPs depending on factors that are related to the economic status of consumers.

2.3 Data and methodology

We used the Special Eurobarometer survey 2018 (European Union, 2018a) as the main dataset for our study. This dataset has already been used by the study (Cantillo et al., 2020) as it has a lot of potential to analyse FAPs consumption issues in the EU due to its representativeness. The survey includes a series of questions that analyse the internal market of FAPs in the EU28 and was conducted at the request of the European Commission between June and July 2018. The surveys were conducted face to face in the 28 countries of the EU, using the native language of the country of residence of the individuals. The final sample consisted of 27734 EU residents and the sample description can be found in Table 2.1, including information on the number of respondents per country and the frequency of the total sample.

Table 2.1. Sample features

Country	Frequency	Percentage (%)
FR - France	1006	3.6
BE - Belgium	1055	3.8
NL - The Netherlands	1006	3.6
DE-W - Germany - West	1011	3.6
IT - Italy	1025	3.7
LU - Luxembourg	506	1.8
DK - Denmark	1020	3.7
IE - Ireland	1011	3.6
GB-UKM - Great Britain	1043	3.8
GR - Greece	1016	3.7
ES -Spain	1035	3.7
PT - Portugal	1082	3.9
DE-E Germany East	539	1.9
FI - Finland	1017	3.7
SE - Sweden	996	3.6
AT - Austria	1044	3.8
CY - Cyprus (Republic)	503	1.8
CZ - Czech Republic	1023	3.7
EE - Estonia	1004	3.6
HU - Hungary	1064	3.8
LV - Latvia	1007	3.6
LT - Lithuania	1015	3.7
MT - Malta	502	1.8
PL - Poland	1033	3.7
SK - Slovakia	1071	3.9
SI - Slovenia	1015	3.7
BG - Bulgaria	1031	3.7
RO - Romania	1021	3.7
HR - Croatia	1031	3.7
Total	27732	100.0

In the present study, the frequency of away-from-home consumption of FAPs is the dependent variable, while the independent variables are associated with attitudes about the consumption of FAPs and sociodemographic characteristics of the individuals. The Eurobarometer survey addressed the frequency of away-from-home consumption of FAPs with the following question:

"How frequently do you eat fishery or aquaculture products at restaurants and other food outlets (canteens, bars, market stands etc.)?". Respondents must choose only one of the following options: "at least once a week", "at least once a month but less than once a week", "several times a year but less than once a month", "less than once a year", "never" and "don't know". Those who replied with the "don't know" option were insignificant and as a result, not considered in the present investigation. According to the Eurobarometer survey, in the EU, 11% of the respondents reported consuming FAPs away-from-home at least once a week, 21% at least once a month but less than once a week, 28% several times a year but less than once a month, 14% less than once a year and 26% never (European Union, 2018a).

With regard to the independent variables, the attitudes towards the reasons for buying or eating FAPs were measured in the Eurobarometer survey by displaying a list of possible options that allowed respondents to select up to three of them, while the preferences for certain product attributes such as the method of harvesting (farmed vs wild), local preference and sea-product preference were assessed through multiple choice questions with a unique answer.

A description of the independent explanatory variables is provided in Table 2.2. Variables that were fixed to 0 for the estimation of the model are accompanied by the word 'base' between brackets. The independent variables were organized according to the following broad categories to facilitate the description and discussion of the results:

- Category 1: Attitudes towards characteristics of the product
- Category 2: Psychological factors related to life conditions and life satisfaction.
- Category 3: Sociodemographic factors.
- Category 4: Economic factors.

Table 2.2. Definitions of the independent variables

Variable	Definition
Attitudes towards characteristics of the product	
6 dummy variables regarding the main reasons for buying or eating FAPs	Healthy
	Taste good
	Are products for special occasions
	Contain little fat
	Easy to digest
	Less expensive than other food
1 wild products preference dummy variable	Wild products preference
1 sea products preference dummy variable	Sea products preference
1 locals products preference dummy variable	Preference for local and national products
Psychological factors related to life conditions and life satisfaction	
4 dummy variables regarding life satisfaction	Very satisfied
	Fairly satisfied
	Not very satisfied
	Not at all satisfied (BASE)
4 Dummy variables regarding the expectations of life conditions in 5 years	Better
	The same/ no change
	Worse (BASE)
	NA
Sociodemographic factors	

Variable	Definition
29 country dummy variables	FR - France
	BE - Belgium
	NL - The Netherlands
	DE-W - Germany - West
	IT - Italy
	LU - Luxembourg
	DK - Denmark
	IE - Ireland
	GB-UKM - Great Britain
	GR - Greece
	ES -Spain
	PT - Portugal
	DE-E Germany East
	FI - Finland
	SE - Sweden
	AT - Austria
	CY - Cyprus (Republic)
	CZ - Czech Republic
	EE - Estonia
	HU – Hungary (BASE)
	LV - Latvia
	LT - Lithuania
	MT - Malta
	PL - Poland
	SK - Slovakia
	SI - Slovenia
	BG - Bulgaria
7 age generations dummy variables	15 - 24 years (BASE)
	25 - 34 years
	35 - 44 years
	45 - 54 years
	55 - 64 years
	65 - 74 years
	75 years and older
4 dummy variables according to household size	Household size (1) (BASE)
	Household size (2)
	Household size (3)
	Household size (4 or more)
3 dummy variables related to the place of living	Rural area (BASE)
	Towns and suburbs/ small urban areas
	Cities/ large urban areas
Economic factors	
3 dummy variables related to difficulties in paying the bills at the end of the month in the last year	Most of the time (BASE)
	From time to time
	Almost never/never
6 dummy variables related to the class of society	The working class (BASE)
	The lower middle class

Variable	Definition
	The middle class
	The upper-middle class
	The higher class
	NA

2.3.1 Methodology

The present investigation uses a heteroscedastic ordered probit model to analyse the determinants of away-from-home consumption of FAPs. The ordered probit model approach was selected considering that the responses given by consumers regarding the frequency of away-from-home consumption were ordinal (Kumar et al., 2008; Thong and Solgaard, 2017). Probit models have been previously selected as an approach to assess fish consumption behaviour in the investigations of Almendarez-Hernández et al. (2017), Kumar et al. (2008), Lee & Nam (2019), Myrland et al. (2000), Terin (2019) and Thong & Solgaard (2017). We selected the form of a heteroscedastic model, which allows the standard deviation of the error term to vary, offering more trustable and less unbiased results than homoscedastic models.

The model has a utility function that relies on a latent dependent variable Y_i, which depends on a linear combination of an independent variable vector X_i and a vector parameter θ_i, and an error term ε_i . as shown in equation 2.1. The vector parameter is to be estimated, while the error term allows obtaining unobserved factors of individual *i*.

$$Y_i = \sum_{k=1}^{K} \theta_i X_i^k + \varepsilon_i \qquad (2.1)$$

The dependent variable Y_i on Equation 1 cannot be observed but can be measured by a set of y_i indicators representing the different levels or categories of the frequency of away-from-home consumption, which in our case consist of five different consumption levels (Equation 2.2). From this equation, the threshold category parameters (μ_1, μ_2, μ_3, μ_4) indicate the points of variation for the level of consumption given a high change in the latent preference and are to be estimated taking into account that $\mu_1 < \mu_2 < \mu_3 < \mu_4$.

1st level – Never: $y_i = 1$ if $Y_i \leq \mu_1$

2nd level: Less than once a year: $y_i = 2$ if $\mu_1 < Y_i \leq \mu_2$

3rd level: Several times a year but less than once a month: $y_i = 3$ if $\mu_2 < Y_i \leq \mu_3$ (2.2)

4th level: At least once a month but less than once a week: $y_i = 4$ if $\mu_3 < Y_i \leq \mu_4$

5th level: At least once a week: $y_i = 5$ if $\mu_4 < Y_i$

Moreover, the model assumes that the independent variables (which explain the behaviour of the dependent variable) are a set of socioeconomic characteristics of individuals as well as particular attitudes towards FAPs. The selection criteria for the independent variables were based on our expertise and the literature review (Table 2.3). We tried to cover all the factors analysed in other studies, with the limitation that the variables were included in the questions answered in the Eurobarometer survey. The model allows estimating the probabilities for each frequency of consumption level according to a variation in the different attributes incorporated.

The heteroscedastic model allows the standard deviation of the error term to vary according to the following equation: $\sigma = \exp(\delta Z_i)$, where Zi is a vector of variables that explain the level of variance and δ is a vector of parameters to be estimated. The parameters are estimated by maximising the log-likelihood function.

Moreover, we estimated the marginal effects for the different attributes, which indicate the change in the probability of away-from-home consumption of FAPs for each level of consumption when there is a change in the value of an independent variable.

Among the limitations of the use of traditional ordered probit models, it should be clarified that these models do not account for unobserved heterogeneity and therefore assume that the estimated parameters are considered to be fixed. However, the specification of a simpler model that does not account for unobserved heterogeneity favours the interpretation of the results, which may be more meaningful for policy analysis.

2.4 Results

Homoscedastic and heteroscedastic ordered probit models were estimated (see Appendix B for full results). We also estimated the marginal effects on different away-from-home consumption patterns of FAPs. In several cases, the results of the heteroscedastic model indicated that the standard deviations of the factors were significant, suggesting that assuming homoscedasticity could lead to biased results for some of the coefficients of the parameters in the homoscedastic model. In addition, the likelihood ratio test showed that the heteroscedastic model was superior to the homoscedastic, thus the results of the investigation will be based on the outcomes of this superior model.

The marginal effects on the away-from-home consumption of FAPs at least once a week are shown in Figure 2.1, while those related to the frequency of consumption at least once a month but less than once a week are shown in Figure 2.2. In these figures, the green colour elements are significant drivers of the frequency of consumption, the red elements are significant drawbacks, and the white elements are non-significant factors. The description of the results is organized according to the categories presented in the previous section.

Figure 2.1. Marginal effects for the away from home consumption of FAPs (At least once a week)

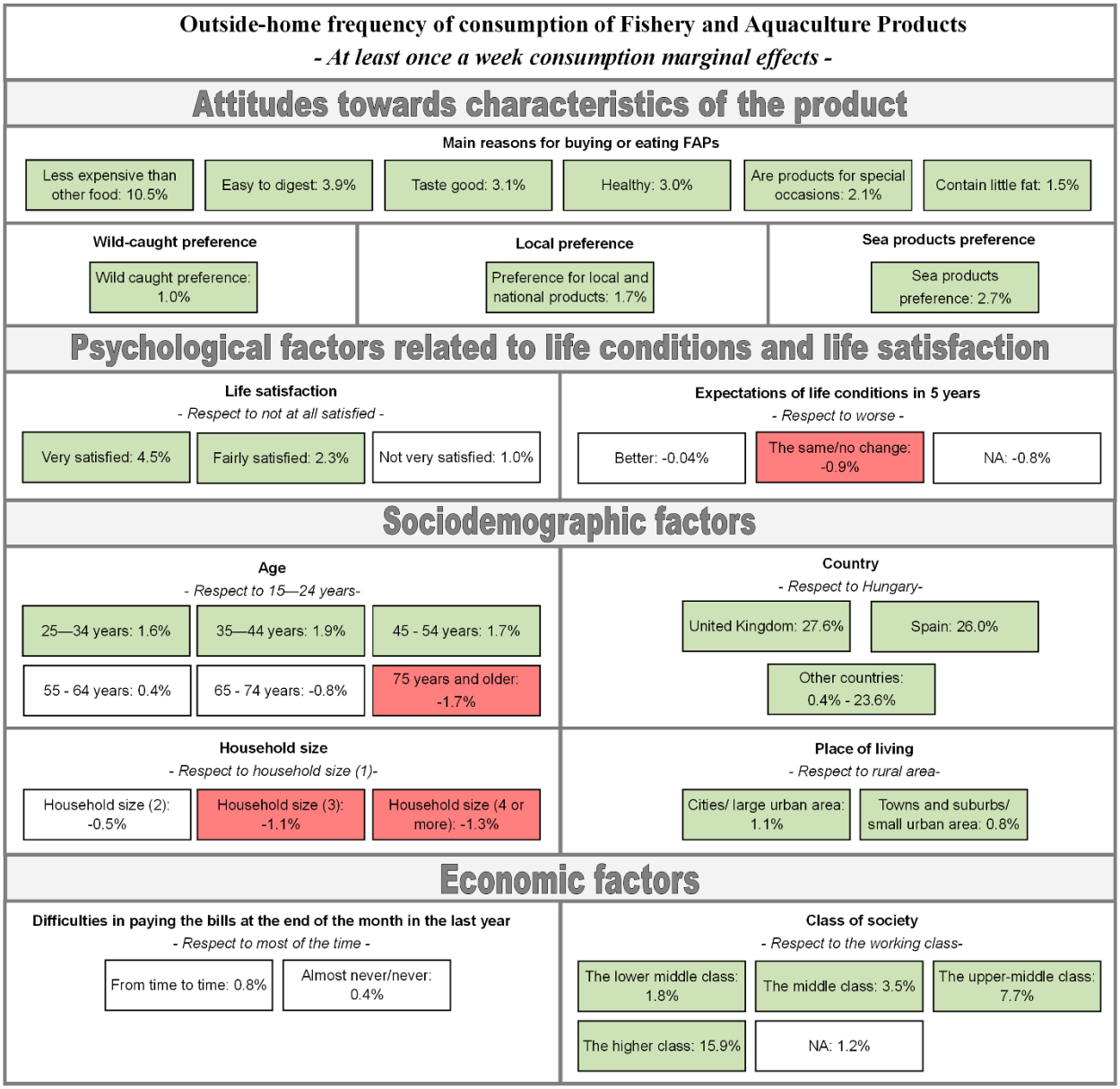
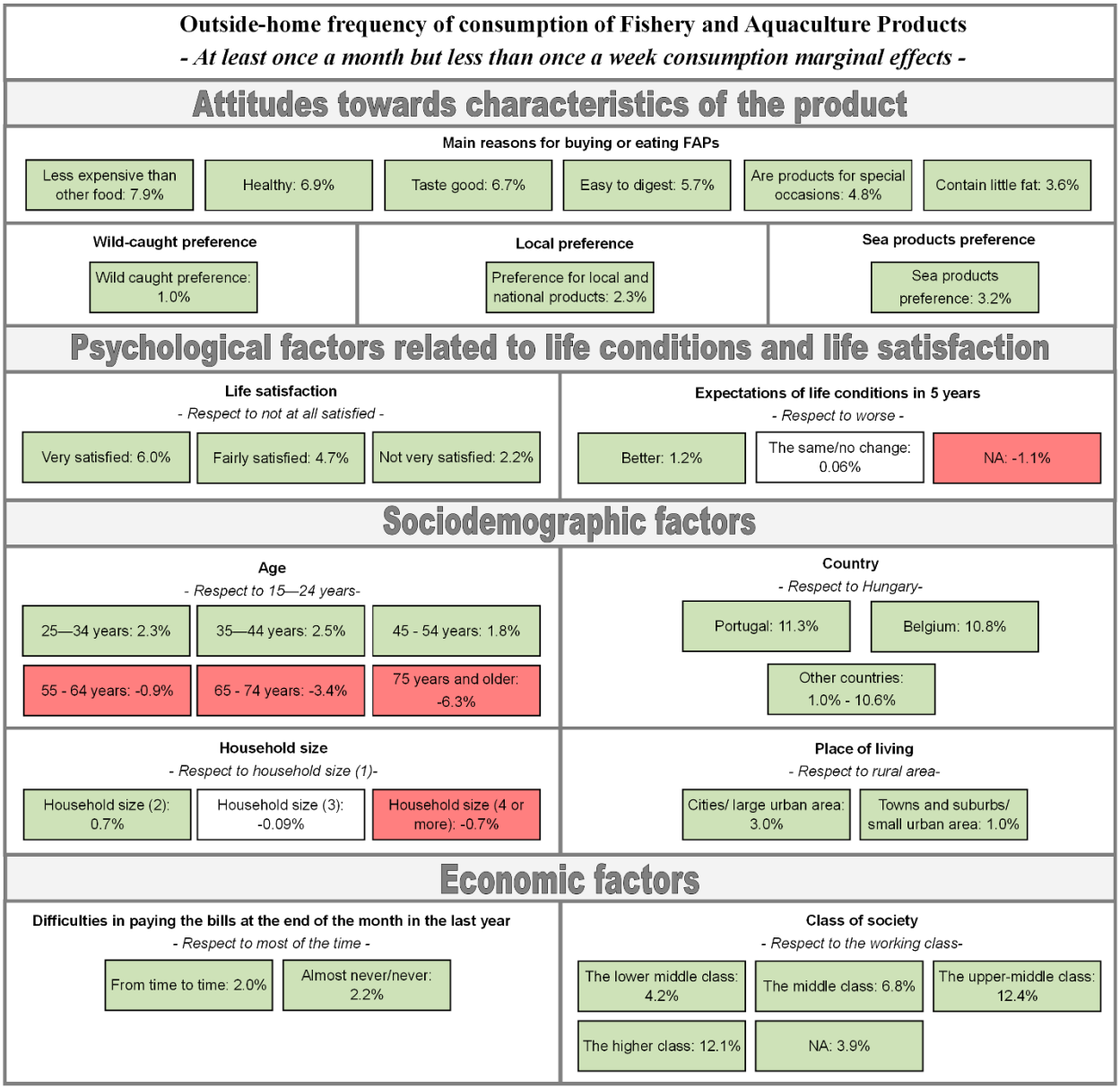


Figure 2.2. Marginal effects for the away from home consumption of FAPs (At least once a month, but not more than once a week)



2.4.1 Attitudes towards the main reasons to eat or buy FAPs

We confirmed that attitudes towards the main reasons for eating or buying FAPs are important determinants of the frequency of away-from-home consumption of FAPs. It was found that the attitude associated with the highest probability to consume FAPs away-from-home more frequently is to consider them as less expensive than other foods, while other important attitudes that increase their consumption is to eat or buy them because they are "easy to digest, healthy, taste good" are products for special occasions or because they contain little fat.

Consumers who consider that one of the main reasons for consuming FAPs is because they are less expensive than other foods, have a higher probability of around 10.5% and 7.9% to consume them at least once a week and at least once a month, respectively. For other reasons, the probability ranges from 1.5% (contain little fat) to 3.9% (easy to digest) for the level of

consumption of at least once a week, and from 3.6% (contains little fat) to 6.9% (healthy) for the level of consumption of at least once a month but less than once a week.

Moreover, the preference for marine products over freshwater products, local versus foreign products, and wild-caught versus farmed products are significant drivers of higher consumption rates, for both at least once a week and at least once a month levels of consumption. Among these, the preference for marine products was the most important aspect for both levels of consumption, increasing the likelihood of consumption at least once a week by 2.7% and of at least once a month by 3.2%.

2.4.2 Psychological factors related to life conditions and life satisfaction

Life satisfaction was also a positive driver of higher consumption rates. In fact, those with the highest level of satisfaction had a higher probability of 4.5% of consuming the products at least once a week and of 6.0% of consuming the products at least once a month compared to those individuals who were not at all satisfied with their lives. With regard to life conditions expectations, it was found that those who consider that their life conditions in five years would be the same have a lower probability of around 0.9% of consuming the products at least once a week, compared to those that are in the endpoints (worse or better life conditions); however, those than consider that they will be better, have a higher probability of 1.2% to consume the products at least once a month but less than once a week than those that expect their conditions to be worse.

2.4.3 Sociodemographic factors

The results show that the frequency of away-from-home consumption of FAPs varies between countries, with British consumers having the highest probability of consumption for the at least once a week level and Portuguese consumers for the at least once a month but less than once a week level. Figure 2.3 and Figure 2.4 show the probabilities of eating FAPs at least once a week and at least once a month away-from-home for the countries, respectively, indicating in general terms, that the residents of the countries located on the western part of the EU28 tend to have a higher probability of consuming FAPs away-from-home more frequently than those located in countries on the eastern part of Europe.

According to the age, the results show that consumers between 25 and 54 years of age are more likely to consume FAPs away-from-home at least once a week of around 1.6% to 1.9%, compared to those between 15 to 24 years; while those over 75 years of age were less likely to consume them at least once a week than the youngest group at around 1.7%. Similar results were found for the consumption level of a least once a month but less than once a week, with residents between 25 and 54 years of age having a higher probability of 1.8% to 2.5% to consume FAPs away-from-home compared to the youngest generation, while those older than 55 had a lower probability of consuming FAPs at least once a month but less than once a week than the youngest generation ranging from 0.9% to 6.3%.

Furthermore, the results show a tendency of a lower frequency of away-from-home consumption of FAPs for larger household sizes, while there is a higher frequency of

consumption for residents living in cities, towns and suburbs compared to those living in rural areas.

Figure 2.3. Probability of eating FAPs away from home for countries at least once a week

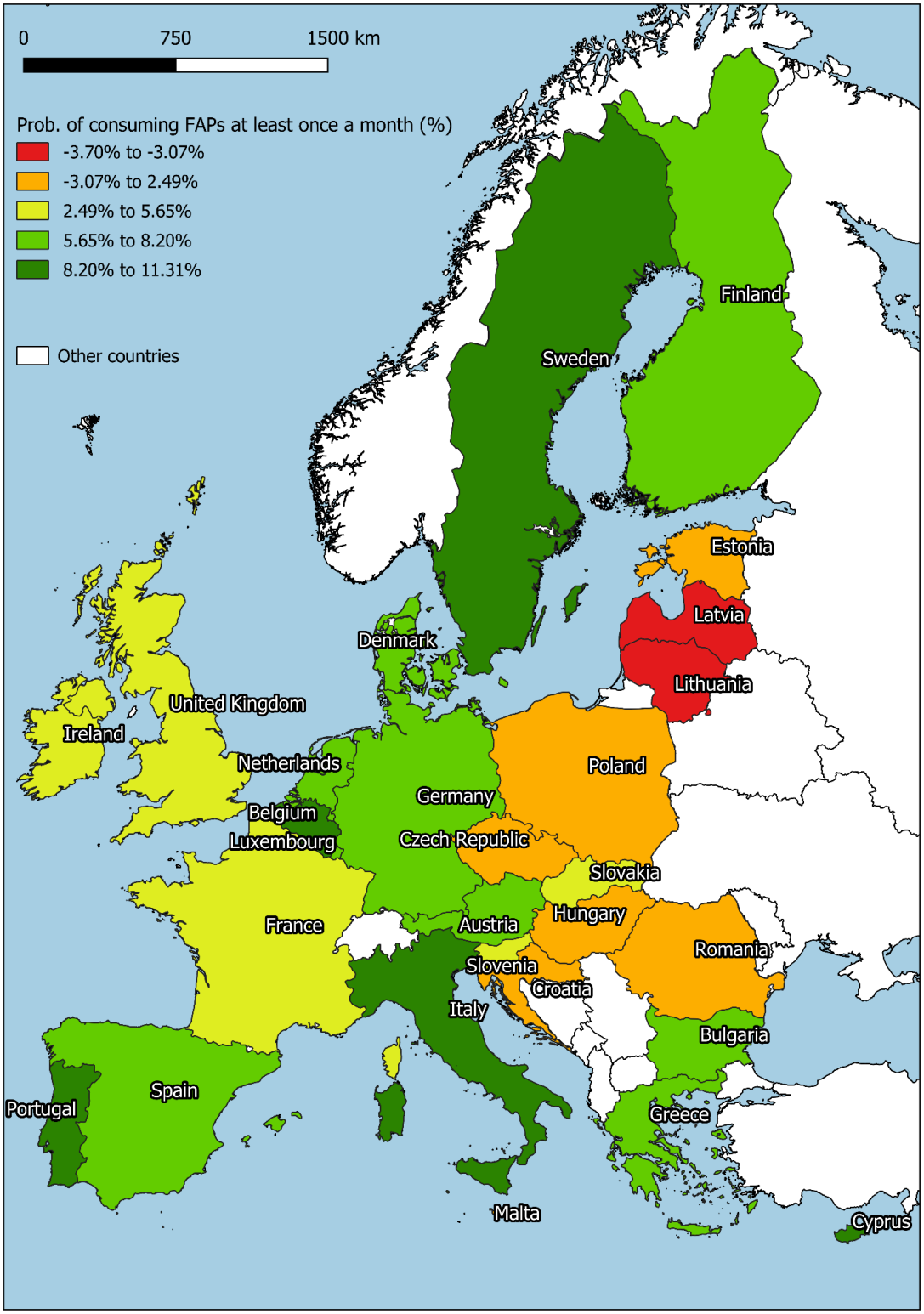
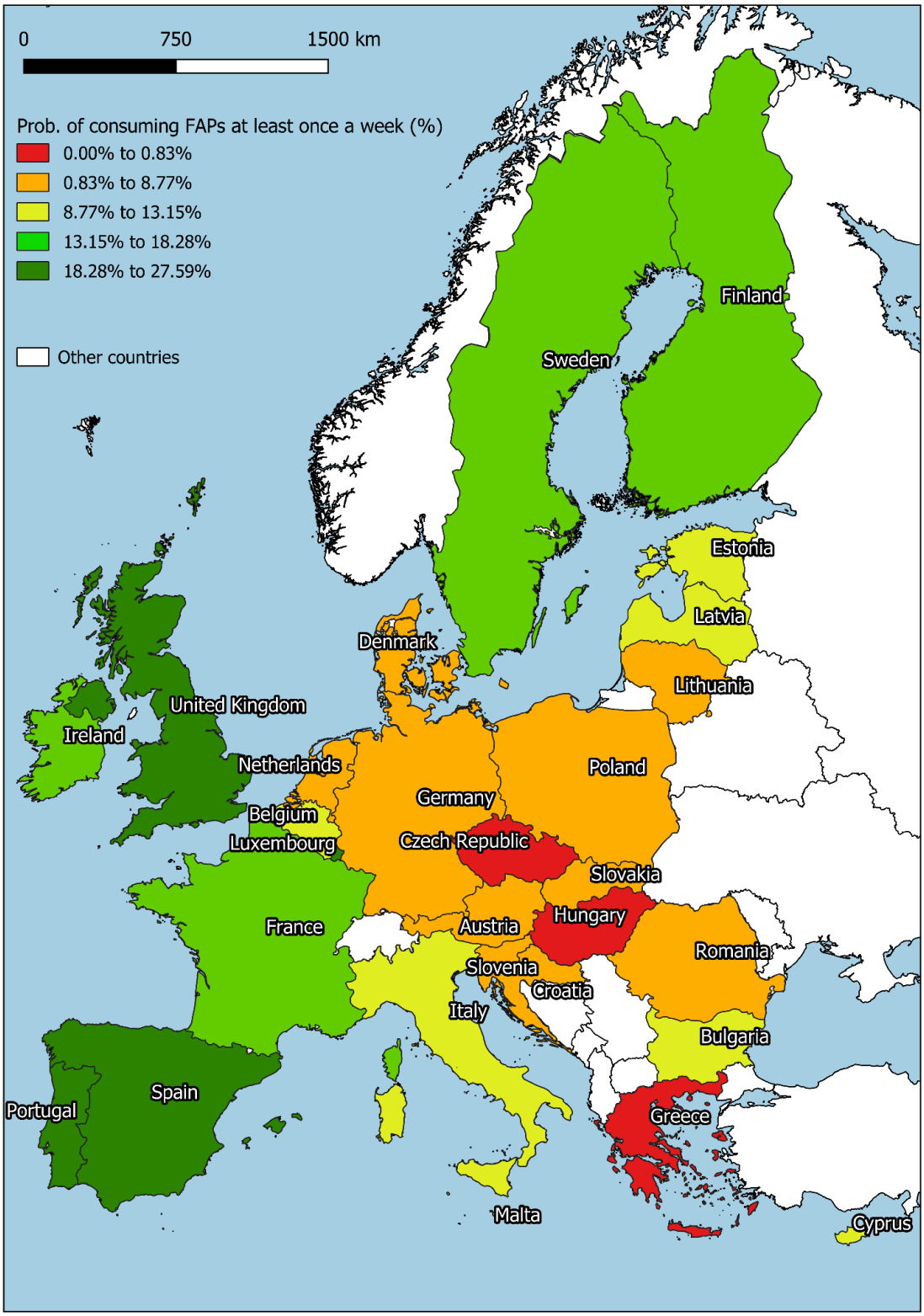


Figure 2.4. Probability of eating FAPs away from home for countries at least once a month



2.4.4 Economic factors

The class of society attribute showed the highest marginal effects and indicated that those in the higher classes have a higher probability to consume FAPS away-from-home more frequently, reaching up to 15.9% for the higher class in the consumption level of at least once a week.

The variable related to the difficulty of paying bills at the end of the month in the last year was not correlated to the frequency of consumption of at least once a week, while for the frequency of consumption of at least once a month, showed a higher frequency of consumption for those with less or no difficulties, compared to those with difficulties most of the time.

2.5 Discussion

2.5.1 The impact of generational differences on away-from-home fish consumption

We found that consumers between 25 and 54 years of age (born between 1964 and 1993) are more likely to consume FAPs away-from-home. Similar results have been found by Baptista et al. (2020) in Brazil, who have determined that consumers born between 1961 and 1997 are more likely to eat seafood products in restaurants than to eat them at-home. This can be explained by the fact that this group is the largest active labour force, which means that they generally have higher incomes, allowing them to spend more money on leisure activities such as eating at restaurants or food outlets. In addition, since this group also tends to have the busiest schedules, it may be more convenient for them to save time by avoiding cooking at home more regularly.

Meanwhile, those over 75 years of age had the lowest probability of consuming FAPs away-from-home more frequently. This may be due to a number of reasons, such as the preference and availability of more time to cook their own meals, as this group of people usually do not work; and it may also be related to dietary restrictions that make it difficult for them to find suitable products that could be consumed away-from-home. In view of this, the strategy that can be implemented is to highlight the importance of the nutritional and health benefits that FAPs can offer.

2.5.2 Away-from-home fish consumption: a luxury meal or an affordable food choice?

In our results, the largest marginal effects were related to the social class of the residents, indicating that there is a higher frequency of away-from-home consumption of FAPs for high-class residents. Similar results were found in the investigations of Baptista et al. (2020) and Herrmann et al. (1994). Both studies found a higher frequency of restaurant purchases of seafood products for consumers with higher incomes. This finding and the fact that those who consider that "FAPs are products for special occasions" are more likely to consume these products more frequently, suggest that seafood could probably be perceived as a luxury food to be eaten away-from-home. However, our findings also indicated that the most important

attitude that contributes to consuming more frequently away-from-home FAPs was to consider them to be less expensive than other foods.

This apparent contradiction can be explained considering different aspects. First, it is important to point out that those higher-income consumers usually eat more often in restaurants, regardless of the product they consume, so the higher frequency of consumption for this group may be the result of a higher presence in restaurants. For this reason, it is important that future studies compare the actual propensity of people with higher incomes to choose fish instead of other food products at restaurants. Some investigations have already shown that affluent consumers usually consume more frequently fish than meat products (Cavaliere et al., 2019; Islam et al., 2018), but the results cannot be generalized to the away-from-home context.

It is also important to consider that there is a wide range of prices that can be found in the European restaurants and food outlets, depending on the type of fishery and aquaculture product consumed and the type of restaurant. Products can therefore be cheaper than other foods if cheap species (such as hake, cod, pangasius and tilapia) are considered in affordable restaurants compared to other protein sources, but at the same time products can be considered as luxury if species such as lobster, salmon, bluefin tuna or caviar are consumed in places specialized in high-income segments. In addition, given the heterogeneity of the sample, the discrepancies may be due to different cultural and social factors regarding the status of fish in each country.

2.5.3 The role of health on away-from-home fish consumption

Other important reasons that increase the frequency of away-from-home consumption of FAPs are to eat or buy them because they are easy to digest, healthy or low-fat products. These attitudes evidence that consumers attach great importance to the health and nutritional benefits of FAPs. This is not surprising given the high recognition of seafood products as healthy and nutritious for benefits such as high content of Omega 3 and low-fat content (Birch and Lawley, 2012; Verbeke et al., 2007d). Other important nutrients found in FAPs include vitamins A and D3, digestible proteins, and minerals such as iodine and selenium (Ramalho Ribeiro et al., 2019).

2.5.4 The role of products' attributes on away-from-home fish consumption

In addition, the findings indicate a higher frequency of away-from-home consumption of FAPs for consumers who prefer wild-caught to farmed products, local to foreign products and sea to freshwater products. Consumers may obtain indirect information on the harvest method and the origin of the FAPs when they eat in restaurants located near a water body (beach or river) and expect that the products are fresh and wild. For example, consumers may choose restaurants located near a beach or a marine, expecting that their products are wild, local and recently caught, because of their proximity to that water source. In this sense, a sort of endogeneity issue might be present in a way that these locations could be indirectly favouring these specific fish attributes in consumers' preferences. The fact that there is a higher frequency of consumption for those who prefer wild-caught products is consistent with many investigations in the literature, in which consumers describe farmed products as being of lower

quality and less healthy when compared to wild-caught (Claret et al., 2014; Verbeke et al., 2007b). Thus, this finding reaffirms that aquaculture producers, authorities and promoters should continue to work on planned programs to change the negative image that aquaculture products currently have (Bronnmann and Hoffmann, 2018). Moreover, the fact that those who prefer local products have a higher frequency of away-from-home consumption was expected, given that many investigations have found similar results, for reasons such as greater trust in local products or the ethnocentrism of consumers (Luomala, 2007; Verlegh and Steenkamp, 1999) or even because of health and food safety issues (Hinkes and Schulze-Ehlers, 2018). Also, the higher frequency of away-from-home consumption of FAPs for those who prefer sea products to freshwater products, indicates that freshwater producers must encourage trust in their products by promoting the quality of their products through marketing campaigns.

2.5.5 Consumers' psychological factors and their relationship with the away-from-home consumption

According to our results, favourable psychological attitudes such as optimism and positiveness in life satisfaction and future living conditions, contribute to increased away-from-home consumption of FAPs. This can be explained considering that, probably due to their current and future good living conditions, consumers are willing to spend more money on eating food away from home on a more frequent basis. Similar results were found in the investigations of Maciel et al. (2016, 2019) who determined that those who consume fish regularly had a better quality of life perception and were more physically active. However, the literature is very scarce on the relationship between FAPs consumption and quality of life, as only the two studies mentioned assess this issue, and they refer to fish consumption in general, and not particularly to the away-from-home consumption.

2.5.6 Home vs away-from-home consumption

In a similar study, using the same Eurobarometer survey but focusing on at-home consumption, Cantillo et al. (2021) found similar trends in some of the variables, as well as opposite results in others. With regard to similarities, it was found that consumers who prefer wild-caught products, who are very satisfied with their lives, who are part of the higher classes of society and never or rarely have any difficulty paying bills, have a higher frequency of at-home consumption of FAPs. In addition, there is a similar trend towards higher consumption of FAPs at home and away from home for countries located on the western side of Europe. Similarly, as in the present study, Cantillo et al. (2021) found that selecting as important any of the reasons listed for eating or buying the products would result in a higher probability of consuming FAPs more frequently, except for the reason "are products for special occasions", which suggest that FAPs are usually consumed at special occasions that are celebrated away-from-home, rather than at those celebrated at-home, in which they probably preferred other food options. Also, regarding the similarities between countries, it was found that countries, such as Portugal and Sweden have a relatively high consumption of FAPs both at home and away-from-home, while other countries, such as the Czech Republic and Hungary have relatively low consumption of FAPs both at home and away-from-home. With respect to the opposite results, Cantillo et al. (2021) found that consumers over 55 years of age tend to eat

FAPs more frequently at-home, which implies that the generational effect is a relevant factor in distinguishing between groups consuming more at-home or away-from-home. It seems evident that the generational effect might depend on the health and cultural reasons. Older consumers usually have more dietary restrictions that restrict them from getting appropriate seafood at restaurants and food outlets, while they can cook the products the way they need at-home. Moreover, the fact that older people were born in a less globalized world, in which at-home consumption was more frequent when they were younger, could also have an impact on their preference to consume more these products at-home. Furthermore, the results of Cantillo et al. (2021) also differed from the current study with respect to the place of living. They found that those living in cities and large urban areas have a lower frequency of at-home consumption of FAPs. This might be in part explained because consumers living in these areas have better access to restaurants and food outlets, and as a result, they consume FAPs more frequently away-from-home. Similarly, the results for those who live in rural areas can be explained analogously. Another interesting difference to highlight is related to the household size, as Cantillo et al. (2021) found that those living in households with 3 or more people tend to consume FAPs at-home more often, suggesting that FAPs are more regarded as a family meal when eating at home, while in restaurants and food outlets, they are more popular with couples and single consumers. Finally, regarding the differences between countries, we found that countries, such as Latvia, Lithuania and Estonia, present an interesting duality regarding the pattern of FAPs consumption: high at home and low away-from-home. On the other hand, Belgium showed the opposite duality, that is, high consumption of FAPs away-from-home and low consumption at-home.

2.6 Conclusions

The findings of this investigation present very important and useful insights for restaurant owners and the rest of the stakeholders of the supply chain who obviously could benefit from an increase in the frequency of away-from-home consumption of FAPs. The information can be used to enhance the marketing campaigns of the products and to look for better strategies that increase the consumption of the products in the EU. In addition, we highlight that the use of a proper representative sample increases the strength and reliability of the results.

We have proved the four hypotheses formulated. For the first hypothesis, we found that certain attitudes that increase the frequency of consumption of FAPs are to consider important the following reasons to buy or eat them: less expensive than other foods, easy to digest, healthy, tasty, low-fat and for special occasions. Also, we found that consumers who prefer wild, local and marine products consume FAPs away-from-home more frequently, which could be an indirect consequence of choosing a restaurant near a water body, as they expect certain fish characteristics based on the selected location. For the second hypothesis, we found that those who are more satisfied with life and optimistic about future living conditions have a higher probability to consume FAPs more frequently away-from-home. With regard to the third and fourth hypotheses, we determined that consumers between 25 and 54 years of age, who live in smaller households not located in rural areas, belonging to the higher class of society and who have fewer financial difficulties are more likely to consume FAPs away-from-home.

The main limitation of this study is that it is based on a survey that is not specific to the consumption of seafood away-from-home but the consumption of seafood in general. As a result, there may be some lack of precision in the results to represent reality, particularly in the attitudes towards the main reasons for the consumption of seafood, as the valuation and preference for attitudes may vary in the differentiation between home and away-from-home consumption. Additionally, another limitation is that the attitudes assessed in the current study describe only beneficial attributes of fish, and therefore those who eat fish will probably find FAPs in a more positive way. The results of this investigation are therefore limited and restricted to the available data, which is a good starting point but requires improvement for more relevant and accurate results. Future research should consider the design of a specific survey, in which the respondents are advised that all the issues addressed fall within the context of away-from-home consumption.

Future studies should focus on similar analyses for particular species in order to obtain clearer results, especially those species that are important for away-from-home consumption should be further analysed. Also, separate analyses are required for fish species and other categories of seafood. Furthermore, it may be relevant to consider the spatial locations of the respondents, to know whether the low away-from-home consumption of FAPs may be due to a lack of specialized seafood restaurants in the area, rather than to consumer preferences. Moreover, future research should also include the spatial location of the consumer, as one possible important driver is how close the consumer lives from a seacoast or a lake.

2.7 Appendixes

2.7.1 Appendix A – Literature review

Table 2.3 presents a review of the main studies which analyse the frequency of consumption of seafood products using a quantitative approach. The table includes the authors, the year of publication, the species analysed, the country or region of application, the methodology, the size of the sample, the context in which the frequency of consumption is studied (general, at-home or away-from-home), the factors considered and the main results.

Table 2.3. Investigations that analyse the frequency of consumption using a quantitative approach

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Almeida et al. (2015)	Seafood products	Portugal	Basic statistics and ANOVA	1240	H&O	Gender, age, education level, work situation, marital status, income, household size, living with children, living environment (rural area, small town, large town), distance from the coast	More knowledgeable consumers had a higher frequency of consumption of seafood and were more interested in information about seafood products. The frequency of at-home consumption was much higher than the frequency of away-from-home consumption.
Almendarez-Hernández et al. (2017)	Tuna	Mexico	Ordered probit model and ordered logit model	364	GC	Income, organic label, free dolphin label, origin, presentation (canned, frozen), price, age, occupation	Higher-income, older and college graduate consumers are more likely to eat fish more frequently. The price of the product was not significant for the frequency of consumption of the product. Consumers who prefer canned tuna have a lower frequency of consumption compared to those who prefer fresh tuna. Consumers who are informed of the "dolphin-safe" eco-label are more eager to consume canned tuna.
Baptista et al. (2020)	Seafood products	Brazil	Multinomial logistic regression	932	H&O	Region of living, gender, generation, marital status, education, family income, children in the family	High-income citizens are more likely to consume seafood products on a weekly basis than those with lower incomes. Consumers who are part of Generation X (born between 1961 and 1980) and Y (born between 1981 and 1997), with high incomes, postgraduate education and families with no children are more likely to eat seafood products in restaurants than to eat them at-home.
Can et al. (2015)	Fish	Turkey	Multiple linear regression (MLR) and statistical analysis	127	GC	Education level, gender, income, primary reasons for fish consumption (economic, health, taste), preferred type of fish (cultivated, caught, frozen), preferred fish marker, fish preparation method, preferred period for fish consumption, number of fish species consumed	Single individuals, students and young people tended to have a higher level of consumption than their counterparts, while females also consumed more fish than males. Health concerns are relevant to fish consumption. The level and frequency of fish consumption were linked to education, total meat consumption and income, while the total number of fish species consumed by consumers and their age are significant predictors of fish consumption. Fresh fish is preferred over processed fish
Cavaliere et al. (2019)	Different food categories, including one for fish	Italy	Ordinary Least Squares (OLS) regression	36032	GC	Education, income, age, gender, household size, marital status	Both socio-economic and demographic factors have an impact on the frequency of fish consumption. Individuals with higher education, higher incomes, young, female, and living with a partner are more likely to consume fish more often.

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Hall and Amberg (2013)	Farmed species grouped in uncommon species, common species, and farmed bivalves	US	Factor analysis	1159	GC	Education, age, income, gender, price, seafood health beliefs, aquaculture problems, aquaculture benefits, wild quality, familiarity, fish concerns, freshness, positive media recall, negative media recall	Price, freshness, and familiarity were the most important factors in the choice of seafood, but they did not predict the consumption of specific classes of farmed species or the overall preference for wild fish rather than farmed products. Beliefs about the benefits of aquaculture were positively linked to increased consumption of aquaculture products, but beliefs about environmental and health-related aquaculture problems did not predict specific choices for consumption. The socio-demographic factors have little or no relation to the consumption of all species. In the case of common fish, education was positively linked to the frequency of consumption of these species.
Hermida and Costa (2020)	Fish and seafood products	Madeira and Porto Santo islands (Portugal)	Generalized linear models (GLM)	465	GC	Age, gender, education level, job, area of residence, job, likes the fish taste, healthy eating, fishing activity	The most important preference and lifestyle factor determining the frequency of consumption of fish and seafood was the taste of fish followed by the activity of fishing. Healthy eating, on the other hand, had no impact on the frequency of consumption. Age had a negative effect on the consumption of seafood (including octopus, shrimp, and limpets additionally from fish) but not on the consumption of fish. Women were more likely to consume both fish and seafood products more frequently. People employed in basic occupations, professionals and technicians had a high level of consumption of fish and seafood, while people outside the workforce had the lowest levels of consumption.
Herrmann et al. (1994)	Finfish and shellfish	US	Logistic regression model and cluster analysis.	1200	H&O	Age, race of the respondent, presence of young children, residence of the respondent, occupation, annual household income, region, recreation fishing by family members, perception variables for fish (readily available, inexpensive compared to other meat, high quality, attractive appearance and packaging, undesirable fish odour, delicate flavour, nutritional value, easy to prepare at-home, has few bones)	Seafood purchases depend on attitudes towards fish, especially on the frequency of purchases at-home. The main drivers of home purchases were white-collar occupation, older age, urban/suburban residence, New England location and recreational fishing participation. Consumers associated with frequent restaurant purchases are likely to be those with the highest income, white-collar occupations, recreational fishing activities and living in households with children aged 10 or under. Attitudinal variables show less correlation with the frequency of purchases at a restaurant than with the frequency of eating at-home.
Higuchi et al. (2017)	Fish	Peru	Probit model	159	GC	Price, age, number of children, family members, education, district, gender.	In predicting the frequency of fish consumption, socio-economic factors have little explanatory power.

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Hori et al. (2020)	Seafood products	Japan	Multiple regression analysis	6000	H&O	Reasons (quality and taste, freshness, expiration date, country of origin, food safety, price, eco-friendliness)	In terms of the frequency of consumption of seafood at-home, quality and taste, freshness, country of origin, eco-friendliness and food safety were significant positive reasons for more frequent consumption of seafood, while the price was a negative reason. The expiry date was not significantly related to the frequency of at-home consumption. As regards the frequency of consumption of seafood away-from-home, eco-friendliness has been a significant positive reason for the more frequent consumption of seafood, while freshness, price, quality and taste and the expiry date have been significant reasons for not consuming seafood more frequently. The country of origin and food safety were not significantly linked to the frequency of away-from-home consumption.
Islam et al. (2018)	Different food categories, including one for fish	Bangladesh	Frequency distribution, factor, and cluster analysis	676	GC	Gender, age, marital status, family size, education, occupation, religion social class, place of living, price preferences (low, high, medium), preference parameters (my family involved in cooking and preparing the meal, quality food with the lowest price, organic food, likeness of shopping food for the family, fresh food, food without preservatives, food nutrition is more important than taste, likeness to go to restaurants, preference to keep fish in the meal, fish over meat, likeness to cook new recipes, likeness to buy new food items)	Fish was mostly consumed by groups related to restaurant consumers and those characterized by a high level of awareness of the quality and price ratio and freshness of food and a high level of concern for the food and cuisine of other family members. The average consumption of fish was higher for men, the upper-middle and upper social classes, living in households with fewer family members, and secondary and higher education levels.
Kumar et al. (2008)	Farm-raised catfish	US	Ordered probit model	1194	GC	Form of purchase, method of preparation, method of serving (main, side dish), place of purchase, freshness, expiration date, origin of the product, USDA labelling, price, packaging preferences, opinion of catfish, ethnicity, marital status, age, household size	Fresh catfish buyers, married couples, Caucasians, and African Americans were more likely to buy catfish more frequently. Also, the positive opinions of catfish, origin labels and vacuum-sealed packaging have had a positive and significant impact on the frequency of purchases.

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Lee and Nam (2019)	Live fish	South Korea	Ordered probit model	766	GC	Residential area, occupation of the respondents, marital status of the respondent, number of family members, household income, preference for live fish, favourable fish species (black rockfish and red seabream), importance of the price, importance of wild-caught products, satisfaction for the safety of live fish.	Respondents with low-priced demand elasticity are likely to consume live fish more frequently. Although the preference for wild-caught fish is relevant to the consumer's choice, it is insignificant for their frequency of consumption. Consumers with higher consumption frequencies usually consider safety to be more relevant than price.
Murray et al. (2017)	Seafood products	Canada	Mixed methods approach (qualitative semi-structured interviews and quantitative survey); Spearman's correlation	315	GC	Important factors when buying seafood (taste, smell and appearance, cultural or religious reasons, wild vs farmed, health benefits and nutritional value, uncomfortable cooking or preparing seafood, price, origin of the product, sustainability of the species, health risks)	There was a significant but small correlation between childhood and adult consumption frequencies. Age was positively correlated with the frequency of adult purchases, while income and gender were not the same. Adult purchase frequency has been positively affected by consumers who have purchased seafood due to its health benefits and nutritional value. The most important factors affecting the decision to purchase seafood were those related to sensory qualities (taste, smell, and appearance). The second most important factor was the price, while other important factors were the distinction between farmed and wild and the origin of seafood and the health benefits.
Myrland et al. (2000)	Three major seafood categories (fat, lean and processed seafood)	Norway	Maximum likelihood probit models and ordered probit models	4014 (Only Norwegian women from 30 to 44 years involved in a medical study)	GC	Age, education, household size, kids in the household, income, region of location, rating level of physical activity, wine consumption, reasons why not to eat more fish (price, too few choices, supply varies too much, quality varies, shortage on prepared dishes, smell during preparation, difficult to prepare, taste, family do not like fish), consumption of other meats and dishes, preference for seafood.	Product attributes are perceived as more important barriers to consumption than price beliefs. The presence and location of school-aged children are relevant factors for the type of seafood consumed, while overall consumption is increased when people are older, have higher education or have a larger household size. Income does not appear to have a direct role to play in the frequency of consumption of seafood. The relationship between the lifestyle and the consumption of fish was assessed on the basis of the level of physical activity and the consumption of wine, the first being a direct relationship to the consumption of fat and lean seafood dishes, probably because they are perceived as healthy dishes; although it could not be possible to attribute a role to wine consumption.

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Terin (2019)	Fish	Turkey	Ordered logit model	260	GC	Income, child number, household head, gender, wife of the house working, other seafood consumption, residence in a rental house, fish prices high, public spots, household head working.	Households with higher incomes and a higher number of children, where the householder works and consumes seafood products other than fish, tend to consume fish more frequently. Households who thought that fish prices were not high or that public places had a positive effect on the consumption of fish tend to consume fish more frequently. The highest marginal effect for the highest level of consumption (more than once a week) is on households that consume other types of seafood other than fish, followed by not considering prices for fish as high.
Thong and Solgaard (2017)	Fish, shrimp, and mussels	France	Ordered probit model	996	GC	Food motives (health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, ethical concern), age, income, education, having child under 15, marital status, family size, gender, region of living	Old and high-income consumers were more likely to consume seafood more frequently, especially fish, while the presence of children in households had a significant impact on the consumption of shrimp, but not on fish and mussels. Single and male consumers eat less seafood than their counterparts, while the family size has a negative effect on the consumption of fish and shrimp. Among the nine reasons assessed for the frequency of fish consumption, the most important ones were weight control (low in fat and calories) and convenience (facility to prepare), the first being a positive driver and the second a barrier. The health motive is a significant predictor of fish consumption, while the natural content is significant for both fish and mussel consumption. Price and household income are major barriers to the consumption of fish and shrimp, while people who consider sensory quality to be important eat fish and shrimp more regularly. Familiarity has a negative impact on the consumption of shrimp and mussels.
Vanhonacker et al. (2013)	Fish products and seabass and seabream	Sweden, Germany, United Kingdom, Romania, Czech Republic, Portugal, Greece, and Italy	Frequency distribution	3213	GC	Country of origin of the respondent	In most of the countries studied, the self-reported consumption of wild fish was higher than the self-reported consumption of farmed fish, except for Germany, Romania, and the Czech Republic. Seabass self-reported consumption was higher than seabream self-reported consumption in Germany, Sweden, the United Kingdom, Greece, and the Czech Republic, while it was the opposite for Italy, Romania, Portugal.

Investigation (year)	Fish species analysed	Country or region of application	Methodology	Sample size	Context of the frequency of consumption	Factors considered	Main results about the frequency of consumption
Yousuf et al. (2019)	Seafood products	Oman	Logit model	906	GC	Nationality, household size job type, education, monthly income, age range of household members, eating preference (home, restaurant, take away, other), form of seafood, expenditure/month, food products preferences (beef, poultry, lamb, vegetables, seafood), seafood, information source, habit, product and physical attributes (quality, taste, protein, convenience, availability, health benefits), selling outlets, price	Nationals, members of smaller households and fresh fish consumers were more likely to consume fish, while consumers with lower incomes and those with persistent habits were more likely to purchase fish more frequently.

H&O: the frequency of consumption is analysed separately by at-home and away-from-home consumption.

GC: the frequency of consumption does not differentiate between the at-home and away-from-home consumption.

2.7.2 Appendix B – Homoscedastic and Heteroscedastic ordered probit models

Table 2.4 presents the complete results of the homoscedastic and heteroscedastic ordered probit models. The values that are in bold letters have a minimum level of significance of 0.05, while those in italics have a minimum level of significance of 0.1.

Table 2.4. Homoscedastic and heteroscedastic model

Value		Homoscedastic model				Heteroscedastic model							
		Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Attitudes towards characteristics of the product													
Reasons for buying	Healthy	0.3841	0.0151	25.3832	0.0000	0.3417	0.0246	3.8688	0.0000	-0.0990	0.0151	6.5699	0.0000
	Taste good	0.3663	0.0140	26.2365	0.0000	0.3144	0.0224	4.0431	0.0000	-0.0836	0.0131	6.3763	0.0000
	Are products for special occasions	0.2435	0.0272	8.9616	0.0000	0.2032	0.0244	8.3409	0.0000	-0.0668	0.0239	2.7894	0.0053
	Contain little fat	0.2004	0.0154	13.0385	0.0000	0.1600	0.0156	0.2626	0.0000	-0.0559	0.0136	4.1024	0.0000
	Easy to digest	0.3000	0.0174	17.2039	0.0000	0.2554	0.0208	2.2675	0.0000	-0.0251	0.0157	1.6054	0.1084
	Less expensive than other food	0.5200	0.0340	15.3045	0.0000	0.4249	0.0406	0.4728	0.0000	0.0649	0.0304	2.1333	0.0329
Wild	Wild products preference	0.0557	0.0156	3.5698	0.0004	0.0458	0.0131	3.4948	0.0005	0.0139	0.0139	1.0035	0.3156
Sea	Sea products preference	0.2011	0.0159	12.6689	0.0000	0.1468	0.0161	9.1477	0.0000	0.0184	0.0142	1.3001	0.1936
Local	Preference for local and national products	0.1451	0.0146	9.9294	0.0000	0.1029	0.0137	7.4913	0.0000	0.0059	0.0133	0.4448	0.6565
Psychological factors related to life conditions and life satisfaction													
Satisfaction	Very satisfied	0.2900	0.0417	6.9526	0.0000	0.2707	0.0392	6.9003	0.0000	-0.0075	0.0394	0.1896	0.8496
	Fairly satisfied	0.2269	0.0390	5.8236	0.0000	0.2204	0.0363	6.0678	0.0000	-0.0521	0.0370	1.4093	0.1587
	Not very satisfied	0.0862	0.0403	2.1387	0.0325	0.0998	0.0364	2.7416	0.0061	-0.0306	0.0386	0.7920	0.4283
Expectations	Better	0.0774	0.0217	3.5640	0.0004	0.0558	0.0186	3.0006	0.0027	-0.0459	0.0198	2.3178	0.0205
	The same/ no change	0.0178	0.0197	0.9066	0.3646	0.0081	0.0168	0.4814	0.6302	-0.0547	0.0183	2.9975	0.0027
	NA	*-0.0583*	0.0307	-1.8976	0.0577	*-0.0499*	0.0274	1.8255	0.0679	-0.0068	0.0291	0.2337	0.8152
Sociodemographic factors													
Countries	FR - France	0.5577	0.0499	11.1667	0.0000	0.4437	0.0473	9.3900	0.0000	0.2523	0.0475	5.3155	0.0000
	BE - Belgium	0.7219	0.0485	14.8800	0.0000	0.5592	0.0463	2.0676	0.0000	0.0148	0.0442	0.3356	0.7371
	NL - The Netherlands	0.4342	0.0503	8.6320	0.0000	0.3263	0.0396	8.2353	0.0000	0.0106	0.0459	0.2319	0.8166
	DE-W - Germany - West	0.2849	0.0498	5.7190	0.0000	0.2383	0.0371	6.4300	0.0000	-0.0933	0.0460	2.0276	0.0426
	IT - Italy	0.6658	0.0497	13.3859	0.0000	0.5347	0.0461	1.5983	0.0000	0.0106	0.0455	0.2318	0.8167
	LU - Luxembourg	0.9338	0.0601	15.5465	0.0000	0.7369	0.0641	1.4899	0.0000	0.2232	0.0560	3.9829	0.0001
	DK - Denmark	0.4649	0.0508	9.1577	0.0000	0.3564	0.0423	8.4191	0.0000	0.0686	0.0468	1.4669	0.1424
	IE - Ireland	0.6233	0.0501	12.4338	0.0000	0.4891	0.0489	9.9953	0.0000	0.2399	0.0485	4.9480	0.0000
	GB-UKM - Great Britain	0.9763	0.0501	19.4925	0.0000	0.7766	0.0623	2.4726	0.0000	0.4009	0.0497	8.0721	0.0000
	GR - Greece	0.3268	0.0511	6.3953	0.0000	0.2619	0.0378	6.9236	0.0000	-0.1851	0.0458	4.0404	0.0001
	ES -Spain	0.9590	0.0498	19.2624	0.0000	0.7871	0.0595	3.2298	0.0000	0.2821	0.0474	5.9548	0.0000
	PT - Portugal	0.9515	*0.0494*	19.2506	0.0000	0.7705	0.0565	3.6448	0.0000	*0.0890*	0.0458	1.9410	0.0523
	DE-E Germany East	0.4628	0.0584	7.9254	0.0000	0.3555	0.0452	7.8590	0.0000	-0.0480	0.0526	0.9121	0.3617
	FI - Finland	0.6137	0.0497	12.3585	0.0000	0.4828	0.0467	0.3375	0.0000	0.1846	0.0460	4.0086	0.0001
	SE - Sweden	0.8358	*0.0506*	16.5114	0.0000	0.6622	0.0521	2.6994	0.0000	0.0913	0.0463	1.9704	0.0488
	AT - Austria	0.4106	0.0493	8.3329	0.0000	0.3349	0.0399	8.3876	0.0000	0.0247	0.0461	0.5350	0.5926

Value		Homoscedastic model				Heteroscedastic model							
		Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
	CY - Cyprus (Republic)	0.5963	0.0603	9.8952	0.0000	0.4874	0.0515	9.4638	0.0000	0.0326	0.0538	0.6062	0.5444
	CZ - Czech Republic	0.0752	0.0497	1.5129	0.1303	*0.0697*	0.0368	1.8956	0.0580	-0.0345	0.0466	0.7413	0.4585
	EE - Estonia	0.2790	0.0503	5.5523	0.0000	0.1765	0.0460	3.8373	0.0001	0.3348	0.0496	6.7480	0.0000
	LV - Latvia	0.0473	0.0507	0.9327	0.3510	-0.1119	0.0547	2.0461	0.0407	0.5038	0.0521	9.6789	0.0000
	LT - Lithuania	-0.0691	0.0512	-1.3492	0.1773	-0.2205	0.0559	3.9410	0.0001	0.4195	0.0526	7.9752	0.0000
	MT - Malta	0.4993	0.0613	8.1461	0.0000	0.3738	0.0604	6.1844	0.0000	0.3560	0.0603	5.9062	0.0000
	PL - Poland	0.2044	0.0497	4.1161	0.0000	0.1155	0.0416	2.7745	0.0055	0.2187	0.0470	4.6530	0.0000
	SK - Slovakia	0.3080	0.0494	6.2294	0.0000	0.2180	0.0420	5.1888	0.0000	0.1894	0.0478	3.9627	0.0001
	SI - Slovenia	0.3551	0.0499	7.1172	0.0000	0.2745	0.0403	6.8126	0.0000	0.0501	0.0464	1.0793	0.2805
	BG - Bulgaria	0.6022	0.0497	12.1116	0.0000	0.4520	0.0461	9.8009	0.0000	0.1460	0.0463	3.1512	0.0016
	RO - Romania	0.2383	0.0498	4.7835	0.0000	0.1351	0.0429	3.1469	0.0017	0.2378	0.0477	4.9847	0.0000
	HR - Croatia	0.2159	0.0498	4.3384	0.0000	0.1118	0.0428	2.6120	0.0090	0.2657	0.0471	5.6413	0.0000
Age	25 - 34 years	0.1315	0.0283	4.6523	0.0000	0.1056	0.0230	4.5941	0.0000	-0.0033	0.0253	0.1300	0.8966
	35 - 44 years	0.1337	0.0272	4.9072	0.0000	0.1145	0.0223	5.1342	0.0000	0.0034	0.0244	0.1397	0.8889
	45 - 54 years	0.1018	0.0275	3.7071	0.0002	0.0822	0.0221	3.7173	0.0002	0.0195	0.0247	0.7916	0.4286
	55 - 64 years	-0.0636	0.0285	-2.2337	0.0255	-0.0482	0.0236	2.0442	0.0409	0.0619	0.0260	2.3856	0.0170
	65 - 74 years	-0.2205	0.0298	-7.3907	0.0000	-0.1792	0.0275	6.5143	0.0000	0.0925	0.0273	3.3836	0.0007
	75 years and older	-0.4229	0.0337	12.5436	0.0000	-0.3737	0.0382	9.7751	0.0000	0.1737	0.0318	5.4530	0.0000
Household size	Household size (2)	0.0418	0.0182	2.2963	0.0217	0.0377	0.0159	2.3702	0.0178	-0.0575	0.0172	3.3507	0.0008
	Household size (3)	0.0042	0.0230	0.1844	0.8537	0.0038	0.0191	0.2006	0.8410	-0.0639	0.0213	3.0001	0.0027
	Household size (4 or more)	-0.0266	0.0218	-1.2179	0.2233	-0.0244	0.0185	1.3189	0.1872	-0.0506	0.0201	2.5140	0.0119
Place of living	Towns and suburbs/ small urban area	0.0705	0.0172	4.0975	0.0000	0.0449	0.0148	3.0272	0.0025	0.0088	0.0160	0.5523	0.5808
	Cities/ large urban area	0.1568	0.0169	9.2725	0.0000	0.1383	0.0163	8.4991	0.0000	-0.0520	0.0156	3.3256	0.0009
Economic factors													
Difficulties	From time to time	0.1134	0.0278	4.0798	0.0000	0.0918	0.0245	3.7507	0.0002	-0.0316	0.0257	1.2295	0.2189
	Almost never/never	0.1276	0.0281	4.5370	0.0000	0.1100	0.0250	4.3915	0.0000	-0.0618	0.0260	2.3747	0.0176
Class of society	The lower middle class	0.1994	0.0220	9.0564	0.0000	0.1830	0.0217	8.4500	0.0000	-0.0615	0.0206	2.9846	0.0028
	The middle class	0.3602	0.0175	20.5501	0.0000	0.3159	0.0241	3.0813	0.0000	-0.0729	0.0165	4.4174	0.0000
	The upper middle class	0.5890	0.0302	19.5250	0.0000	0.4970	0.0378	3.1316	0.0000	-0.1279	0.0272	4.6968	0.0000
	The higher class	0.6864	0.0785	8.7423	0.0000	0.6417	0.0777	8.2573	0.0000	-0.0025	0.0719	0.0344	0.9726
	NA	0.1699	0.0346	4.9075	0.0000	0.1667	0.0316	5.2792	0.0000	-0.0786	0.0333	2.3617	0.0182

Value	Homoscedastic model				Heteroscedastic model							
	Parameter (θ)				Parameter (θ)				Standard deviation of the parameter (σ) Parameter (δ)			
	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Threshold parameters												
Thresholds	Estimate	Std. err.	t-stat	p-val.	Estimate		Std. err.		t-stat		p-val.	
μ_1	1.1937	0.0620	19.2380	0.0000	1.0077		0.0696		14.4840		0.0000	
μ_2	1.6803	0.0624	26.9430	0.0000	1.4302		0.0886		16.1480		0.0000	
μ_3	2.5011	0.0629	39.7360	0.0000	2.1135		0.1245		16.9710		0.0000	
μ_4	3.3435	0.0637	52.5260	0.0000	2.8160		0.1646		17.1070		0.0000	
Model adjustment												
Initial Log-Likelihood	-42574.91				-42574.91							
Final Log-Likelihood	-38587.58				-38032.22							
McFadden's R2	0.0937				0.1067							
AIC	77305.16				76316.45							
Likelihood-ratio test - Homoscedastic model vs. Heteroscedastic model												
Degrees of freedom	61											
LRT	1110.7											
P-value	0.0000											
Statistically superior model:	Heteroscedastic model											
LRT = chi-square test statistic for the likelihood-ratio test: -2(LogLmodel1-LogLmodel2)												
Degrees of freedom = degrees of freedom for the χ^2 test statistic defined as the difference												

Table 2.5 presents the results of the marginal effects of the heteroscedastic model on the frequency of consumption at least once a month but less than once a week (y=4) and at least once a week (y=5).

Table 2.5. Marginal effects

Value		Marginal effects of the Heteroscedastic model							
		Frequency of consumption at least once a month but less than once a week (y=4)				Frequency of consumption at least once a week (y=5)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
Attitudes towards characteristics of the product									
Reasons for buying	Healthy	**0.0692**	0.0028	24.6283	0.0000	**0.0301**	0.0028	0.6919	0.0000
	Taste good	**0.0669**	0.0027	25.0816	0.0000	**0.0315**	0.0028	1.0842	0.0000
	Are products for special occasions	**0.0478**	0.0053	9.0714	0.0000	**0.0213**	0.0064	3.3227	0.0009
	Contain little fat	**0.0358**	0.0029	12.3943	0.0000	**0.0146**	0.0033	4.4099	0.0000
	Easy to digest	**0.0571**	0.0033	17.1885	0.0000	**0.0392**	0.0043	9.2037	0.0000
	Less expensive than other food	**0.0788**	0.0070	11.3326	0.0000	**0.1047**	0.0111	9.4073	0.0000
Wild	Wild products preference	**0.0103**	0.0028	3.6889	0.0002	**0.0098**	0.0032	3.0468	0.0023
Sea	Sea products preference	**0.0323**	0.0029	11.1893	0.0000	**0.0270**	0.0034	8.0333	0.0000
Local	Preference for local and national products	**0.0227**	0.0027	8.5328	0.0000	**0.0170**	0.0030	5.6892	0.0000
Psychological factors related to life conditions and life satisfaction									
Satisfaction	Very satisfied	**0.0595**	0.0087	6.8510	0.0000	**0.0446**	0.0095	4.6727	0.0000
	Fairly satisfied	**0.0467**	0.0074	6.2902	0.0000	**0.0228**	0.0074	3.0680	0.0022
	Not very satisfied	**0.0222**	0.0085	2.6207	0.0088	0.0099	0.0084	1.1691	0.2424
Expectations	Better	**0.0116**	0.0041	2.7963	0.0052	-0.0004	0.0044	0.0860	0.9315
	The same/ no change	0.0006	0.0037	0.1649	0.8691	**-0.0094**	0.0040	2.3318	0.0197
	NA	*-0.0112*	0.0059	-1.9064	0.0566	-0.0085	0.0059	1.4374	0.1506
Sociodemographic factors									
Countries	FR - France	**0.0499**	0.0098	5.0964	0.0000	**0.1540**	0.0141	0.9573	0.0000
	BE - Belgium	**0.1084**	0.0117	9.2951	0.0000	**0.1319**	0.0138	9.5866	0.0000
	NL - The Netherlands	**0.0689**	0.0100	6.9168	0.0000	**0.0663**	0.0126	5.2549	0.0000
	DE-W - Germany - West	**0.0581**	0.0102	5.7218	0.0000	**0.0228**	0.0109	2.1032	0.0355
	IT - Italy	**0.1056**	0.0119	8.8813	0.0000	**0.1235**	0.0141	8.7803	0.0000
	LU - Luxembourg	**0.0752**	0.0135	5.5584	0.0000	**0.2360**	0.0187	2.6470	0.0000
	DK - Denmark	**0.0670**	0.0100	6.7061	0.0000	**0.0877**	0.0136	6.4315	0.0000
	IE - Ireland	**0.0565**	0.0103	5.4572	0.0000	**0.1634**	0.0145	1.2863	0.0000
	GB-UKM - Great Britain	**0.0428**	0.0104	4.1261	0.0000	**0.2759**	0.0146	8.8671	0.0000
	GR - Greece	**0.0688**	0.0116	5.9103	0.0000	0.0083	0.0105	0.7909	0.4290
	ES -Spain	**0.0680**	0.0109	6.2145	0.0000	**0.2598**	0.0147	7.6545	0.0000
	PT - Portugal	**0.1131**	0.0124	9.1155	0.0000	**0.2189**	0.0152	4.4072	0.0000
	DE-E Germany East	**0.0820**	0.0124	6.6097	0.0000	**0.0603**	0.0147	4.0977	0.0000
	FI - Finland	**0.0658**	0.0101	6.5167	0.0000	**0.1490**	0.0141	0.5662	0.0000
	SE - Sweden	**0.1035**	0.0120	8.6319	0.0000	**0.1828**	0.0152	1.9999	0.0000
	AT - Austria	**0.0689**	0.0101	6.8200	0.0000	**0.0717**	0.0125	5.7466	0.0000
	CY - Cyprus (Republic)	**0.0933**	0.0134	6.9784	0.0000	**0.1161**	0.0172	6.7405	0.0000
	CZ - Czech Republic	*0.0154*	0.0086	1.7818	0.0748	0.0042	0.0094	0.4429	0.6578
	EE - Estonia	0.0110	0.0082	1.3369	0.1813	**0.1096**	0.0130	8.3961	0.0000
	LV - Latvia	**-0.0307**	0.0066	-4.6707	0.0000	**0.0945**	0.0126	7.5061	0.0000
	LT - Lithuania	**-0.0370**	0.0063	-5.8488	0.0000	**0.0564**	0.0117	4.8167	0.0000
	MT - Malta	**0.0249**	0.0112	2.2228	0.0262	**0.1607**	0.0179	8.9888	0.0000
	PL - Poland	*0.0141*	0.0078	1.8204	0.0687	**0.0690**	0.0119	5.8075	0.0000
	SK - Slovakia	**0.0314**	0.0087	3.5906	0.0003	**0.0837**	0.0125	6.7050	0.0000
	SI - Slovenia	**0.0547**	0.0097	5.6600	0.0000	**0.0634**	0.0123	5.1727	0.0000
	BG - Bulgaria	**0.0690**	0.0105	6.5727	0.0000	**0.1315**	0.0137	9.6146	0.0000
	RO - Romania	*0.0153*	0.0080	1.9175	0.0552	**0.0775**	0.0122	6.3303	0.0000
	HR - Croatia	0.0100	0.0075	1.3232	0.1858	**0.0794**	0.0124	6.4271	0.0000
Age	25 - 34 years	**0.0233**	0.0050	4.6451	0.0000	**0.0165**	0.0061	2.6858	0.0072

Value		Marginal effects of the Heteroscedastic model							
		Frequency of consumption at least once a month but less than once a week (y=4)				Frequency of consumption at least once a week (y=5)			
		Value	Std. err.	t-stat	p-val.	Value	Std. err.	t-stat	p-val.
	35 - 44 years	**0.0252**	0.0048	5.2753	0.0000	**0.0193**	0.0060	3.2281	0.0012
	45 - 54 years	**0.0180**	0.0047	3.8201	0.0001	**0.0171**	0.0059	2.8832	0.0039
	55 - 64 years	*-0.0090*	0.0047	-1.9180	0.0551	0.0048	0.0058	0.8423	0.3996
	65 - 74 years	**-0.0343**	0.0048	-7.1994	0.0000	-0.0080	0.0056	1.4125	0.1578
	75 years and older	**-0.0633**	0.0049	13.0329	0.0000	**-0.0166**	0.0059	2.8181	0.0048
Household size	Household size (2)	**0.0072**	0.0035	2.0322	0.0421	-0.0054	0.0037	1.4491	0.1473
	Household size (3)	-0.0009	0.0045	-0.2034	0.8388	**-0.0115**	0.0044	2.6072	0.0091
	Household size (4 or more)	*-0.0069*	0.0041	-1.6582	0.0973	**-0.0132**	0.0042	3.1680	0.0015
Place of living	Towns and suburbs/ small urban area	**0.0100**	0.0032	3.1592	0.0016	**0.0086**	0.0036	2.4032	0.0163
	Cities/ large urban area	**0.0300**	0.0032	9.4736	0.0000	**0.0113**	0.0036	3.1798	0.0015
Economic factors									
Difficulties	From time to time	**0.0201**	0.0054	3.6902	0.0002	0.0081	0.0057	1.4221	0.1550
	Almost never/never	**0.0223**	0.0051	4.3607	0.0000	0.0044	0.0056	0.8000	0.4237
Class of society	The lower middle class	**0.0420**	0.0047	9.0062	< 2.2e-16	**0.0180**	0.0050	3.6048	0.0003
	The middle class	**0.0683**	0.0035	19.7614	< 2.2e-16	**0.0347**	0.0037	9.4461	0.0000
	The upper middle class	**0.1243**	0.0074	16.7263	< 2.2e-16	**0.0768**	0.0089	8.6326	0.0000
	The higher class	**0.1215**	0.0195	6.2271	0.0000	**0.1588**	0.0295	5.3913	0.0000
	NA	**0.0393**	0.0079	4.9952	0.0000	0.0120	0.0078	1.5465	0.1220

3 Paper: A Best-Worst Measure of Attitudes toward Buying Seabream and Seabass Products: An Application to the Island of Gran Canaria

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Abstract

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Processing, Preservation and Analysis of Seafood Products

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Message from the Guest Editor

Fisheries and aquaculture are very important for the provision of food, income, and livelihoods for hundreds of millions of people worldwide and it is predicted that it will contribute significantly to food security and nutrition for 9.7 billion people by 2050. However, up to 35% of seafood produced globally each year is wasted due to pre- or post-harvesting problems, including handling, processing, storage, and distribution steps, usually related to safety or spoilage aspects. This Special Issue presents up-to-date knowledge regarding current and emerging technologies in aquatic food processing and preservation, with advances in analyses towards safety, shelf-life extension, quality assurance, and detection of adulteration. By developing and employing innovative approaches, researchers can provide new knowledge of seafood technology and analytical or management tools to benefit individuals, industries, and communities involved in the seafood industry supply. This Special Issue welcomes original research articles and reviews related to this topic.

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Special Issue

Attitudes are important key drivers that affect consumers' seafood consumption. The present investigation uses a best-worst scaling approach to measure the level of importance and satisfaction of some consumers' attitudes towards the purchase of seabream and seabass in Gran Canaria (Spain). The investigation also compares the results of the best-worst scaling (BWS) approach with those of the traditional Likert-scale method and offers a different perspective of the results using an Importance-Satisfaction Analysis (ISA). The results indicate that the most important attributes concerned the hygiene and safety of the product, the health benefits, the freshness, the taste and the nutrients. At the same time, these attributes were ranked as those which satisfy consumers the most. However, some of the results obtained from the methodologies differed. The results suggest that, in the Likert-scale task, respondents might be overstating the importance and satisfaction of the attributes; while in the BWS, consumers were forced to evaluate a trade-off in the selection of the best and worst attributes in each scenario, so the task impeded in principle to define every attribute as very important and providing a high satisfaction. As a result, we consider that BWS offers more reliable and clearer results than traditional Likert-scale experiments.

Keywords: Best worst scaling; Satisfaction; Importance; Attitudes; Seabream and seabass products; Island of Gran Canaria.

3.1 Introduction

Fish consumption behaviour depends on determinants such as the attitude towards fish consumption, social norms and perceived behavioural control (Ajzen, 1991; Arsil et al., 2019; Verbeke and Vackier, 2005). Amongst these, the attitude is the main element that explains fish consumption behaviour (Bredahl and Grunert, 1995; Higuchi et al., 2017; Olsen, 2004; Thong and Olsen, 2012; Tomić et al., 2016; Tuu et al., 2008), and can be defined as a psychological trend expressed by evaluating an individual entity (for example a seafood product) with a certain degree of favour, likeness or satisfaction (Eagly and Chaiken, 1993); whereas social norms refer to the social pressure to perform a particular behaviour (Ajzen, 1991) and the perceived behavioural control reflects past experiences that facilitate conditions or anticipate difficulties (Vermeir and Verbeke, 2008).

The attitude depends on the different characteristics of the products, such as the sensory qualities (freshness, texture, taste and smell), health benefits and price (Arsil et al., 2019). The evaluation of these determinants may be either positive or negative and represent respectively drivers or barriers to fish consumption behaviour. Common drivers for fish consumption related to attitudes are: (1) good taste (Birch et al., 2012; Bredahl and Grunert, 1995; Brunsø et al., 2009; Gempesaw et al., 1995; Olsen, 2004, 2001); and (2) freshness (quality), ease of preparation or high nutritional value (Olsen, 2004). On the contrary, the proven major barriers to fish consumption are related to unpleasant sensory qualities of seafood such as distasteful smell, unpleasant taste or texture, and the presence of bones (Bredahl and Grunert, 1995; Brunsø et al., 2009; Olsen, 2004; Rortveit and Olsen, 2009; Verbeke and Vackier, 2005); although some authors have found that price is the most relevant barrier to seafood consumption (Brunsø et al., 2009; Myrland et al., 2000; Olsen, 2004; Verbeke and Vackier, 2005).

Moreover, in a literature review of 49 studies that assessed consumer behaviour in the purchase of fish and seafood products (Carlucci et al., 2015), the authors found that the main drivers for fish consumption are the sensory liking of fish, perceived health benefits and fish-eating habits, while the most important barriers are the sensory disliking of fish, health risk concerns, high price perceptions, lack of convenience, lack of availability of the preferred fish products and lack of knowledge in the selection and preparation of fish.

The EU is the largest trader of fishery and aquaculture products (FAPs) in nominal terms (FAO, 2020c). From the countries that constitute the EU, Spain has the third-highest per capita consumption and is the third-largest spender of FAPs, while it also constitutes by far the largest producer in the EU in terms of volume for farmed species (EUMOFA, 2020). In addition, Spain is the fourth largest country in the world with respect to the total production of seabream and seabass, which are the second and third most important species of Mediterranean aquaculture in terms of production after trout (FEAP, 2020).

In particular, the Canary Islands represent the third-largest Spanish region in terms of production of farmed fish species, accounting for around 25% and 15% of seabass and seabream produced in Spain, respectively (APROMAR, 2019). Despite this, the average fish consumption in the Canary Islands is below the national average (Rodríguez Feijoo et al., 2018).

Thus, given the large impact on the Canary Islands on the national production of seabream and seabass species, it is important to understand why this relevance in terms of production is not aligned in terms of consumption. To this end, it is important to analyse consumer preferences and attitudes towards these products, in order to facilitate the implementation of strategies that could increase the consumption of these two relevant species. In addition, a better understanding of the internal market for FAPs enables operators to improve their competitiveness and adopt or modify their current strategies on the basis of consumer demand to strengthen and expand the internal market, thereby encouraging job creation (European Union, 2018a).

In this investigation, the main objective is to measure the level of importance and satisfaction of certain consumer attitudes towards the purchase of seabream and seabass in Gran Canaria, the second most populated island in the Canary Islands, with a population of 851231 in 2019 (Spanish National Institute of Statistics, n.d.).

Another objective of this investigation is to evaluate alternative approaches to survey response mechanisms that can lead to more robust results. Thus, we compare the results of the traditional widely-used Likert-scale responses, in which consumers are asked to rate their level of importance and satisfaction for certain attitudes, perceptions and experiences on a scale from 1 to 9; with that obtained from best-worse scaling (BWS) methods, initially proposed by Finn and Louviere (Finn and Louviere, 1992). In this case, consumers are presented with different scenarios from which they must select the most and least important attributes, as well as those from which they were more and least satisfied with, regarding their last shopping experience of seabream/seabass.

The purpose of this comparative analysis relies on shedding light of some disadvantages of the traditional Likert-scales, in which how a respondent evaluates their position on that scale varies across respondents. For example, what is sufficient to make a respondent very satisfied may not be enough to satisfy others (Beck and Rose, 2016), which affects the means and the variance of the estimates obtained from these types of surveys (Steenkamp and Baumgartner, 1998). Also, Likert-scale questions allow consumers to take shortcuts in the tasks by rating everything as good or bad, while also making it difficult to understand the priority of the various issues assessed (Beck and Rose, 2016). On the other hand, a benefit of the BWS is that respondents are forced to discriminate between items and cannot constantly select the middle or endpoints of the scale (Cohen and Markowitz, 2002). The answers are also less ambiguous, as people are usually clearer about extreme options, and it seems easier for respondents to respond to the questionnaire task compared to other methods (Marley, 2010; Marley and Louviere, 2005). In addition, BWS is better at determining the relative impact of a large number of attributes, in particular qualitative effects (Beck and Rose, 2016).

Finally, another objective of the paper is to provide a different perspective of the results in absolute terms of the BWS estimates and Likert-scale ratings, using a similar approach to the common Importance-Performance Analysis (IPA) (Martilla and James, 1977), replacing the performance dimension by the satisfaction dimension, naming this as an Importance-Satisfaction Analysis (ISA). This analysis facilitates the interpretation of the most important

attributes by using a two-dimensional plot and makes it easy to understand the comparison between the values for importance and the satisfaction of the different attributes.

The framework suggested in this paper allows the simultaneous calculation of both satisfaction and importance constructs; a process that, if not more difficult, is much harder using other approaches (Beck and Rose, 2016). The BWS methodology has been previously used to evaluate meat consumption habits in households with and without children in Italy, by analysing the relative importance of 12 meat choice purchasing attributes; finding that price and animal welfare were found to be the most relevant attributes (Merlino et al., 2017). Moreover, other authors used the Importance-Confidence Analysis (ICA) adapted from the Importance-Performance Analysis (IPA) to understand the level of importance and confidence in the production and source attributes of seafood purchases in the US (Jodice and Norman, 2020). However, according to our best knowledge, this is the first time that the BWS Methodology and Importance-Satisfaction Analysis has been used to analyse attitudes towards fish consumption. Similarly, this investigation constitutes the first study that analyses and ranks attitudes towards the consumption of seabream and seabass in Gran Canaria.

The results provide key insights into the attributes that conform the attitudes that should be highlighted in the production and marketing initiatives for seabream and seabass products in Gran Canaria. In addition, researchers, academics and institutions could also benefit from the results to guide the extent of future research. The rest of the paper is organized as follows: Section 2 describes the materials and methods; Section 3 details the results; Section 4 discusses the results; and Section 5 provides some concluding remarks.

3.2 Materials and methods

The data used in this research were obtained from surveys conducted online using the Google forms platform. The surveys were administered between April 28 and June 14 of 2020 to adults living in Gran Canaria, Spain, who were responsible for buying food from their homes and who were consumers of seabream and seabass species. The survey was distributed through emails directed to all the population associated with the University of Las Palmas de Gran Canaria, the main public university of the island. A first e-mail was sent to introduce and explain the questionnaire in April and a second e-mail was sent two weeks later to remind the community about the questionnaire. To incentive the participation of the public, in the emails sent, respondents were informed about a prize to be raffled amongst them.

Respondents interested in filling the survey were first asked to confirm that they were residents of the island, that they were responsible for buying food at home and that they were consumers of seabream/seabass. Only those who fit the criteria were allowed to continue with the questionnaire (351 respondents). Next, some questions were asked about their patterns of consumption and preferences for seafood, fish, seabream and seabass (see Table 3.1).

Table 3.1 shows some descriptive statistics on the patterns of consumption of respondents. Results indicate that more than 81.2% consume seafood at home at least once a week, while more than 52.7% consume seafood outside-home at least once a month. Specifically, for

seabream and seabass, the pattern of consumption is more similar to the consumption of seafood outside the home than for home consumption, with around 59.5% consuming seabass or seabream at least once a month. Moreover, regarding the most consumed species, we find that tuna, followed by hake, seabream, salmon and seabass are the most popular species consumed in the island. Finally, with regard to the places where respondents buy their fish products, around 86% buy them in supermarkets, while around 55% buy them on markets. A small proportion gets their fish directly from fish companies or fishermen.

Table 3.1. Consumption descriptive statistics

Frequency of consumption			
Frequency	Seafood and fish		Seabream and seabass
	At home	Outside-home	
Never/Almost never	1.1%	15.1%	9.4%
Sometimes in a year	1.4%	32.2%	31.1%
Once a month	4.3%	22.8%	23.7%
2 or 3 times a month	12.0%	17.4%	21.7%
Once a week	43.3%	10.5%	11.1%
2 or 3 times a week	37.0%	2.0%	3.1%
Everyday	0.9%	0.0%	0.0%
Top three species consumed			
Species	Percentage		
Tuna	19.7%		
Hake	15.0%		
Seabream	12.9%		
Salmon	11.8%		
Seabass	8.6%		
Sole	7.2%		
Cod	5.8%		
Mackerel	4.8%		
Wreckfish	4.4%		
Sama	4.1%		
Other	5.8%		
Locations to buy fish and seafood (several options possible)			
Location	Percentage		
Markets	55.0%		
Supermarkets	86.0%		
Fish companies	1.1%		
Fishers directly	5.1%		

Number of respondents: 351

After that, a series of traditional ratings-based tasks were presented to understand the importance and satisfaction of different attitudes when buying seabream and seabass species. Respondents were asked first, to determine in a scale from 1 (absolutely not important) to 9 (extremely important) how important 16 different attributes were with respect to their last purchase of seabream/seabass. Similarly, after that, using a similar scale from 1 (completely unsatisfied) to 9 (completely satisfied) they were asked to rate how satisfied they were with their last purchase of seabream/seabass according to each one of the same 16 attributes presented previously. The attributes included were related to health and nutritional issues,

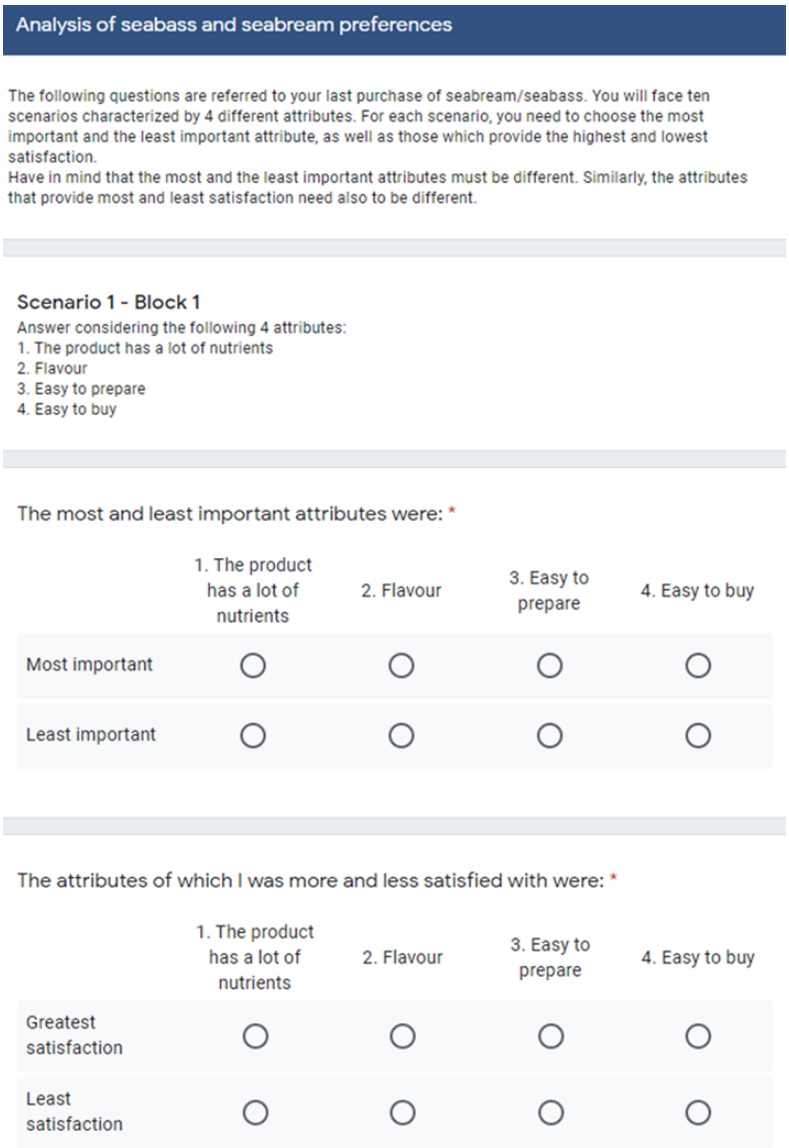
safety issues, sustainability issues, sensorial characteristics, convenience characteristics, social behaviour characteristics and the price. These attributes were developed following an extensive review by the authors of the relevant literature. The attributes included were: (1) Eating fish is healthy; (2) The product has a lot of nutrients; (3) Is easier to digest than the red meat; (4) Hygiene and food safety of the product; (5) More sustainable than red meat; (6) Flavour; (7) Knowing that the fish is fresh; (8) Easy to prepare; (9) Easy to buy; (10) The bones are not a problem; (11) The size (ration) of the seabream/seabass is appropriate; (12) The fishmonger can prepare it as wished; (13) It can be bought the 365 days of the year; (14) Custom or habit since child; (15) My close family and friends also eat seabream/seabass; (16) Price.

After completing the rating tasks, respondents were asked to execute some best-worst case 1 tasks. In total, respondents were asked to make choices in 10 different scenarios, selecting according to their last purchase of seabream/seabass, the most and least important attributes from the alternatives, as well as the attributes from which he/she was most and least satisfied with. Each one of these scenarios (see Figure 3.1 for an example) consisted of 4 alternatives built out of the same set of 16 attributes that were evaluated for the traditional rating tasks.

A balanced incomplete block design (BIBD) was used to reduce to 10 the tasks required for each respondent. We used the software package "crossdes" and the "findBIB" function in the statistical software R (R Core Team, 2013), from which we obtained a set of 20 choice tasks for the 16 attributes considered, which were divided into two blocks of 10 tasks each, in order to facilitate the survey administration (see the appendix for the full list of tasks per block). Finally, 167 respondents answered to the tasks of Block 1 and 184 to those of Block 2. Our design ensures that: (1) every attribute is shown at least once per block, (2) every selection task includes four attributes, (3) each attribute appears five times considering all the 20 selection tasks and (4) every attribute co-occurs exactly one time with every other attribute over the selection tasks.

Thus, a total of 351 respondents answered to the BWS experiment and considering that each one of them answered to 10 different scenarios with four different choices for each one (most important, least important, most satisfied, least satisfied), our final sample of pseudo-individuals for the estimation of the models were 14040.

Figure 3.1. Best-worst measurement of attitudes towards the purchase of seabream and seabass



Analysis of seabass and seabream preferences

The following questions are referred to your last purchase of seabream/seabass. You will face ten scenarios characterized by 4 different attributes. For each scenario, you need to choose the most important and the least important attribute, as well as those which provide the highest and lowest satisfaction.
Have in mind that the most and the least important attributes must be different. Similarly, the attributes that provide most and least satisfaction need also to be different.

Scenario 1 - Block 1
Answer considering the following 4 attributes:
1. The product has a lot of nutrients
2. Flavour
3. Easy to prepare
4. Easy to buy

The most and least important attributes were: *

	1. The product has a lot of nutrients	2. Flavour	3. Easy to prepare	4. Easy to buy
Most important	○	○	○	○
Least important	○	○	○	○

The attributes of which I was more and less satisfied with were: *

	1. The product has a lot of nutrients	2. Flavour	3. Easy to prepare	4. Easy to buy
Greatest satisfaction	○	○	○	○
Least satisfaction	○	○	○	○

Moreover, in the questionnaires, respondents also answered questions about the image of aquaculture products, which are not discussed in the present investigation. Finally, the questionnaire ended with a series of questions concerning the socio-demographic features of respondents. Table 3.2 includes a description of the 351 respondents of the survey. Approximately 47% of respondents were between 18 and 35 years of age, while approximately 41% were older than 46 years of age. The majority of respondents were female (60.7%) and single (47.9%). Interestingly, more than 81% of respondents have at least a minimum degree of university education. In addition, 39.03% were public sector workers and 36.18% were students. The overwhelming majority of respondents reported that they had incomes below the national average (70.4%).

Table 3.2. Sample descriptive statistics according to age, gender, marital status, education level, occupation and income

Age range		**Maximum education level reached**	
18-25	28.8%	Primary school	1.4%
26-35	18.5%	High school	10.5%
36-45	11.4%	Technician degree	6.6%
46-55	23.9%	University degree	43.3%
56 or older	17.4%	University postgrad	38.2%
Gender		**Occupation**	
Male	39.3%	Independent worker	6.0%
Female	60.7%	Public employee	39.0%
Marital status		Private sector employee	14.3%
Single	47.9%	Student	36.2%
Married	34.8%	Unemployed	2.0%
Living with a partner	16.8%	Retired	0.9%
Widow	0.6%	Housekeeper	1.7%
Income			
Below national average	13.7%		
Around national average	70.4%		
Above national average	16.0%		

Number of respondents: 351

The conceptual framework of the methodologies used are explained below:

3.2.1 Best-worst scaling (BWS)

The analysis of BWS response data is based on the random utility theory (RUT) (McFadden, 1974; Thurstone, 1927), which suggests that consumers select the alternative that provides them with the highest utility. This utility consists of two components: a systematic and deterministic measurable component and a random component. While the systematic part depends on the alternatives' attributes as well as on the individual's socio-economic characteristics, the random part represents the unobserved attributes.

The BWS was introduced by Finn and Louviere (Finn and Louviere, 1992) as a method of data collection that can prevent and overcome certain limitations of rating-based methods and similar measurement methods. One of the main disadvantages that rating scale experiments exhibit is that respondents are usually biased to select the middle or endpoints of the scale. Thus, the comparison between items is usually obscured. In addition, it is extremely difficult to understand what rating scales values mean, and rating scales are frequently unknown about their reliability and validity (Flynn and Marley, 2014).

Louviere (Louviere et al., 2000) proposed three different BWS cases, all of which show differences in the nature and complexity of the items selected. In this case, we use the simplest BWS case (case 1) to determine the relative values for each item in the list. In this case, researchers must first select a list of objects and create choice sets, and then individuals (on a subjective scale) are asked to choose the best and worst options in these sets.

Some psychological problems may arise if the size of the choice sets is not consistent. BIBDs are common to solve this issue. The BIBD is a type of design that ensures that selection sizes are equal, each selection option appears equally often, and co-appears equally frequently with each other choice option. This reduces the chance of respondents to make incorrect assumptions about objects, based on design aspects. More information and a detailed guide of choice set construction in BIBDs can be consulted in (Louviere et al., 2015).

3.2.1.1 Implementation of the BWs

We estimated a multinomial logit model. For each choice set, we considered 8 utility functions: the first 4 utility functions for the importance parameters, and the other 4 utilities for the satisfaction parameters. The dataset resembles that of an unlabelled experiment to measure importance and satisfaction in which the alternatives i (the subindices in eqs. 1 and 2) simply reflect the specific position for the task (1 = top, 2 = second from the top, 3 = second from the bottom, 4 = bottom). Each task provides two observations for modelling, one for the best choice and the other for the worst choice. The analysis of best choices is based on utility maximization, whereas the worst choices are based on the maximization of the negative of the utility. As a result, when coding the explanatory attributes, we will consider (-1) instead of (1) for the worst-case observation. Thus, the dummy coded 1 or the negative dummy coded -1 is used when the attribute represents the alternative *i* for the best- and worst-case choices.

For modelling purposes, the four alternatives shown in the choice task are always available when asking for the best options. However, the best-chosen option is no longer available when choosing the worst option because the same alternative cannot be evaluated, at the same time, as the best and the worst option. This means that the availability of alternatives for the worst choices is determined by the previous best choices of the individual and, in our case, there are always three alternatives available for the worst choices. The utility functions for both, importance and satisfaction of the alternative *i* are:

$$U_i^{Imp} = ASC_i + \sum_{k=1}^{15} \beta Imp_k \times Imp_{ik} \quad \text{with } i = 1,2,3,4 \qquad (3.1)$$

$$U_i^{Sat} = ASC_i + \sum_{k=1}^{15} \beta Sat_k \times Sat_{ik} \quad \text{with } i = 1,2,3,4 \qquad (3.2)$$

Where the explanatory attributes are defined as:

ASC_i = reflect the positional and other ordering effects

Imp_{ik} = 1 (or -1) if the attribute *k* is shown in alternative *i* for best (or worst) choices and 0 otherwise

Sat_{ik} = 1 (or -1) if the attribute *k* is shown in alternative *i* for best (or worst) choices and 0 otherwise

Since our study includes 16 attributes, we have included 15 dummy variables considering that the last one acts as a reference. The coefficients βImp_k and βSat_k can be understood as the degree of importance and satisfaction for the attribute k, respectively. The interpretation of the parameters is based on the reference with effect "0", which correspond to the attribute "(16) price". Therefore, negative parameters mean that the respective attributes are less important or satisfying than the price, while positive parameters indicate that they are more important or satisfying than the price. Similarly, the statistical significance of the parameters indicates differences in the level of importance or satisfaction with respect to attribute 16.

We used four alternative specific constants (ASC_i) to reflect the positional and other ordering effects that might exist within the data, being the constant of the alternative presented in the fourth place (ASC_4) normalized to 0. Besides the observed utility component, the multinomial logit model included an error term. The free software "Biogeme" was used to estimate the multinomial logit model (Bierlaire, 2003).

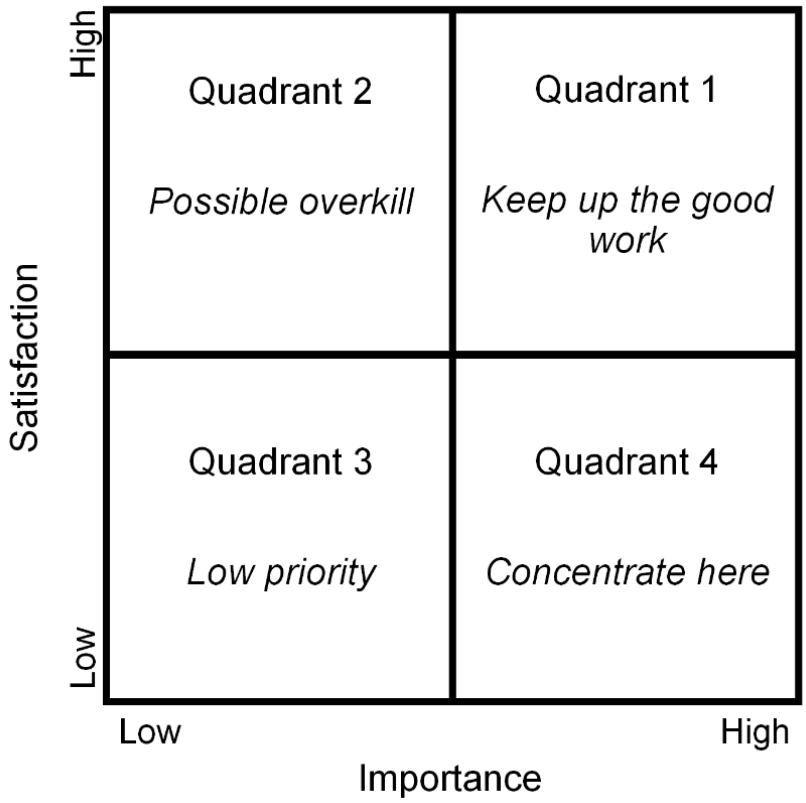
3.2.2 Importance-Satisfaction Analysis

In order to better understand the results of Likert-scale and BWS tasks, we used an Importance-Satisfaction Analysis (ISA) in which the main objective is to identify the most important/satisfying attributes using a two-dimensional plot that facilitates the interpretation of the data. Figure 3.2 shows the importance-satisfaction analysis (ISA) plot, in which the attributes in the plot are divided into four quadrants.

Each one of the attributes is plotted in a coordinate system according to the means of the ratings given by respondents in the Likert-scale experiment and the values obtained for the parameters in the multinomial logit model estimated for the BWS results. Moreover, the axes for the quadrants can be obtained according to different methods such as scale averages or data averages. In our study, the data average values are used for both the Likert rating scale and the estimated parameters obtained for the BWS method. The chart is known as the Data Centred Quadrant Model Representation (DCQMR) (Martilla and James, 1977).

The first quadrant, "Keep up the Good Work" includes high satisfaction and importance attributes that indicate that these attributes are performing well. The characteristics of the second quadrant "Possible overkill" are good in terms of satisfaction, but they are not very important. In addition, the "low priority" of Quadrant 3 included attributes that are not very good in terms of satisfaction but are considered relatively insignificant in importance for respondents. Therefore, managers should not be too concerned about these attributes. Finally, Quadrant 4 "Concentrate here" is the most important region in the plot, in which the attributes are considered to be of high importance but are under-performing, and thus are those in which the focus should be placed (Sever, 2015).

Figure 3.2. Importance-Satisfaction Analysis (ISA) plot



3.3 Results

3.3.1 Rating scale results

Regarding the rating tasks, respondents were asked to rate their degree of satisfaction and the importance level of each one of the 16 attributes using a nine-point Likert scale. The mean, median and standard deviation values for each one of them are presented in Table 3.3.

We found that 3 of the 16 attributes have a median of 9 out of a maximum of 9 for importance ratings, with five having a median of 8, six having a median of 7 and two having a median of 6. Similar results were found for the satisfaction question, with three attributes having a median of 9, four having a median of 8, eight having a median of 7 and only one having a median of 6. Moreover, for half of the attributes, the mean importance value is higher than the mean value for the satisfaction questions.

The top three rated attributes for importance were "hygiene and food safety of the product", "eating fish is healthy" and "knowing that the fish is fresh"; while the bottom three rated were "It can be bought the 365 days of the year", "The bones are not a problem" and "My close family and friends also eat seabream/seabass". On the other hand, on the basis of the degree of satisfaction, the top and bottom three rated attributes are the same as those judged by importance, except for the inclusion of the attribute "Custom or habit since child" instead of "It can be bought the 365 days of the year" for the bottom three.

Table 3.3. Importance and satisfaction rating task results (Mean, Median and Standard deviation of the attributes)

Attributes	Importance			Satisfaction		
	Mean	Median	Std dev	Mean	Median	Std dev
Health and nutritional issues						
(1) Eating fish is healthy	8.30	9	1.13	8.29	9	1.19
(2) The product has a lot of nutrients	7.89	8	1.33	7.75	8	1.52
(3) Is easier to digest than the red meat	6.98	8	2.28	7.03	8	2.27
Safety issues						
(4) Hygiene and food safety of the product	8.59	9	1.02	8.29	9	1.27
Sustainability issues						
(5) More sustainable than red meat	6.68	7	2.18	6.74	7	2.17
Sensorial characteristics						
(6) Flavour	7.99	8	1.30	7.76	8	1.46
(7) Knowing that the fish is fresh	8.09	9	1.39	7.98	9	1.52
Convenience characteristics						
(8) Easy to prepare	6.72	7	1.83	6.91	7	1.89
(9) Easy to buy	7.10	7	1.69	7.16	7	1.78
(10) The bones are not a problem	5.81	6	2.63	6.01	7	2.56
(11) The size (ration) of the seabream/seabass is appropriate	6.73	7	1.78	6.82	7	1.79
(12) The fishmonger can prepare it as wished	7.14	8	1.93	7.23	8	1.88
(13) It can be bought the 365 days of the year	6.56	7	2.18	6.69	7	2.14
Social behaviour characteristics						
(14) Custom or habit since child	6.93	7	2.06	6.47	7	2.38
(15) My close family and friends also eat seabream/seabass	5.51	6	2.28	5.49	6	2.33
Price						
(16) Price	7.45	8	1.60	7.21	7	1.80

3.3.2 Best worst scale results

Initially, a multinomial logit model based on the best-worst tasks was estimated considering all attributes (see appendix for the results). With the results of this initial model, we estimated the 95% confidence intervals for the satisfaction and importance values of the different attributes. Based on these, we estimated a new model (see Table 3.4) restricting as equal the importance and satisfaction parameters of an attribute whose 95% confidence intervals overlap. Also, in the new model, we fixed as 0 the importance and satisfaction parameters for the attributes that were not significantly different from the base attribute "Price" according to a significance level of 0.1. Table 3.4 shows at the beginning the attributes in which the importance and satisfaction parameters were fixed as equal, following those in which they differ.

We found that in 7 of the 15 attributes, the importance and satisfaction confidence intervals overlapped, which is why for these cases, both parameters were restricted to be equal. In all cases, they turned out to be statistically significant (with a level of 0.05), indicating that the importance and satisfaction of these attributes were different from the importance and satisfaction of the "Price" attribute. From these attributes, 3 of them ("the bones are not a

problem", "the size (ration) of the seabream/seabass is appropriate" and "custom or habit since child") had a negative sign, suggesting that these attributes are less important and offered less satisfaction than the "Price" attribute; while 4 had a positive sign ("eating fish is healthy", "the product has a lot of nutrients", "flavour", "knowing that the fish is fresh"), indicating that they were more important and offered higher satisfaction than "Price".

Moreover, in 7 of the 15 attributes, different parameters were estimated for the importance and satisfaction estimates. Specifically, respect to the importance results, we found that all values were statistically significant (with a level of 0.1), indicating that the importance of these attributes was different from the importance of the "Price" attribute. From them, 6 attributes had a negative sign and were statistically significant, suggesting that these attributes are less important than the "Price" attribute, while the remaining significant positive attribute "hygiene and food safety of the product" resulted to be more important than the "Price". In addition, regarding the satisfaction results, 3 of the attributes were found to be significant and negative, implying that consumers were less satisfied by these attributes respect to the "Price" attribute, while the attributes " hygiene and food safety of the product" and "easy to prepare" were statistically significant and positive, showing that consumers were more satisfied by them, in comparison to the "Price" attribute.

The results indicate that the first three ASCs are statistically significant and positive, which means that respondents were more likely to select one of the first three items shown in the choice set rather than the fourth alternative in terms of the order, ceteris paribus.

Table 3.4. Best-worst task estimates – Model 2

Attributes in which the importance and satisfaction are the same						
Attributes	IMP-SAT		t-stat		p-val.	
Health and nutritional issues						
(1) Eating fish is healthy	**1.55**		27.36		0.00	
(2) The product has a lot of nutrients	**0.833**		16.63		0.00	
Sensorial characteristics						
(6) Flavour	**1.12**		22.03		0.00	
(7) Knowing that the fish is fresh	**1.63**		30.14		0.00	
Convenience characteristics						
(10) The bones are not a problem	**-0.839**		-16.9		0.00	
(11) The size (ration) of the seabream/seabass is appropriate	**-0.269**		-5.52		0.00	
Social behaviour characteristics						
(14) Custom or habit since child	**-0.363**		-7.43		0.00	
Attributes in which the importance and satisfaction differ						
Attributes	IMP	t-stat	p-val.	SAT	t-stat	p-val.
Health and nutritional issues						
(3) Is easier to digest than the red meat	**-0.485**	-7.02	0.00	**-0.191**	-2.89	0.00
Safety issues						
(4) Hygiene and food safety of the product	**2.48**	30.39	0.00	**1.8**	25.31	0.00
Sustainability issues						
(5) More sustainable than red meat	**-0.268**	-3.96	0.00	0.00	-fixed-	-fixed-
Convenience characteristics						
(8) Easy to prepare	*-0.113*	-1.73	0.08	**0.226**	3.59	0.00

Attributes in which the importance and satisfaction are the same						
Attributes	IMP-SAT		t-stat		p-val.	
(9) Easy to buy	0.00	-fixed-	-fixed-	0.00	-fixed-	-fixed-
(12) The fishmonger can prepare it as wished	**-0.302**	-4.25	0.00	0.00	-fixed-	-fixed-
(13) It can be bought the 365 days of the year	**-1.02**	-14.46	0.00	**-0.693**	-10.46	0.00
(15) My close family and friends also eat seabream/seabass	**-1.45**	-19.94	0.00	**-1.04**	-15.59	0.00
Price						
(16) Price	0.00	-fixed-	-fixed-	0.00	-fixed-	-fixed-
Alternative specific constants (ASCs)	Value		t-stat		p-val.	
ASC1	**0.178**		5.64		0.00	
ASC2	**0.131**		4.38		0.00	
ASC3	**0.161**		5.62		0.00	
ASC4	0.00		-fixed-		-fixed-	
Goodness of fit						
McFadden's pseudo R^2 (ρ^2)	0.194					
Adjusted McFadden's pseudo R^2 (Adjusted ρ^2)	0.193					
Final Log-likelihood	-14053.504					
Number of observations	14040					

3.3.3 Comparing the approaches

In order to illustrate the results more precisely, we normalized the importance and satisfaction estimates of the results presented in Table 3.3 and the model presented in Table 3.4, by giving the lowest score a 0 and the highest score a 1. This has been achieved by taking the difference between each item and the minimum value and dividing the result by the range (the difference between the largest and the smallest values). The results can be seen in Figure 3.3 for the traditional Likert-scale and in Figure 3.4 for the BWS. The rescaled results are shown in blue for the importance index, while green for the satisfaction index. In addition, the differences between the two indexes for the same attribute indicate a discrepancy between the relative satisfaction and the importance of the attribute.

Figure 3.3. Traditional Likert-scale relative importance and satisfaction results

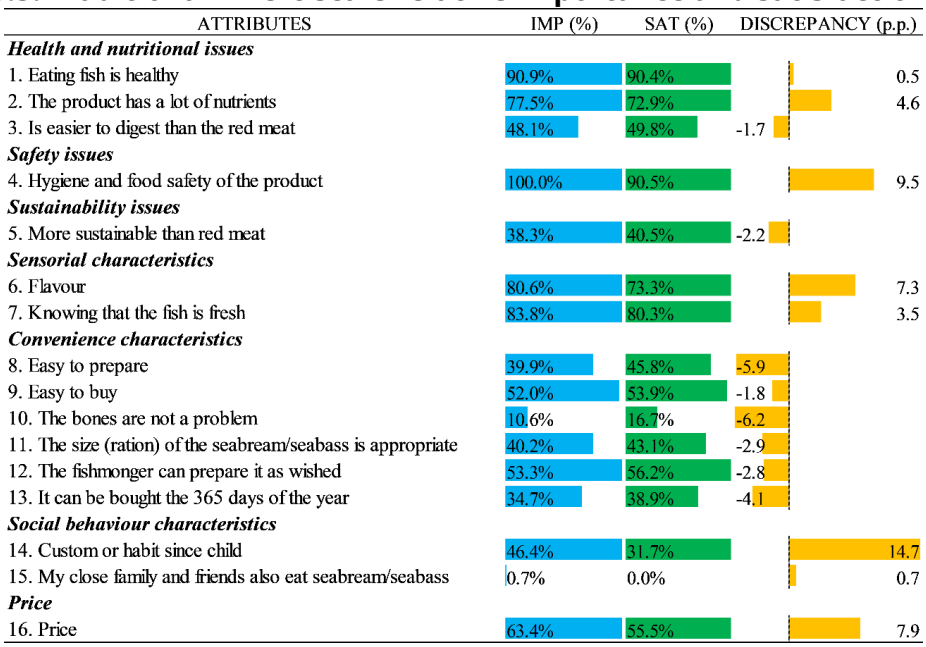


Figure 3.4. Best worst relative importance and satisfaction results

ATTRIBUTES	IMP (%)	SAT (%)	DISCREPANCY (p.p.)
Health and nutritional issues			
1. Eating fish is healthy	76.3%	76.3%	0.0
2. The product has a lot of nutrients	58.1%	58.1%	0.0
3. Is easier to digest than the red meat	24.6%	32.0%	-7.5
Safety issues			
4. Hygiene and food safety of the product	100.0%	82.7%	17.3
Sustainability issues			
5. More sustainable than red meat	30.1%	36.9%	-6.8
Sensorial characteristics			
6. Flavour	65.4%	65.4%	0.0
7. Knowing that the fish is fresh	78.4%	78.4%	0.0
Convenience characteristics			
8. Easy to prepare	34.0%	42.6%	-8.6
9. Easy to buy	36.9%	36.9%	0.0
10. The bones are not a problem	15.5%	15.5%	0.0
11. The size (ration) of the seabream/seabass is appropriate	30.1%	30.1%	0.0
12. The fishmonger can prepare it as wished	29.2%	36.9%	-7.7
13. It can be bought the 365 days of the year	10.9%	19.3%	-8.3
Social behaviour characteristics			
14. Custom or habit since child	27.7%	27.7%	0.0
15. My close family and friends also eat seabream/seabass	0.0%	10.4%	-10.4
Price			
16. Price	36.9%	36.9%	0.0

From the BWS results, it can be observed that the most important attributes in order are "hygiene and food safety of the product", "knowing that the fish is fresh", "eating fish is healthy", "flavour" and "the product has a lot of nutrients", while the least important attributes are "my close family and friends also eat seabream/seabass", "it can be bought the 365 days of the year" and "the bones are not a problem". In addition, the attributes with the highest and lowest satisfaction levels are the ones same listed as the most and least important, respectively. However, the highest positive discrepancy (higher importance and less satisfaction) was observed in the most important and most satisfying attribute: "hygiene and food safety of the product".

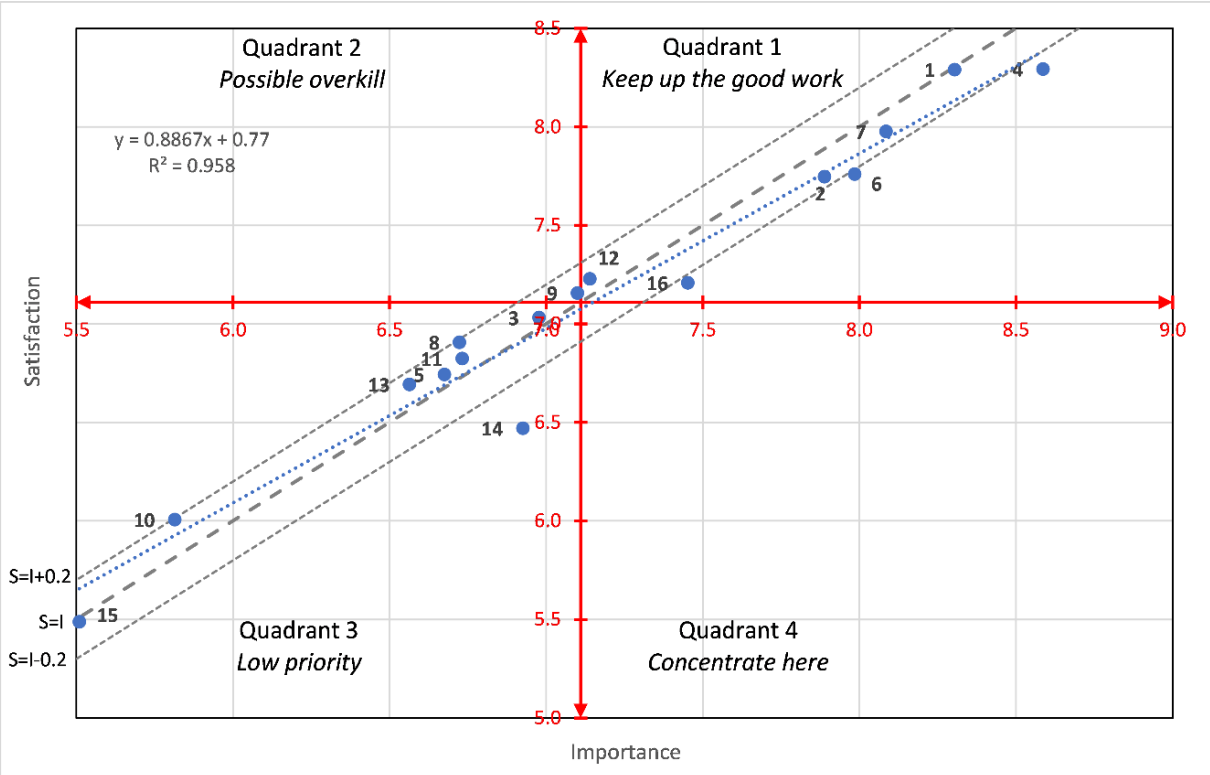
In addition, we observed some differences when comparing the rescaled data from the BWS and the traditional Likert-scale. For example, in the BWS results, we found that the second most important and the second most satisfying attribute was "knowing that the fish is fresh," while for the Likert scale it was "eating fish is healthy"; however, for the third position, these two attributes switch position accordingly in each case. A similar situation occurs for two of the top three least important attributes: "the bones are not a problem" and "it can be bought the 365 days of the year". Moreover, the differences increase if the magnitudes of the values are considered, in which almost all values related to the importance and satisfaction of the Likert-scale results are higher than the values of the BWS. Further, the attribute "it can be bought the 365 days of the year" with 34.7% is rated as three times higher in importance compared to the results of the BWS (10.9%), while similarly for this same attribute, the value on the Likert-scale for the satisfaction (38.9%) doubles the one found with the BWS (19.3%). Another example occurs with the attribute "is easier to digest than red meat" which is rated almost twice as important in the Likert-scale results (48.1%) in comparison with the BWS results (24.6%).

Another difference between the two types of data can be found in the discrepancy between the importance and satisfaction results, in which the same attributes can have different results. For

example, in the Likert-scale results, it was observed that the highest discrepancy is related to the attribute "custom or habit since child", which shows higher importance and less satisfaction, whereas, in the BWS results, there was no discrepancy at all.

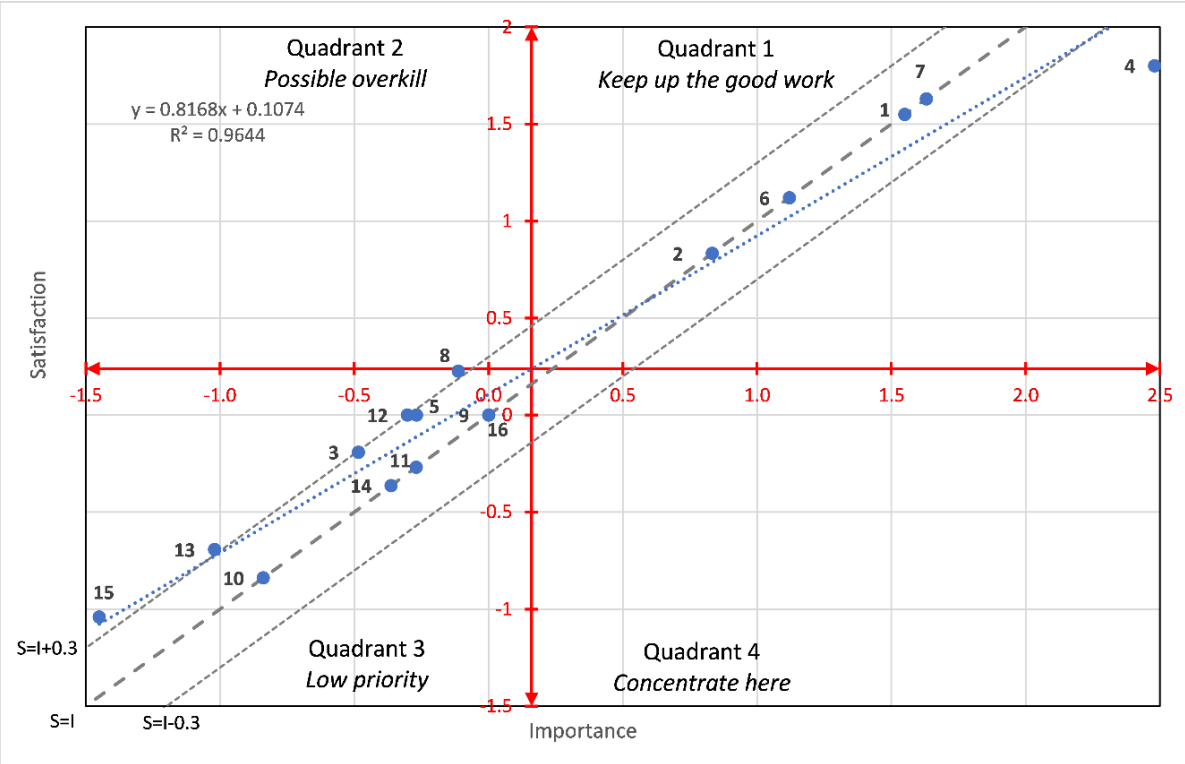
Moreover, Figure 3.5 and Figure 3.6 present a different perspective of the results according to the two-dimensional importance-satisfaction grid. In the figures, the red lines separate the quadrants of the importance-satisfaction analysis according to the average values of the attributes for the Likert rating scale, and the estimated coefficients for the BWS method. In IPA parlance, this is known as the Data Centred Quadrant Model Representation (DCQMR) (Martilla and James, 1977). The figures also show three dashed grey diagonal lines that represent the discrepancy analysis (Rial et al., 2008). The diagonal line (S=I) is known as the iso-rating line which is characterized because the discrepancy is zero. The line above the diagonal is characterized because the discrepancy is constant and satisfaction is higher than importance, so independently of the quadrant, these attributes are considered as consumers' satisfiers. The opposite logic prevails for the diagonal lines below the iso-rating line. Moreover, the figures also include an additional dotted blue line with the regression of the satisfaction values over the importance values. Both figures show that almost all the attributes are located in the quadrants 1 and 3 (except for attribute 9 in the Likert-scale results), indicating either that there is good satisfaction for important attributes or that, if some attributes provide low satisfaction levels, they are not of the highest priority or importance. Additionally, it can be concluded from the figures that importance and satisfaction are highly correlated. The particular case of attribute 9 for the Likert-scale results, which is located in quadrant 2, indicates that it has higher satisfaction than its actual importance.

Figure 3.5. Importance-Satisfaction Analysis based on Likert-scale scores



The red lines represent the axes that divide the quadrants, the blue line the linear adjustment of the points and the grey lines the diagonal lines (S=I, S=I+0.2, S S=I-0.2)

Figure 3.6. Importance-Satisfaction Analysis based on BWS scores



The red lines represent the axes that divide the quadrants, the blue line the linear adjustment of the points and the grey lines the diagonal lines (S=I, S=I+0.3, S=I-0.3)

In general, we observed that apart from the differences in the rankings between the two methods, the magnitude of the importance and satisfaction results of the Likert-scale task were higher than in the BWS task, which suggests that, in the Likert-scale task, respondents might be overstating the importance and satisfaction of the items. This result is related to the social desirable responding and acquiescence bias (Watson, 1992; Weijters et al., 2010). Meanwhile, in the BWS, consumers were forced to evaluate a trade-off in the selection of the best and worst alternatives in each scenario, so the task impeded in principle to define every item as very important and very satisfying attribute. As a result, it can be concluded that BWS offers more reliable and clearer results than traditional IPAs based on semantic scales.

In addition, the BWS method forces respondents to consider relative levels of importance and satisfaction, which involves a more direct evaluation between the attributes differentiation than simply rating the attribute's importance and satisfaction. Thus, the BWS proposed in the paper is very different from the traditional ratings as, for example, it can be seen that in the BWS results (Figure 3.4) there is only 1 positive discrepancy against 6 negative discrepancies, while in the Likert-scales results (Figure 3.3), there is an equal number of positive and negative discrepancies (8). Thus, it can be concluded that the discrimination enforced by the BWS method and the estimates obtained from the model overcame a number of issues that have been cited when researchers use the Likert rating scales (Lee et al., 2008; Massaglia et al., 2019).

3.4 Discussion

In this section, the results of the BWS methodology are considered to propose some marketing implications. The first actions to be considered by the authorities and stakeholders are those related to attributes that have been ranked as the most important, but which level of satisfaction does not have the expected results. The most important attributes concerned the hygiene and safety of the product, the healthiness, the freshness, the flavour and the nutrients that it possesses. At the same time, these attributes were ranked as those from which consumers were most satisfied. In all cases, however, the level of satisfaction was not at the same level as the importance. The results of the BWS show a relatively lower level of satisfaction with the "hygiene and food safety of the product" attribute which was ranked as the most important attribute. A study found that in India the freshness and cleanliness of food products were the most important attributes for food choice, and therefore suggested that food retailers should focus on satisfying this item (Ali et al., 2010). Moreover, a study found in China that consumers were most willing to pay for enhanced food safety when purchasing shrimp and imported tilapia (Ortega et al., 2014). Based on these findings, strategic plans to improve customer satisfaction with the hygiene and safety of these products are very important, especially given that other studies have shown that consumers are willing to pay premiums for safety claims that enhance some aspect of product safety (Fernández-Polanco et al., 2013; Fonner and Sylvia, 2015). For this purpose, the seabream and seabass industry can follow the example of the salmon industry, where stakeholders have adopted new safety procedures during different phases of production, processing, distribution and wholesale and retail sales in order to meet the growing demand for safe farmed Atlantic salmon (Haghiri, 2011). Also, a study found that, for safety reasons, consumers agreed to the idea of using traceability methods and quality control systems in the salmon industry, despite the increase in the cost of the product (Haghiri, 2014), which is consistent with another study that found that those with a higher frequency of consumption tend to regard the safety of the product as more important than the price, therefore, the provision of promotional activities underlining the safety of fish can make a significant contribution to increase fish consumption (Lee and Nam, 2019).

The ISA plots for the BWS results indicate that the attributes are already either important and with a high level of satisfaction (Quadrant 1) or with a low level of satisfaction and a low level of importance (Quadrant 3). Nevertheless, although the attributes of the "keep good work" quadrant indicate good levels of both importance and satisfaction, it is useful to continually improve them because they can be seen in some circumstances as the main attributes to provide competitive advantages. In the case of the BWS results, the following attributes were located in this quadrant: (1) Eating fish is healthy, (2) The product has a lot of nutrients, (4) Hygiene and food safety of the product, (6) Flavour and (7) Knowing that the fish is fresh.

Given the previous results, first, it is important to implement strategies that increase the satisfaction for the health benefits offered by these products. Fish and seafood products are generally perceived as healthy due to a number of health and nutritional benefits, especially their high content in omega-3 fatty acids and protein as well as their low-fat content (Arvanitoyannis et al., 2004; Birch and Lawley, 2012; Brunsø et al., 2009; Hall and Amberg, 2013; Stefani et al., 2012; Verbeke et al., 2007d). Nevertheless, consumers also weigh different risks,

which could also constitute an obstacle to their consumption (Birch and Lawley, 2012). In fact, consumers may simultaneously perceive both the health benefits and the health risks of fish consumption, with an anticipated antagonistic impact on their choices (Carlucci et al., 2015). While health benefits influence positively fish consumption behaviour in terms of their nutritional values and lower risk of diseases, health risks related to chemical contaminants such as mercury have been identified as barriers for fish consumption (Arsil et al., 2019). Given this, marketing campaigns should focus on increasing the health benefits of fish consumption, as well as explaining how to avoid the possible risks related to their consumption. In addition, several investigations have shown that consumers are willing to pay extras for products highlighting benefits such as the improvement of heart function (Banovic et al., 2019; Lim et al., 2018) and brain function (Banovic et al., 2019); therefore, producers should focus on producing fish that contribute to an enhanced health condition in an attempt to increase both their revenue and the perceived satisfaction of costumers for the health benefits associated to fish consumption.

Regarding our finding of the importance given to nutrients, another study also found that the high nutritional value of fish products is an important driver of its consumption (Olsen, 2004). Some of the relevant nutrients found in fish are digestible proteins, vitamins A and D3, trace minerals such as iodine and selenium, and n-3 long-chain polyunsaturated fatty acids (Ramalho Ribeiro et al., 2019). Given that some studies have found that consumers are willing to pay extras for products with a high content in omega-3 fatty acids (Banovic et al., 2019; Bi et al., 2016; Fernández-Polanco et al., 2013; Rudd et al., 2011) or fortified with beneficial and healthy compounds (Ramalho Ribeiro et al., 2019), producers and sellers are encouraged to invest on these types of products.

As far as flavour is concerned, similar results on the importance of this attribute have been obtained in the literature. On one hand, a study on Hawaiian consumers considered that taste was the most important reason to consume seafood and to prefer wild products to aquaculture production (Davidson et al., 2012). Similarly, another study found that flavour was the second most important attribute for the consumption of farmed seabream (Ramalho Ribeiro et al., 2019), while another study argued that taste was one of the most important drivers for eating fish (Verbeke and Vackier, 2005). Given the importance and the fact that satisfaction is not at the same level, some strategies need to be considered in order to improve the taste of the products, such as marketing campaigns highlighting different recipes to cook seafood, which might be more pleasant in terms of flavour than the usual ways of cooking fish.

The freshness of the product is important as sometimes it is associated with its quality (Olsen, 2004). In the literature, several studies have shown a general preference and greater willingness to pay for fresh products over other types of presentations (Ankamah-Yeboah et al., 2019, 2018; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Darko et al., 2016; Davidson et al., 2012). A study found that freshness was the most important attribute for farmed seabream consumption in Portugal (Ramalho Ribeiro et al., 2019), while another study in Europe found that one of the most important reasons for buying local and European products was its greater freshness (Zander and Feucht, 2018). This preference for fresh products implies that efforts should be made to optimize the supply chain for fisheries and aquaculture to ensure that more

fresh products are marketed (Cantillo et al., 2020a). However, not knowing how to evaluate if the fish is fresh or not can be a barrier to its consumption (Birch and Lawley, 2012), which is why marketing campaigns should provide a guide for consumers in the assessment of freshness of products.

Finally, although managers should not pay much attention to the attributes located in the "low priority" quadrant because they are not important or satisfactory, they remain a matter of concern that the authorities should address in the case that some changes are observed.

3.5 Conclusions

The results of the present investigation are a source of valuable information to be used for product improvement and marketing by the various stakeholders involved in the production of seabream and seabass in Gran Canaria. The findings do not only help to understand the attributes that consumers consider to be the most important and the level of satisfaction they have with them but also help to understand how the two of them interact together, allowing to determine which attributes should be of greater concern for improving the quality of seabream and seabass products in Gran Canaria.

Comparing the results of the two experiments, in general, we find that the magnitude of the importance and satisfaction results in the Likert-scale task were higher than in the BWS task, which suggests that in the Likert-scale tasks respondents might be overrating the importance and satisfaction of the items; while in the BWS, consumers were forced to select the best and worst alternatives in each scenario. Thus, the task impeded in principle to define every item as very important and very satisfying, and as a result, we concluded that BWS offers more reliable and clearer results.

The results of the analysis indicated that the most important attributes, and those that consumers are more satisfied with, are related to the hygiene and safety of the product, the health issues, the freshness, the flavour and the nutrients it contains. However, in some cases the level of satisfaction assigned to them differed from the level of importance, indicating that actions are needed to improve efficiently the quality of the products, especially for the case of the attribute related to the hygiene and food safety of the product, which was considered to be the most important, but whose level of satisfaction was relatively lower in magnitude, according to the BWS results. In addition, the results of the Importance-Satisfaction analysis for the BWS experiment show that all attributes were either considered as important and have a high level of satisfaction, or low satisfaction and low level of importance, which did not indicate critical issues that should be addressed with higher priority.

The main limitation of the study relates to data collection, as it was collected online by sending invitations to students and staff members related to the University of Las Palmas de Gran Canaria, and although it was clarified in e-mails that the survey could be shared with others outside the university context, most of the respondents were probably somehow related to the university. This also explains why the sample presents a high volume of respondents with a university degree, as well as a high number of students. Also, we used a convenience sampling

method because it was not possible to know the population of adults in Gran Canaria that buy seabass and seabream products, and that are also responsible for buying the products at their home, which were two mandatory conditions for answering the survey.

One major consideration for future research is to circumvent the main limitation of the study extending the sample to more population segments in Gran Canaria, as well as more regions in the EU and the world. Moreover, future research should establish different types of analysis for farmed and wild products, as attributes such as safety might be valued differently by consumers. This was already identified in a study, in which respondents agreed that farmed fish were safer due to major controls and balanced feeding (Claret et al., 2014). Future research should also assess the reliability of the results of the relationship between importance and satisfaction for the different attributes, as attributes may be of little importance for respondents once they have exceeded a particular level of satisfaction. An example of this occurs in the automobile market of some countries, where safety has become less important, as all vehicles sold must comply with minimum safety standards, so they are considered to be safe for this matter (Beck and Rose, 2016). A similar situation might be happening with some of the attributes listed in this study. In addition, the current study also provides interesting issues for authorities, marketers, and producers related to farmed seabream and seabass, as they can evaluate the degree of satisfaction that different attributes provide to consumers in relation with the importance that consumers give to these attributes. In a more industrial setting, our study could be extended to analyse specific product formats, selling establishments or even consumers' characteristics that could determine market segmentation. With enough and adequate data, the model could be enriched with new covariates that provide better insights to the stakeholders. This is a promising area for future research. In any case, the interest of using an alternative approach for the assessment of consumers' attitudes towards purchase of seabream and seabass will continue. The study is somewhat localized and dealing with an insular population (islanders), but inferences can be made to other similar geographies in which seabream and seabass consumption is also common.

3.6 Appendix

Table 3.5 shows all the scenarios included in the survey for the Best-Worst experiment.

Table 3.5. Distribution of alternatives in scenarios per block

Block 1				
Scenario	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1	Attribute 2	Attribute 6	Attribute 8	Attribute 9
2	Attribute 1	Attribute 6	Attribute 7	Attribute 16
3	Attribute 1	Attribute 2	Attribute 10	Attribute 12
4	Attribute 2	Attribute 15	Attribute 11	Attribute 5
5	Attribute 4	Attribute 7	Attribute 10	Attribute 13
6	Attribute 4	Attribute 8	Attribute 16	Attribute 12
7	Attribute 14	Attribute 16	Attribute 10	Attribute 11
8	Attribute 14	Attribute 9	Attribute 7	Attribute 3
9	Attribute 6	Attribute 11	Attribute 3	Attribute 12
10	Attribute 1	Attribute 15	Attribute 3	Attribute 13
Block 2				
1	Attribute 15	Attribute 8	Attribute 9	Attribute 10
2	Attribute 15	Attribute 7	Attribute 5	Attribute 12
3	Attribute 1	Attribute 14	Attribute 8	Attribute 5
4	Attribute 4	Attribute 6	Attribute 14	Attribute 15
5	Attribute 8	Attribute 7	Attribute 11	Attribute 13
6	Attribute 1	Attribute 4	Attribute 9	Attribute 11
7	Attribute 4	Attribute 2	Attribute 16	Attribute 3
8	Attribute 6	Attribute 10	Attribute 5	Attribute 3
9	Attribute 2	Attribute 14	Attribute 12	Attribute 13
10	Attribute 9	Attribute 16	Attribute 5	Attribute 13

Attributes: (1) Eating fish is healthy; (2) The product has a lot of nutrients; (3) Is easier to digest than the red meat; (4) Hygiene and food safety of the product; (5) More sustainable than red meat; (6) Flavour; (7) Knowing that the fish is fresh; (8) Easy to prepare; (9) Easy to buy; (10) The bones are not a problem; (11) The size (ration) of the seabream/seabass is appropriate; (12) The fishmonger can prepare it as wished; (13) It can be bought the 365 days of the year; (14) Custom or habit since child; (15) My close family and friends also eat seabream/seabass; (16) Price.

Table 3.6 shows the results of the initial estimated multinomial logit model based on the best-worst tasks. It includes the importance and satisfaction results for the attributes, with their respective t-statistics and p-values.

Table 3.6. Best-worst task estimates – Model 1

Attributes	IMP	t-stat	p-val.	SAT	t-stat	p-val.
Health and nutritional issues						
(1) Eating fish is healthy	**1.54**	16.31	0.00	**1.50**	16.82	0.00
(2) The product has a lot of nutrients	**0.860**	9.6	0.00	**0.742**	8.8	0.00
(3) Is easier to digest than the red meat	**-0.553**	-6.5	0.00	**-0.202**	-2.42	0.02
Safety issues						
(4) Hygiene and food safety of the product	**2.46**	25.17	0.00	**1.78**	20.38	0.00
Sustainability issues						
(5) More sustainable than red meat	**-0.337**	-3.91	0.00	*-0.155*	-1.86	0.06
Sensorial characteristics						
(6) Flavour	**1.06**	12.25	0.00	**1.10**	12.99	0.00
(7) Knowing that the fish is fresh	**1.66**	17.8	0.00	**1.53**	17.44	0.00
Convenience characteristics						
(8) Easy to prepare	**-0.182**	-2.11	0.03	**0.222**	2.67	0.01
(9) Easy to buy	-0.0997	-1.18	0.24	0.100	1.20	0.23
(10) The bones are not a problem	**-0.982**	-11.39	0.00	**-0.778**	-9.23	0.00
(11) The size (ration) of the seabream/seabass is appropriate	**-0.413**	-4.79	0.00	**-0.199**	-2.35	0.02
(12) The fishmonger can prepare it as wished	**-0.367**	-4.14	0.00	-0.0310	-0.36	0.72
(13) It can be bought the 365 days of the year	**-1.10**	-12.41	0.00	**-0.696**	-8.15	0.00
Social behaviour characteristics						
(14) Custom or habit since child	**-0.500**	-5.76	0.00	**-0.315**	-3.78	0.00
(15) My close family and friends also eat seabream/seabass	**-1.54**	-16.61	0.00	**-1.05**	-11.83	0.00
Price						
(16) Price	0.00	-fixed-	-fixed-	0.00	-fixed-	-fixed-
Alternative specific constants (ASCs)	Value		t-stat		p-val.	
ASC1	**0.172**		5.44		0.00	
ASC2	**0.133**		4.39		0.00	
ASC3	**0.166**		5.74		0.00	
ASC4	0.00		-fixed-		-fixed-	
Goodness of fit						
McFadden's pseudo R^2 (ρ^2)	0.195					
Adjusted McFadden's pseudo R^2 (Adjusted ρ^2)	0.193					
Final Log-likelihood	-14039.592					
Number of observations	14040					

Chapter II

The risk management of European Aquaculture companies

4 Paper: Understanding European aquaculture companies' perceived risks and risk management practices

J. Cantillo, D. Van Caillie.

Abstract

Aquaculture is the fastest-growing food production technology, having surpassed wild catch as a source of seafood (Bronnmann and Asche, 2017). Yet, modern aquaculture is one of the riskiest businesses to enter as entrepreneurs, farmers or investors (Asche et al., 2008). As a result, it is critical to understand how aquaculture companies perceive risks, as well as their most relevant risk sources and management practices, as these are necessary steps towards creating a safer environment for aquaculture development. Using a mixed-methods approach, the current study examines the perceptions of risk sources and risk management practices by European aquaculture companies. Also, the study aims to know if there are differences in the perceptions and ratings depending on the type of aquaculture company (grow-out or full-cycle company). Initially, based on the results of a survey and for each type of company, we built risk matrices and determined the most relevant risks. Also, we determined the most effective risk management practices and some attitudes towards risk for the different types of aquaculture companies. To deepen the understanding of the results, online interviews were used to supplement the responses. Our findings indicate that diseases risks are the most important type of risk for both full-cycle and grow-out companies; however, there are still differences in the ratings for the different types of risks between the two types of companies in both the magnitudes and the orderings. Similarly, results show that there are differences in the ratings of risk management practices among the types of companies. The findings also indicate that full-cycle companies are more willing to take risks than grow-out companies, even though both types of companies consider aquaculture to be a risky business.

Keywords: perceptions and attitudes towards risk; European aquaculture companies; risk sources; risk management practices; risk matrix.

4.1 Introduction

Aquaculture is the fastest-growing food production technology, having surpassed wild catch as a source of seafood since 2014 (Bronnmann and Asche, 2017). Capture production, on the other hand, has remained relatively stable since the late 1980s, whereas aquaculture has grown rapidly since 1950 (FAO, 2018). In fact, global fish production reached around 171 million tonnes in 2016, with aquaculture accounting for 53% of it (FAO, 2018). Yet, modern aquaculture is one of the riskiest businesses to enter as entrepreneurs, farmers or investors (Asche et al., 2008). Indeed, several risks in the production process are related to biophysical uncertainties associated with the environment, climatic conditions, and diseases (Kumbhakar, 2002; Tveterås, 1999). Furthermore, some species necessitate a lengthy production cycle, which increases the likelihood of production risks. (Asche et al., 2008). However, the risks do not only pertain to production, as market prices in the industry are typically volatile, and there is also constant competition with new companies entering the market, and access to the market is sometimes restricted due to changing trade regulations (Anderson, 2003). In addition, aquaculture businesses, like any other, face risks related to the organizations and personnel involved in the farm, as well as social and political risks that may arise depending on the context in which the activity is developed. Moreover, similar to agriculture, there are risks associated with the aquaculture industry such as poor quality, disease, competition, machinery failure, and environmental disasters, but aquaculture includes additional specific risks such as water quality and competition with capture fishery companies (McIntosh, 2008). Given the preceding, it is critical to comprehend how aquaculture companies manage and assess risk.

Risk is defined as the likelihood of an uncertain event occurring and the consequences associated with it (Sjöberg et al., 2004). In line with this, risk consists of two major components: first, the likelihood of a hazard affecting something, and second, the severity of the consequences associated with it (Arthur et al., 2009). Risk perceptions are primarily influenced by personal experience and trust, but cultural and individual factors such as age, education level, social status, gender, perceived salary, and others also play a role (Wachinger et al., 2013).

In the case of aquaculture literature, some studies have looked into the importance of various risk sources and risk management strategies/practices for farmers (Ahsan, 2011; Ahsan and Roth, 2010; Alam and Guttormsen, 2019; Bergfjord, 2009; Darby and Incedursun, 2019; Elwin et al., 2020; Joffre et al., 2019, 2018; Kabir et al., 2020; Le Bihan et al., 2013; Le and Cheong, 2010, 2009; Lebel et al., 2020, 2016, 2016, 2015; Pimolrat et al., 2013; Rahman et al., 2020; Theodorou, 2015). Most of these studies have only considered a quantitative approach by using surveys, with the goal of determining the main risk sources and risk management practices from the perspective of fish farmers. However, to the best of our knowledge, none of these studies has used as a complement a qualitative approach, such as post-survey interviews, to explore deeper into the answers obtained in those surveys.

In addition, in these articles, the authors typically refer to the actions towards the control of risk as risk management strategies, but since management strategies relate to actions carried out as a result of an event and the actions analysed in the papers relate more closely to daily

activities performed to manage risk, the definition of risk management practices seems more appropriate. We will therefore refer to this as risk management practices throughout the paper.

Another aspect to consider in the present study is that different types of companies emerge in commercial intensive aquaculture based on the stages of the life cycle that they execute in the production of the fish. Some are solely hatcheries, which carry out activities such as broodstock selection and conditioning, spawning, egg fertilisation, larval rearing, and post-larval and juvenile rearing. Others are grow-out companies, which buy juveniles from hatcheries and rear them until they reach commercial size. Finally, other companies carry out both the activities of hatcheries and grow-out companies, completing the entire life cycle of the fish, which is why they are referred to as full-cycle companies. Given that the risks that a company face may vary depending on the activities performed, it is crucial in risk management for aquaculture to differentiate farmers' attitudes and preferences based on the type of company. In this study, we will concentrate on two of the previous types of companies: full-cycle and grow-out companies, which are the most common in commercial aquaculture.

Following the previously exposed, the purpose of the current investigation is twofold: (1) understand the main insights into aquaculture companies' risk preferences and identify the most important risk sources and risk management practices, using for the first time in the aquaculture risk management field a mixed-methods approach with qualitative and quantitative data, and (2) determine whether the preferences for risk sources and risk management practices differ between full-cycle and grow-out aquaculture companies.

4.2 Literature review and hypotheses

Previous research has shown that the risk preferences of aquaculture farms may differ depending on certain farm characteristics, such as farm size (Le and Cheong, 2010; Rahman et al., 2020), culture method used (intensive, semi-intensive, or extensive) (Joffre et al., 2018; Lebel et al., 2020), where the fish are farmed (ponds or cages) (Lebel et al., 2020) and the type of species farmed (Lebel et al., 2020). Furthermore, risk preferences may differ based on farmer characteristics such as age (Le Bihan et al., 2013), education level (Lebel et al., 2020), gender (Lebel et al., 2020) and previous experiences with losses (Lebel et al., 2020).

Concerning farmers' risk attitudes, previous research in the context of Norwegian farmers producers revealed that aquaculture farmers are moderately risk-averse, and would rather sacrifice profits if it meant reducing risks (Bergfjord, 2009). Similar behaviour was observed among shrimp farmers in Bangladesh, who would prefer to sacrifice income if it meant avoiding risk or uncertainty (Ahsan, 2011). Nonetheless, a previous study of Norwegian salmon farmers found that they perceived themselves to be anywhere between risk-neutral and risk-seeking (Darby and Incedursun, 2019).

In the following subsections, we present and discuss briefly the most important key findings on aquaculture farmers' preferences for risk sources, and risk management practices. Also, we present the hypotheses that will be assessed in the present study.

4.2.1 Risk sources

Amongst the risk sources, the risk of diseases or pathogens is one of the most important risk sources identified in the literature. A previous study in the context of shrimp farming even argued that disease outbreak mortality is the greatest threat that could be faced (Ahsan, 2011).

Other significant risk sources identified in the literature include market risks that affect the company's finances, such as future price/price variation, market uncertainty (inaccessibility or demand), price of quality fingerlings or other inputs. In the case of future price/price variation risk, there has been failed experiences of some aquaculture companies due to continuous low salmon prices (Bergfjord, 2009) and fluctuating tilapia and pangasius fish prices (Rahman et al., 2020). Similarly, export-oriented industries, such as the mussel industry in Denmark, have previously been impacted by price fluctuations in the Dutch market (Ahsan and Roth, 2010). Furthermore, the catfish industry in Vietnam has experienced sale price fluctuations, which have resulted in significant losses for farmers, particularly during 2008, when farmers were forced to sell at 10% to 15% less than the production cost (Le and Cheong, 2009).

Regarding the risk of market uncertainty (accessibility or demand), shrimp farmers in Bangladesh are concerned about demand uncertainty because it is heavily influenced by conditions of major importers such as the economy, trade policies, and consumer preferences (Ahsan, 2011). This risk has also been a major issue for Catfish in Vietnam, where there has been an oversupply of product, making it impossible for catfish processors to buy all of the catfish, resulting in a loss to producers who had to continue feeding the fish, causing them to be oversized and with lower meat quality, resulting in a decrease in their selling prices (Le and Cheong, 2010).

Concerning the risk of the price of quality fingerlings or other inputs, in countries such as Bangladesh, private hatcheries, which are the majority of suppliers, are not regulated on seed prices, causing them to raise their prices arbitrarily, which is a major constraint for shrimp aquaculture (Ahsan, 2011). Moreover, input prices for catfish in Vietnam are imperfect in the pricing mechanism, which causes them to vary frequently, creating an uncontrolled situation for farmers (Le and Cheong, 2009).

There are also operational risk sources, such as the use of illegal chemicals and medications. In this context, different countries have different safety standards and regulations, and as a result, some countries, particularly those that are highly developed, demand strict and high standards, such as zero-tolerance on residues of prohibited medicines and chemicals, which farmers in less developed countries, such as Vietnamese catfish producers, cannot always meet, resulting in losses, considering that they are unable to sell their fish to these markets (Le and Cheong, 2010).

Other risk sources are related to the environment, such as pollution, bio-physical shocks/extreme weather events, and temperature rises or falls. There are also social risks, such as changes in future regulations (Ahsan and Roth, 2010; Darby and Incedursun, 2019). Finally, there are risk sources related to farm personnel and the functioning of the organization, such

as the risk of farmer health/disability or worker safety (Le Bihan et al., 2013; Theodorou, 2015) and exploitation from middlemen (Ahsan, 2011).

4.2.2 Risk management practices

Some important risk management practices identified in the literature include the supply and selection of quality fingerlings and inputs, the prevention of diseases and escapes, producing at the lowest possible cost (ceteris paribus), selecting a good quality/brand of feed, and maintaining a well-managed water environment (Ahsan and Roth, 2010; Alam and Guttormsen, 2019; Bergfjord, 2009; Joffre et al., 2019, 2018; Le and Cheong, 2009; Lebel et al., 2015; Rahman et al., 2020; Theodorou, 2015).

Maintaining good relationships with other farms and authorities is another important risk management practice considering that small farmers typically have only hands-on experience, while authorities have technical knowledge that can be beneficial to them (Lebel et al., 2016). Similarly, a good relationship with other farmers would allow them to share experiences and offer assistance to one another (Lebel et al., 2016).

There are numerous risk management practices aimed at preserving the company's financial health. Insurance is one of them, and it primarily reduces production risks such as diseases, escapes, and environmental shocks (Bergfjord, 2009), but its effectiveness as a solution is dependent on the type and scope of coverage provided (Darby and Incedursun, 2019). Furthermore, financial credit reserves and off-farm employment are two risk management practices that could be used for small-scale farmers (Theodorou, 2015).

Finally, other risk management practices found in the literature are related to the optimization of a company's supply chain by removing the influence of middlemen (Ahsan, 2011) and the optimization of employees' work by using practices such as best management practices and training (Joffre et al., 2018).

4.2.3 Hypotheses

Based on the previous literature review, we developed the following hypotheses, which will be assessed in the present investigation:

- H1: Risks sources are rated differently depending on the type of aquaculture company (full-cycle and grow-out companies).
- H2: Risks management practices are rated differently depending on the type of aquaculture company (full-cycle and grow-out companies).
- H3: There are differences in the attitudes towards risks depending on the type of aquaculture company (full-cycle and grow-out companies).

4.3 Data and methodology

The current study employs a mixed-methods approach, specifically a quantitative-qualitative approach. The significance of using a mixed-methods approach stems from the fact that all previous studies on the topic used only a quantitative approach based on surveys, intending to

determine the main risk sources and risk management practices. The approaches were based on a rating scale of the various risk sources and risk management practices, with no insights or clear explanations as to why those elements were given such specific ratings.

Finally, most previous studies explained differences in risk source ratings and risk management practices based on assumptions, rather than attempting to understand the differences and inconsistencies based on farmers' actual opinions. All these issues can be overcome or at least improved by incorporating a qualitative approach in addition to the quantitative approach.

4.3.1 Data collection

Initially, a survey was used to understand risk attitudes and rank different risk sources in terms of severity of their consequences and likelihood of occurrence and to rank the most important risk management practices, from the perspective of Aquaculture European companies. Following that, a qualitative approach using online interviews to a subsample of the respondents was used to supplement the responses and understand why each risk source and risk management practice was deemed important/unimportant.

4.3.1.1 Quantitative approach – Surveys

A survey was distributed to various European fish companies for the quantitative approach section. The questionnaires were distributed via email, and the companies were informed that all information gathered would be treated anonymously. In order to identify the more significant types of risks, the survey included a rating of different types of risks in terms of their severity and likelihood of occurrence. Following that, respondents must select the top three specific risks for each risk category based on their likelihood of occurrence and expected consequences. It also included an assessment of the effectiveness of various risk management practices that had been considered in previous studies in the literature. Also, the survey asked respondents to rate their level of agreement with various statements to determine their risk attitudes.

The main characteristics of the sample surveyed are shown in Table 4.1. We received 14 responses in total, with 8 of them relating to European aquaculture grow-out companies and 7 relating to full-cycle companies involving both the hatchery unit and the grow-out facilities.

Table 4.1. Characteristics of the sample

Countries	**%**	**Species**	**%**
Germany	13.3%	Trout	26.67%
Switzerland	13.3%	Meagre	26.67%
Ireland	13.3%	Salmon	20.00%
Cyprus	6.7%	Seabass	20.00%
Poland	6.7%	Seabream	20.00%
Greece	6.7%	Carp	13.33%
Czech rep.	6.7%	Perch	13.33%
Portugal	6.7%	Pike	13.33%
Turkey	6.7%	Sturgeon	13.33%
United Kingdom	6.7%	Amberjack	6.67%
Belgium	6.7%	Artic Char	6.67%
Spain	6.7%	Coregonus	6.67%
		Pagrus	6.67%
Total production (Avg of 2019 and 2020)	**%**	Tench	6.67%
Less than 10 tons	20.0%	**Type of company**	**%**
11 to 50 tons	6.7%	Full-cycle	46.7%
51 to 100 tons	13.3%	Grow-out	53.3%
101 to 400 tons	13.3%	**Employees**	**%**
401 to 1000 tons	6.7%	1-10 employees	53.3%
1001 to 2000 tons	20.0%	21-50 employees	33.3%
2001 to 5000 tons	13.3%	101-150 employees	6.7%
150000 tons	6.7%	Over 150 employees	6.7%

4.3.1.2 Qualitative approach – Interviews

Semi-structured interviews were conducted with some of the European Aquaculture companies during the qualitative section of the investigation to supplement the responses and understand why each risk source and risk management practice was deemed important/unimportant. Individual interviews were conducted, and they were directed to the farm's production manager, but they could have also been answered by someone familiar with the company's production and organization, such as the CEO.

In total, we conducted four interviews to supplement the survey data, two of which were with full-cycle companies and the other two with grow-out companies. One of the full-cycle companies was based in Cyprus and produced around 5000 tons of fish between seabream, seabass, and meagre farmed in cages in the ocean, while the other was a company based in Switzerland and produced around 400 tons of Perch using a Recirculating Aquaculture System (RAS) without the use of antibiotics and medications. The RAS is a land-based aquatic system that reuses water after mechanical and biological treatment to reduce water and energy needs as well as nutrient emissions in the environment (Martins et al., 2011).

From the grow-out companies, one is based in Spain and produces around 4000-5000 tons of fish between seabream, seabass, and meagre farmed in cages in the ocean, while the other is based in Switzerland and produces sturgeon for caviar and perch, pikeperch, and Coregonus species using RAS technology.

4.3.2 Methodology for obtaining the most important risk sources using Discrete choice models

Initially, we identified the most relevant categories of risk types. After that, we obtained the highest important specific risks for each risk category based on the severity of their consequences and likelihood of occurrence. To do this, we initially estimated discrete choice models, based on the section that asked respondents to select the top three specific risks for each risk category based on their likelihood of occurrence and severity of the expected consequences. Each selection made by the respondents was considered as a choice based on a set of alternatives.

The conceptual framework of Discrete Choice Models is based on random utility theory (RUT) (McFadden, 1974; Thurstone, 1927), which proposes that respondents choose the alternative with the highest utility. This utility is made up of two parts: a systematic and deterministic measurable component, and a random component. While the systematic part is determined by the attributes of the alternatives, the random part represents the unobserved attributes.

We estimated two multinomial logit models for each type of risk, one related to full-cycle companies and one for grow-out companies. In each model and for each choice set, we considered half utility functions for responses related to the importance of the risks according to the severity of their consequences and the other half for responses related to the likelihood of occurrence of the risks.

When asked for the best options, the alternatives shown in the choice task are always available for modelling purposes. However, the best-chosen option is no longer available when selecting the second-best option because the same alternative cannot be evaluated as both the best and second-best option at the same time. Similarly, when selecting the third-best option for each type of risk and selection (consequences or likelihood), the best and second-best options are not available. The utility functions for the consequences and likelihood decisions of the alternative i are:

$$U_i^{Consequences} = \sum_{k=1}^{n} \beta Consequences_k \times Consequences_{ik} \text{ with } i = 1, \ldots, m \qquad (5.1)$$

$$U_i^{Likelihood} = \sum_{k=1}^{n} \beta Likelihood_k \times Likelihood_{ik} \text{ with } i = 1, \ldots, m \qquad (5.2)$$

Where the explanatory attributes are defined as:

$Consequences_{ik}$ = 1 if the risk k is shown in alternative i as one of the most important risks in terms of the severity of its consequences and 0 otherwise

$Likelihood_{ik}$ = 1 if the risk k is shown in alternative i as one of the most important risks in terms of its likelihood of occurrence and 0 otherwise

One of the dummy variables was set to 0 and served as a reference for each type of risk. The coefficients $\beta Consequences_k$ and $\beta Likelihood_k$ can be understood as the degree of importance for the risk k based on the consequences and likelihood of occurrence, respectively. The parameters are interpreted using the reference with effect "0," which corresponds to the fixed alternatives. Thus, negative parameters indicate that the respective risks are less important in terms of consequences or likelihood of occurrence than the fixed risk, whereas positive parameters indicate that they are more important in terms of consequences or likelihood of occurrence than the fixed risk. Similarly, the statistical significance of the parameters indicates differences in the level of importance in terms of the consequences or likelihood of occurrence with respect to the fixed risks. The multinomial logit models were estimated using the free software "Biogeme"(Bierlaire, 2003).

Following the obtention of the models, each of the specific risks is plotted on a relative scale ranging from 0% to 100% based on the values obtained for the parameters in the multinomial logit models, with 0% assigned to the lowest value of the parameters obtained and 100% assigned to the highest value of the parameters obtained. This was done for each type of risk, company, and type of selection [consequences (C) or likelihood (L)].

4.4 Results and discussion

Based on the survey data and differentiating between full-cycle and grow-out companies, in this section, we present the results and discuss the most relevant risk sources, risk management practices, and attitudes and perceptions toward risks by aquaculture European companies.

4.4.1 Most relevant risk sources

The findings show that, when it comes to ranking risk types based on their level of risk, both full-cycle and grow-out companies have similar preferences in the order, except for environmental and market and financial risks, which exchange second and third place for each type of company. Even though the orderings for both companies are similar, the magnitudes of the scores differ greatly, with grow-out companies self-reporting higher levels of risk than full-cycle companies. Table 4.2 displays detailed information about the scores obtained for each type of company and risk.

According to the findings, the most significant risk for both types of companies is the risk of diseases. According to one of the full-cycle companies interviewed, they have previously had significant issues with diseases, but vaccination has served as an important tool for reducing diseases occurrence. Nonetheless, the company added that diseases risk is not under control, as there is always the possibility of something going wrong. Aside from the losses that it may represent, it may also erode customer trust, resulting in a loss of clients. Furthermore, the risk of diseases may result in significant losses, particularly for companies using RAS. The interviewed grow-out company using this system indicated that due to a disease issue, they will stop production next year to disinfect their system because, with RAS, it is mandatory to empty the system to completely clean it. The full-cycle company using RAS, on the other hand, clarified

that the risk of diseases is greater for grow-out companies because these companies buy juveniles, whereas full-cycle companies grow their own, resulting in greater control over production and thus a lower risk of diseases.

Environmental risks are ranked second for full-cycle companies, while market and financial risks are ranked second for grow-out companies. For each company, these two types of risks switched places for the second and third places. Concerning environmental risks, two of the companies interviewed clarified that geographical location is an important factor that may determine how important this issue is, particularly in terms of the risk of bad weather and pollution, as these issues are particularly more significant in certain locations. Regarding market and financial risks, two of the companies interviewed claimed that these are low for businesses that already have a stable customer base and differentiate themselves from the competition. Nonetheless, a full-cycle company interviewed argued that market and financial risks are significant because they represent something that cannot be controlled and can derail a company's plans, especially given that aquaculture farming is a process that can take a long time, so companies must plan their production with great anticipation, which may not be under the expected future market demand or prices.

Finally, for both types of companies, the operational risks, organizational and human risks, and social and political risks are ranked fourth, fifth, and sixth, respectively. According to one of the full-cycle companies interviewed, operational risks are usually caused by human errors, so it is critical that major tasks and decisions are performed and checked by at least two people. An interviewee added that operational risks may be more pressing for companies using RAS systems because there is a combination of humans and machines, which may necessitate more effort in their synchronization to control the operations. In terms of organizational and human risks, a company stated that experience, as well as having the right people for the job, are important factors in the company's organizational management. Employee polyvalence is also a valuable asset in the management of organizational risks. Meanwhile, all the companies interviewed agreed that social and political aspects do not change much, and thus do not represent major concerns, which explains their low valuation.

Table 4.2. Average scores for the types of risk

	Full-cycle companies				Grow-out companies			
Type of risk	Mean consequences (C)	Mean Likelihood (L)	Level of risk (C x L)	Rank	Mean consequences (C)	Mean Likelihood (L)	Level of risk (C x L)	Rank
Diseases risks (DR)	3.43	2.71	9.31	1	4.00	3.63	14.50	1
Environmental risks (ER)	3.57	2.29	8.16	2	3.38	3.00	10.13	3
Market and financial risks (MFR)	3.00	2.57	7.71	3	3.75	2.75	10.31	2
Operational risks (OR)	2.57	2.14	5.51	4	3.50	2.75	9.63	4
Organizational and human risks (OHR)	2.29	1.86	4.24	5	2.88	2.88	8.27	5
Social and political risks (SPR)	2.29	1.43	3.27	6	2.50	2.13	5.31	6

Based on the previous findings, we developed a risk matrix for full-cycle companies (see Table 4.3) and grow-out companies (see Table 4.4), considering average scores for the risks in terms of their consequences and likelihood of occurrence. The risk matrices are divided into four sections: one green for low risks, one yellow for moderate risks, one orange for high risks, and one red for extreme risks. We found that social and political risks are low for both types of companies, whereas diseases risks, as well as market and financial risks, are considered high risks for both types of companies. Furthermore, full-cycle companies rated organizational and human risks as low, whereas grow-out companies rated them as high. Similarly, while operational and environmental risks were rated as moderate for full-cycle companies, they were rated as high for grow-out companies.

Table 4.3. Risk matrix for full-cycle companies

Likelihood (L)	Consequences (C)				
	1. Very low or minor impact	2. Low	3. Moderate	4. High	5. Very high or severe impact
1. Very rare occurrence		SPR			
2. Low probability to happen		OHR	OR	ER	
3. Moderate probability to happen			DR, MFR		
4. High probability to happen					
5. Almost certain occurrence					

Table 4.4. Risk matrix for grow-out companies

Likelihood	Consequences				
	1. Very low or minor impact	2. Low	3. Moderate	4. High	5. Very high or severe impact
1. Very rare occurrence					
2. Low probability to happen		SPR			
3. Moderate probability to happen			ER, OHR	MFR, OR	
4. High probability to happen				DR	
5. Almost certain occurrence					

For the obtention of the most important specific risks for each category, we considered the results of multinomial logit models that analyse the choices of the respondents for the most important specific risks, which can be observed in the Appendix. Based on the values of the parameters obtained, we plotted on a relative scale from 0% to 100% each of the specific risks

according to each risk category, type of company and type of selection (consequences or likelihood of occurrence). The results can be observed in Figure 4.1.

Figure 4.1. Relative scale results of the specific risks according to the severity of the consequences (C) and the likelihood of occurrence (L)

Diseases risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
High death rate due to diseases	100.00%	71.55%	100.00%	84.13%
Fingerlings infected by diseases	75.83%	100.00%	56.71%	25.94%
Inability to control diseases from environmental sources	57.08%	76.66%	89.63%	100.00%
Severe malformations or skeletal anomalies	0.00%	0.00%	21.65%	0.00%
Non-severe malformations or skeletal anomalies	N/A	0.00%	0.00%	N/A

Environmental risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Drought	100.00%	72.66%	51.23%	0.36%
Bad weather/Bio-physical shocks (storms, temperature changes, etc.)	96.04%	100.00%	97.88%	100.00%
Pollution	86.21%	69.92%	88.30%	35.59%
Pests (Fouling organisms/Predators)	60.34%	64.14%	100.00%	75.41%
Flood	0.00%	0.00%	0.00%	0.00%

Market and Financial risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Price of feed	100.00%	100.00%	50.93%	52.57%
Fish price variability/Future fish price	81.60%	99.65%	100.00%	100.00%
Taxation/Taxes	70.20%	30.03%	N/A	0.00%
Future wages of labour	63.31%	30.03%	0.00%	0.00%
Uncertainty about market access/trade policy	46.47%	51.42%	30.93%	50.15%
Future fish demand	46.18%	37.31%	46.93%	35.05%
Price of fingerlings	5.21%	1.82%	0.53%	1.51%
Market regulation measures	5.21%	N/A	1.33%	0.00%
Under financing by own capital, credits, loans or subsidies	2.31%	0.00%	N/A	N/A
Price of farm equipment	0.00%	N/A	0.00%	0.00%
Future interest/exchange rate	N/A	N/A	N/A	N/A

Operational risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Technical failure (machinery, equipment)	100.00%	100.00%	100.00%	100.00%
Low quality of feed	95.27%	84.10%	3.42%	0.00%
Escapes	73.59%	89.13%	70.00%	39.10%
Availability of production inputs	44.17%	2.56%	49.57%	28.37%
Accidents on the fishing vessels	4.85%	37.95%	35.04%	29.41%
Low-quality fingerlings	2.91%	0.00%	73.68%	61.25%
Overfeeding causing pollution and waste accumulation	2.91%	0.00%	32.05%	23.88%
Applying chemical and medicines improperly	0.00%	3.08%	N/A	25.95%
Use undersize/oversize fingerlings	0.00%	N/A	N/A	N/A
A poor or inexistent water treatment system	N/A	N/A	N/A	N/A
Over (density) stocking fingerlings	N/A	46.15%	0.00%	N/A

Organizational and Human risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Risk of losing key employees	100.00%	100.00%	45.19%	70.90%
Risk of injuries/health problems among employees	85.54%	28.41%	92.96%	100.00%
Sufficient supply of competent labour	80.75%	64.35%	100.00%	90.87%
Logistics and transportation issues	34.74%	7.54%	44.44%	46.22%
'Moral risk': untrustworthy/corrupt employees	0.00%	53.33%	0.00%	0.78%
Influence of middlemen or distribution organizations	0.00%	0.00%	25.19%	0.00%

Social and Political risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Changes in environmental policy and regulations	100.00%	100.00%	72.47%	100.00%
Future changes in the licensing system	50.79%	35.71%	94.12%	97.01%
Changes in government policy on product development strategy	46.83%	32.14%	1.82%	38.92%
Changes in animal health regulations	42.06%	36.61%	52.42%	94.01%
Public view of farms (concerns about safety and sustainability)	28.57%	46.43%	100.00%	44.91%
Political shocks	2.38%	0.00%	37.37%	0.00%
Governmental support removal	2.38%	35.71%	3.19%	1.80%
Uncertainty about food safety policy	1.19%	N/A	N/A	N/A
Certification systems	0.00%	30.36%	0.00%	N/A
Sufficient sea area access	N/A	N/A	0.00%	76.05%
Changes in work environment regulations	N/A	28.13%	N/A	63.47%

We summarized in Table 4.5 the findings of the three most important specific risks based on the severity of their consequences and likelihood of occurrence according to the results of Figure 4.1. A discussion of the impact of the top-three most important specific risks according to the severity of their consequences and likelihood of occurrence for each risk category are discussed in the sub-sections below.

Table 4.5. Most important risks for full-cycle companies and grow-out companies

Type of risk	Full-cycle companies		Grow-out companies	
	Consequences	Likelihood	Consequences	Likelihood
Diseases risks	1. High death rate due to diseases 2. Fingerlings infected by diseases 3. Inability to control diseases from environmental sources	1. Fingerlings infected by diseases 2. Inability to control diseases from environmental sources 3. High death rate due to diseases	1. High death rate due to diseases 2. Inability to control diseases from environmental sources 3. Fingerlings infected by diseases	1. Inability to control diseases from environmental sources 2. High death rate due to diseases 3. Fingerlings infected by diseases
Environmental risks	1. Drought 2. Bad weather/Bio-physical shocks (storms, temperature changes, etc.) 3. Pollution	1. Bad weather/Bio-physical shocks (storms, temperature changes, etc.) 2. Drought 3. Pollution	1. Pests (Fouling organisms/Predators) 2. Bad weather/Bio-physical shocks (storms, temperature changes, etc.) 3. Pollution	1. Bad weather/Bio-physical shocks (storms, temperature changes, etc.) 2. Pests (Fouling organisms/Predators) 3. Pollution

Market and financial risks	1. Price of feed 2. Fish price variability/Future fish price 3. Taxation/Taxes	1. Price of feed 2. Fish price variability/Future fish price 3. Uncertainty about market access/trade policy	1. Fish price variability/Future fish price 2. Price of feed 3. Future fish demand	1. Fish price variability/Future fish price 2. Price of feed 3. Uncertainty about market access/trade policy
Operational risks	1. Technical failure (machinery, equipment) 2. Low quality of feed 3. Escapes	1. Technical failure (machinery, equipment) 2. Escapes 3. Low quality of feed	1. Technical failure (machinery, equipment) 2. Low-quality fingerlings 3. Escapes	1. Technical failure (machinery, equipment) 2. Low-quality fingerlings 3. Escapes
Organizational and human risks	1. Risk of losing key employees 2. Risk of injuries/health problems among employees 3. Sufficient supply of competent labour	1. Risk of losing key employees 2. Sufficient supply of competent labour 3. 'Moral risk': untrustworthy/corrupt employees	1. Sufficient supply of competent labour 2. Risk of injuries/health problems among employees 3. Risk of losing key employees	1. Risk of injuries/health problems among employees 2. Sufficient supply of competent labour 3. Risk of losing key employees
Social and political risks	1. Changes in environmental policy and regulations 2. Future changes in the licensing system 3. Changes in government policy on product development strategy	1. Changes in environmental policy and regulations 2. Public view of farms (concerns about safety and sustainability) 3. Changes in animal health regulations	1. Public view of farms (concerns about safety and sustainability) 2. Future changes in the licensing system 3. Changes in environmental policy and regulations	1. Changes in environmental policy and regulations 2. Future changes in the licensing system 3. Changes in animal health regulations

4.4.1.1 Diseases risks (DR)

In terms of the severity of the consequences, both full-cycle and grow-out companies identified the risk of the high death rate due to diseases as the most important risk of diseases. According to one full-cycle company interviewed, it is the most serious problem they could face because it forces the company to change its schedule, which could result in the failure to meet the expected fish demand on time for some clients, posing an imminent high risk of losing clients. According to one of the grow-out companies interviewed, one of the biggest consequences of this risk, is that it represents a huge economic cost for the companies, as not only the production is lost, but also all the money invested in the feed and inputs used to grow the fish.

Both types of companies ranked the fingerlings infected by diseases and the inability to control diseases from environmental sources as the second and third most important risks in terms of the severity of their consequences, but the positions in the ranking differed according to the type of company. Concerning the risk of fingerlings infected by diseases, one of the full-cycle companies stated that the problem with this risk is that if there is an issue with the fingerlings,

they must start from zero in the hatchery unit, which also affects the on-growing facilities because there is nothing to stock in there. Also, the other full-cycle company expressed concern about viruses infecting their fingerlings because, although they usually produce their own eggs, genetic issues occasionally arise that cause them to seek new genitors or eggs from the lake, and it is unknown whether these eggs are completely disease-free. According to one of the interviewed grow-out companies, the reason why fingerlings infected with diseases are less important for grow-out companies is that there is usually a previous control of those fingerlings in hatcheries, which grow-out companies demand before buying them. Despite this, the company added that the quality of those fingerlings, as well as the logistics processes associated with them, may differ between companies, with not all of them guaranteeing good quality.

Regarding the risk of being unable to control diseases from environmental sources, one of the grow-out companies stated that this is a very serious issue for farms using only one RAS, as it is not possible to get rid of infection unless the system is shut down, which is not feasible for grow-out facilities that must keep running and do not normally schedule a shutdown. However, a full-cycle company interviewed that also uses RAS stated that this risk is low for them because they are on inland facilities where environmental conditions are easier to control than on farms operating in nature. Nonetheless, a significant difference between grow-out companies with RAS and fingerling producers, according to the grow-out company, is that once the batch is out, fingerling producers stop, disinfect, and then restart, whereas grow-out producers do not because the fish are typically going in and out continuously.

In the case of the most probable diseases risks occurring, full-cycle companies assigned the highest probability to the risk of fingerlings infected by diseases, while grow-out companies assigned it to the third position. In contrast, the inability to control diseases from environmental sources was ranked as the most probable risk for grow-out companies, while it was ranked second most probable for full-cycle companies. Finally, the risk of a high death rate due to diseases was chosen as the second most likely to occur by grow-out companies, while it was chosen as the third most likely to occur by full-cycle companies.

According to the literature review, risk diseases were expected to be one of the most important, so we asked additional questions in the surveys to analyse some aspects about the concerns for different issues for disease transmission (see Table 4.6) and the level of concern regarding different types of diseases (see Table 4.7). In both cases, the scores are ranked from 1 to 6.

According to the findings, disease transmission in new fish is a major concern for both full-cycle companies and grow-out companies. One of the grow-out companies interviewed expressed concern because, while hatcheries typically perform analysis to ensure the health of the fish, there is a possibility that no actual study was conducted. According to the other grow-out company, the main pathway of pathogens for RAS is with new fish introduced into the system, which is why they have primarily one supplier that operates efficiently and with a high hygienic level for each fish species. One of the full-cycle companies interviewed added that they sometimes need to import fingerlings for various reasons, and even though they have the

opinion of an ichthyologist to avoid problems with the fingerlings, there is still a chance of a problem arising.

Furthermore, full-cycle companies ranked water supply and equipment second and third, respectively, while both issues tied for second and third place for grow-out companies. The main problem with the water supply issue on disease transmission is related to full-cycle companies because whether they operate with or without RAS, their hatchery units use tanks, where it is more likely that something bad happens because of the supplied water; whereas grow-out farms that operate in the ocean, for example, claim that this is not a problem for them, as there is no supply, but a recirculating action in the cages on the open sea. Regarding the equipment, an interviewee stated that they sometimes exchange their equipment or boats amongst their various farms, so if there is a problem with one of the farms, it could spread to the others after a few days. Finally, the people were the least valued issue for both types of companies, with all interviewees claiming to rate it lowest because they have ideal employees.

Table 4.6. Level of concern of companies about the impact of some issues on disease transmission

Issue	Full-cycle companies	Grow-out companies
New fish	4.43	4.25
Water supply	4.29	3.63
Equipment	3.29	3.63
People	2.86	3.13

In terms of the most important types of diseases, full-cycle companies gave viral diseases the highest score, followed by bacterial diseases. According to a full-cycle company interviewed, bacterial and viral diseases are a major concern for farms around the Mediterranean Sea because if there is a problem of this type in one country, it may spread to other countries in the Mediterranean after a few years. Another full-cycle company interviewed stated that, due to their concern for bacterial diseases, they analyse at least twice a day samples of water from every tank in the company. Meanwhile, parasitic diseases are the most important types of diseases for grow-out companies, followed closely by viral and bacterial diseases. However, in the interviews, the concern for parasitic diseases seems to be lower, as one of the interviewees stated that parasitic diseases primarily appear because of human errors. The other grow-out company added that there are viruses that do not cause death but can harm the fish's immune system, causing anaemia and, as a result, preventing the fish from growing properly. However, the RAS-based grow-out company added that the concern for bacteria is greater than for viruses because the former is typically more severe and long-lasting than the latter.

Moreover, fungal diseases were ranked fourth in terms of importance for full-cycle companies, while skeletal anomalies or malformations were ranked last. Similarly, for grow-out companies, these two types of diseases were at the bottom of the list. According to one grow-out company interviewed, fungal diseases are not a problem for grow-out companies operating solely in the ocean because fungal diseases do not exist there, whereas another grow-out company using a RAS system stated that this type of disease appears only if something goes wrong. In addition, in the last ten years, a full-cycle company added that they only had one or two problems associated with fungal diseases, which explains the low ranking in terms of concern. Concerning

malformations, a grow-out company interviewed contended that hatcheries normally control skeletal anomalies because they perform screens to remove fish with anomalies when they are between 3 and 10 grams in weight. Also, two full-cycle companies and a grow-out company indicated that abnormalities are not a major issue because their losses are not as severe when compared to other types of diseases, due to the usual low percentage of fish with malformations. Some companies even stated that abnormal fish can still be sold at a reduced price, and that if the fish is filleted, the anomaly may be undetectable.

Table 4.7. Level of concern of companies about the impact of different types of diseases

Issue	Full-cycle companies	Grow-out companies
Overall concern about avoiding disease	5.43	4.75
Concern about viral diseases	5.43	4.75
Concern about parasitic diseases	4.43	4.88
Concern about bacterial diseases	5.00	4.75
Concern about fungal diseases	4.00	3.63
Concern about skeletal anomalies/malformations	3.57	3.63

4.4.1.2 Environmental risks (ER)

In terms of the severity of the consequences, full-cycle companies ranked drought and bad weather/bio-physical shocks (storms, temperature changes, etc.) highest, while grow-out companies ranked pests (fouling organisms/predators) and bad weather/bio-physical shocks (storms, temperature changes, etc.) as the most important environmental risks. Meanwhile, pollution was ranked third in terms of the consequences and likelihood of occurring for both full-cycle and grow-out companies. In the case of drought, one of the full-cycle companies expressed concern for this risk because they rely on a water source that comes from the mountain, which is not guaranteed to be there in the future, which is why they are improving the farm's water needs and looking for ways to use less water every day. Concerning pests, a grow-out company that uses RAS expressed concern because they had incidents with birds attacking the fish through a small piece of the tanks that were not completely covered, transmitting bacteria (Aeromonas salmonicidas) from one tank to the next.

In terms of the risk of bad weather, one of the grow-out companies stated that storms and sudden temperature changes may affect seabream species, whereas calm ocean currents affect seabass species more. Lightning strikes could disrupt electrical devices in farms using RAS, according to the other grow-out company. They have experienced some short current cuts during lighting events, which are poorly handled by equipment such as the frequency inverter sensor. In addition, according to one of the full-cycle companies, the weather is a major source of concern because it is uncontrollable, and the consequences grow with the duration of the event because if the event lasts a few days, they are unable to go inside the farms and fix small issues that, after a few days of inaction, turn into big problems, such as fish escapes due to holes in the nets. This company also indicated that the geographical location of the farms plays a big part in the consequences related to this risk, as the weather conditions depend greatly on this.

Furthermore, both full-cycle and grow-out companies identified bad weather/bio-physical shocks (storms, temperature changes, etc.) as the most significant environmental risk in terms of likelihood of occurrence. Meanwhile, the risk of drought was the second most important in terms of likelihood for full-cycle companies, while pests (fouling organisms/predators) were the second most important for grow-out companies.

4.4.1.3 Market and financial risks (MFR)

In terms of the severity of the consequences, full-cycle companies assigned the highest score to the price of feed, while grow-out companies assigned it to fish price variability/future fish price, with these two risks trading places as the second-highest rated for each type of company. Furthermore, the third highest-rated risk for full-cycle companies was taxation/taxes, while future fish demand was the third highest-rated risk for grow-out companies.

The price of feed is important for grow-out companies because it is one of the most important inputs in terms of the financial aspect. A grow-out company recommends having at least two feed suppliers, which is supported by the fact that all the companies interviewed have at least two feed distributors. Meanwhile, a full-cycle company stated that feed price concerns are more prevalent in companies that only do "proteins", as the price of the feed is directly related to the product price, whereas companies that differentiate their products from the rest have less reliance on feed price to set their product prices.

Concerning the risk of fish price variability/future fish price, two interviewed companies agreed that the risk of fish price variability is enormous, given that the aquaculture business is a long-term investment that is done under certain expectations and margins, including selling prices, that can change all the time and, if they drop too much, can have a significant impact on the business's success. In addition, one grow-out company claimed that fish price variability is in great part caused by the influence of international producers who enter European markets at lower prices, with which European firms cannot compete. Meanwhile, a full-cycle company was unconcerned about future prices because they are investing in marketing and communication of their products, which has helped them differentiate their products from the competition and thus be less affected by market price drops. They advise other companies to take actions that secure a fair market price for their products.

In terms of likelihood of occurrence, both companies rank fish price variability/future fish price and feed price as the two most important risks. Furthermore, the third highest-rated risk for both types of companies was the uncertainty about market access/trade policy.

4.4.1.4 Operational risks (OR)

Regarding the severity of the consequences, the highest-rated operational risks for both full-cycle and grow-out companies were, in order, technical failure (machinery, equipment), low feed quality, and escapes. In the case of technical failure, the RAS grow-out company stated that it is an ever-present risk, but it can be managed by having a good technical team that knows what they are doing and considers everything that could possibly go wrong. Furthermore, the RAS requires additional machinery capacity to make repairs. For example, the main RAS for this

grow-out company has four pumps that run at 80% capacity, allowing for the possibility of removing one, repairing it, and reinstalling it without completely shutting down the system and, more importantly, without the fish noticing any difference. On the contrary, despite having high-level machinery and equipment such as automatic feeding systems, there aren't many major machinery issues for a full-cycle company operating in the ocean. However, this could be because these systems were designed for their specific case and needs, making any problems that may arise easier to resolve.

Concerning the risk of low feed quality, a full-cycle company interviewed stated that they always conduct checks on the fish feed purchased as well as in the fish by analysing the Feed Conversion Ratio (FCR) to ensure that the feed quality is as expected. Another full-cycle company expressed concern about this risk after discovering that feed suppliers were changing their products without informing their customers, which could harm the business. Furthermore, because RAS is a closed system, companies that use it report no issues with escapes, while full-cycle and grow-out companies that use sea cages did.

In terms of likelihood of occurrence, both full-cycle and grow-out companies assigned technical failure the highest probability of occurrence. The results also show that for full-cycle companies, the second and third highest-rated risks in terms of likelihood of occurrence were related to escapes and low quality of feed, respectively, while for grow-out companies, they were related to low-quality fingerlings for second place and escapes for third place. When comparing low-quality fingerlings to high-quality fingerlings, one of the grow-out companies interviewed stated that it is a significant risk because it results in a lower quality final product and possibly requires more time to fatten the fish to the expected weight.

4.4.1.5 Organizational and human risks (OHR)

In terms of organizational and human risks, both full-cycle and grow-out companies chose the same top-three risks according to the severity of their consequences: risk of employee injuries/health problems, risk of losing key employees, and sufficient supply of competent labour, but in a different order. Regarding the risk of injuries/health problems among employees, the grow-out company that operates in the ocean stated that injuries in the ocean are common and thus a problem. It is dangerous, especially for divers, whose injuries necessitate lengthy recovery times, forcing the company to replace the diver and thus, incurring additional costs. Another grow-out company interviewed stated that even if someone is unavailable for any reason, they are never in a position where they cannot run the farm because they always have one or two backups, as employees' knowledge is not organized by specific area, but they all know how to operate all of the farm's systems.

Concerning the risk of losing key employees, all of those interviewed agreed that it is essential to keep their best employees. One full-cycle company commented that it is a concern, but not the most important one, because key employees in their company are usually stable, and some of them have been with the company for many years. A grow-out company added that key employees are extremely valuable to them because they have few employees, and these

employees become extremely difficult to replace as they gain experience and become effective and suitable for use in emergencies.

With respect to the risk of a sufficient supply of competent labour, one grow-out company interviewed indicated that it is a high risk due to the difficulty in finding qualified employees in aquaculture, as working conditions are not the best because normally, the personnel working on the farms have to live near the farm, working on weekends and sometimes 24 hours a day make it difficult to find qualified supply on some occasions. Furthermore, one of the full-cycle companies interviewed stated that it was difficult to find personnel to work on the farm from their country (Switzerland) because that country did not have that type of learning, so they rely on finding personnel from other countries, which complicates matters for this issue.

In terms of likelihood of occurrence, the highest risk for full-cycle companies was the risk of losing key employees, while the risk of injuries/health problems among employees was the highest risk for grow-out companies. A sufficient supply of competent labour was the second highest-rated in terms of likelihood of occurrence for both full-cycle and grow-out companies. Finally, the third highest-rated risk for full-cycle companies was related to 'moral risk': untrustworthy/corrupt employees, while the third position for grow-out companies was related to the risk of losing key employees.

4.4.1.6 Social and political risks (SPR)

Changes in environmental policy and regulations was chosen as the highest-rated risk for full-cycle companies in terms of the severity of their consequences, and the third-highest ranked risk by grow-out companies. According to one grow-out and one full-cycle company interviewed, changes in environmental policy and regulations are normal, but they see them as good assets to improve management, product quality and safety. Also, these improvements in the certifications are highly desired by their clients, as they serve as indirect proof of the product's quality. However, the issue with these changes is that they demand improvements in current regulations, that usually countries outside of the EU do not have, allowing them to sell the same products at a lower price, resulting in an unbalanced competition.

In terms of the severity of their consequences, the public view of farms is the highest-rated risk for grow-out companies. One of the full-cycle companies interviewed stated that public perception of farms is always an issue, particularly because people are concerned about their sustainability, while a grow-out company stated that people are concerned about the visual impact of aquaculture cages on the coast. Another grow-out company interviewed stated that in order to improve the public's perception of farms, the industry must change consumers' negative perceptions, and one way to do so is to show consumers how the farm operates and the facility, as well as the positive aspects.

Furthermore, the second highest-rated risk for both full-cycle and grow-out companies was related to future changes in the licensing system. The risk of changes in government policy on product development strategy was rated as the third highest risk for full-cycle companies, while grow-out companies considered as third-ranked the risk of changes in animal health

regulations. One of the grow-out companies interviewed stated that they do not see a significant issue with future licenses because they are typically renewed every 5 to 20 years, so the times are not close enough to be considered an issue, and the renovation process is not as difficult as the initial license assignment. A full-cycle company also stated that it is not a major issue because their country has stopped issuing licenses to new farms, so major changes for farms that already have a license are not expected. On the other hand, a grow-out company interviewed expressed some concern about future license changes, stating that it is impossible to predict what will happen, especially because in their country, there has been discussion about in which cases new production licenses should be granted or not, which is a significant risk for the existing sector and a significant limitation for future development.

In the case of the most relevant risks in terms of likelihood of occurrence, both full-cycle and grow-out companies found that the most important risk was related to changes in environmental policy and regulations. Meanwhile, the risk of future changes in the licensing system was ranked second for Grow-out companies, while the public view of farms occupied this position for full-cycle companies. Finally, changes in animal health regulations and governmental support removal was ranked third for both types of companies

4.4.2 Most relevant risk management practices

The ranking of risk management practices differed significantly between full-cycle and grow-out aquaculture companies, as shown in Table 4.8. In the case of full-cycle companies, the highest-ranked practice was to prevent diseases and escapes, whereas this practice was only ranked sixth in the case of grow-out companies. Also, this risk management practice had the greatest difference in the scores between full-cycle and grow-out companies. In terms of diseases and escapes, a full-cycle company interviewed stated that it is crucial to prevent diseases and escapes because these issues are costly to the company. Another full-cycle company interviewed stated that disease prevention is a quality policy, which is why it is critical to use a quality management program to prevent diseases and ensure the fish's health.

The highest-ranked risk management practice for grow-out companies was to manage well the water environment, while this practice was the fourth-highest ranked for full-cycle companies. According to a grow-out company interviewed, it is still important to control the water quality, ensuring that there are no feed residues, no feed at the bottom of the cages, and that cages are free of any kind of cabbage or elements that could be ingested by the fish and cause them to die. Nevertheless, it was not a major concern for the grow-out company that used RAS, as RAS allows them to rely less on water from outside sources. The full-cycle company working with RAS, on the other hand, stated that water quality is the main problem for diseases in their case, so the company constantly checks the quality of the water.

Moreover, production at the lowest possible cost/keep the fixed cost low was the second-highest-rated risk management practice for full-cycle companies, while it was the fifth-highest ranked practice by grow-out companies. According to one full-cycle company interviewed, due to their location, all transport of their fish to their international final clients must be done by air transportation, which is an additional cost for them, so they want to keep production costs low

to compete. Similarly, the other full-cycle company stated that they are currently working to reduce production costs.

Choosing good inputs for production (feed, raw materials, etc.) was the second-highest-rated risk management practice for grow-out companies, while it was the fifth-highest ranked by full-cycle companies. According to one grow-out company, this is an important factor because having bad input materials will not produce the same results on the fish as having good input materials.

Financial health measures (such as increased solvency ratio/prioritize liquidity/prioritize solidity (low debt/equity ratio)/financial credit reserves) were the third highest-rated risk management practice for full-cycle companies, and the seventh-highest ranked by grow-out companies. According to one of the full-cycle companies interviewed, it is critical that the company takes financial measures to be strong because there are events, such as those associated with the COVID-19 pandemic, that would necessitate some financial strength to overcome, making this a mandatory management practice for the company.

Improve fingerlings selection (carefully checking fingerlings when buying/buy fingerlings only from certified producers/use large size fingerlings) was the third highest-rated risk management practice for grow-out companies, while it was the sixth-highest ranked by full-cycle companies. According to one grow-out company interviewed, it is important for grow-out companies to purchase the highest quality fingerlings available to avoid risk. In the same vein, the other grow-out company stated that they had to change their fingerling selection strategy when it comes to external producers, and that they are now much more stable, with better performance and fewer issues. The company warns that having a competent supplier of fingerlings is also important because, unfortunately, not all suppliers are. On the other hand, one of the full-cycle companies interviewed believes that this practice is not as important because the company believes that they already have a good selection system and that improving it would not make a significant difference.

Other risk management practices, while not at the top of the list, were highlighted by the companies interviewed. One of them was the use of consultancy services (veterinaries, economists, risk management consultants, and so on), which was highlighted as an important practice for those companies that do not have these services within their regular personnel. For one of the companies interviewed, they are especially useful for certifications because it helps them solve any problems that may arise during the certification due to their inexperience in this aspect. Another highlighted risk management practice was surplus machinery capacity companies operating with RAS, as it is what keeps the system in a constant state even in the event of machine failure. The go-out RAS company interviewed indicated that fish should not notice a machine malfunction because consistent conditions and environment are what give grow-out companies the best results. Some examples of surplus machinery capacity include emergency generators, oxygen suppliers that are larger than they need to be, and recirculating pumps that are running at 80% capacity so that if one needs to be repaired, the others can work at 100% capacity and maintain the same flow. Diversification was also mentioned in the interviews as a relevant risk management practice, but in this case, one full-cycle company and

one grow-out company thought that companies should focus on one species to get better at their processes. As a result, interviewees advised that if a company wants to add a new species to its business plan, it should look for a different location and involve different personnel. According to one of the full-cycle companies, adding another species to the business plan doubles the risks, particularly those of diseases, because if something happens to one species, with time, it spreads to the others, making it difficult to determine where it originated.

Derivatives to hedge interest rates or exchange rates were the lowest valued risk management practice for full-cycle companies and the second-lowest for grow-out companies. One of the full-cycle companies interviewed claimed that they have this issue under control and therefore do not consider it an important risk management practice. Furthermore, reducing farm size to an appropriate scale was the lowest valued risk management practice for grow-out companies. Concerning this, a full-cycle company interviewed stated that this practice must be assessed when the farm is built and should not be treated as an ongoing risk management practice; thus, it should be a concern, but not a risk. Furthermore, the two grow-out companies contended that they should look for the opposite conditions, as farms are expected to increase their production year after year to become more efficient.

Finally, even though insurance is considered one of the least valued practices for full-cycle companies and mid-value for grow-out companies, most of the total sample surveyed (73%) agreed to use some type of insurance for their production. All of those interviewed acknowledged the importance of insurance particularly for unexpected events that could result in large losses for businesses.

Table 4.8. Most important risks management practices for full-cycle companies and grow-out companies

Risk management practice	Full-cycle companies	Rank	Grow-out companies	Rank	Difference (full-cycle - grow-out)
Prevent diseases and escapes	4.57	1	3.50	6	1.07
Production at lowest possible cost/keep fixed cost low	4.14	2	3.63	5	0.52
Financial health measures (Increase solvency ratio/Prioritize liquidity/Prioritise solidity (low debt/equity ratio)/Financial credit reserves)	4.14	3	3.50	7	0.64
Manage well the water environment/Regular checking of quality of supply water	4.00	4	4.13	1	-0.13
Choosing good inputs for the production (feed, raw materials, etc)	4.00	5	4.00	2	0.00
Improve fingerlings selection (Careful checking fingerlings when buying/Buy fingerlings only from certified producers/ Use large size fingerlings)	3.86	6	4.00	3	-0.14
Use consultancy services (veterinaries, economists, risk management consultants, etc)	3.43	7	3.00	15	0.43

Risk management practice	Full-cycle companies	Rank	Grow-out companies	Rank	Difference (full-cycle - grow-out)
Keep a good relationship with the community and the government	3.29	8	3.75	4	-0.46
Cooperation and experience sharing with other farms	3.29	9	3.13	12	0.16
Market monitoring	3.29	10	3.00	16	0.29
Use a quality management program	3.14	11	3.13	13	0.02
Diversification (Produce new fish species/Spatial diversification/Diversification of products)	3.14	12	2.38	18	0.77
Reduce the density of fingerling stocking	3.00	13	3.00	17	0.00
Vertical and horizontal integration of the firm	3.00	14	3.13	14	-0.13
Reduce farm size to an appropriate scale	3.00	15	2.25	20	0.75
Surplus machinery capacity	2.71	16	3.25	11	-0.54
Participation in government supporting programs	2.71	17	3.38	8	-0.66
Insurance (against damage to farm, loss of/damage to fish, injuries for employees and boat insurance)	2.71	18	3.38	9	-0.66
Forwards/futures contracts	2.71	19	3.38	10	-0.66
Derivatives to hedge interest rate or exchange rates	2.00	20	2.38	19	-0.38

4.4.3 Attitude towards risk

We presented some statements in the survey and asked respondents to rate their level of agreement with them in order to assess respondents' attitudes toward risks. Table 4.9 displays the mean average result for each statement for each type of aquaculture company, whereas Table 4.10 displays the results of some self-reported attitudes and perceptions of risk. Based on these findings, we concluded that both types of companies strongly agree that aquaculture is a risky industry, with full-cycle companies agreeing slightly more strongly with it. According to a grow-out company, aquaculture is riskier financially, especially because it requires a large financial outlay, but fortunately, aquaculture producers receive a large set of government subsidies. A full-cycle company added that aquaculture is a risky business because many factors are beyond the farmers' control, such as weather, pollution, marketing, and product demand. Furthermore, a grow-out company and a full-cycle company agreed that aquaculture is a risky business because it involves living animals that can die.

Both full-cycle and grow-out companies agreed that they avoid more risks than other farmers. One of the grow-out companies stated that they avoid risks better than other farms due to their experience and knowledge, as well as the fact that they compare themselves to other farms and appear to have fewer issues. A full-cycle company interviewed added when compared to other farmers, they avoid more risks in production while taking more risks in the market.

Moreover, both full-cycle and grow-out companies agreed that they are willing to take risks if they believe it will be profitable. Nevertheless, both full-cycle and grow-out companies expressed neutrality in response to statements indicating that they were willing to take more risks than other farmers, that they avoid risk to obtain a certain but possibly lower profit, and that they are more willing to take on risk now than earlier. One of the grow-out companies explained that because they are working with living animals, they have a great deal of responsibility, so they must be aware of all the risks and weigh how much risk they are willing to take against the potential gain, as they do not want to gamble in an already high-risk industry.

The findings also show that both full-cycle and grow-out firms were more willing to take risks in marketing than in production and financial issues. Marketing risks, according to one grow-out company and one full-cycle company, are a game that can be won or lost, but that can bring profit to the company and whose risk is acceptable, whereas production risks can bring huge losses that represent significant bigger damage, so those risks should be avoided or, if taken, companies must be certain about the changes that are being made.

According to the findings, full-cycle companies were more willing to take risks than grow-out companies. In fact, full-cycle companies identified themselves on a spectrum ranging from very risk-averse to very risk-seeker, with a preference for neutral and risk-seeker; whereas grow-out companies agree on a narrower spectrum ranging from risk-averse to risk-seeker, with a preference for neutral.

Finally, managers of full-cycle companies recognize the importance of risk analysis in aquaculture more than managers of grow-out companies. According to one of the full-cycle companies, risk analysis allows for greater control, which is critical for aquaculture to improve things and avoid future problems in the operation. Similarly, the other full-cycle company interviewed agreed that it is wise to approach companies' risks, as the strategy should be risk-based. Also, one of the grow-out companies stated that risk analysis is important, particularly for farms using a RAS system, because in RAS, trying to fix issues after the system has already been implemented is extremely difficult, but it is extremely easy and cheaper to fix issues before the system is started.

Table 4.9. Average agreement level for different statements and attitudes towards risk

Statements	Full-cycle companies	Grow-out companies
Fish farming is risky compared to other industries	4.57	4.13
Compared to other fish farmers we avoid risks	4.29	3.88
I am willing to take more risks than other farmers	3.00	2.63
We avoid risk to get a certain, although maybe lower profit	3.29	3.25
We take on risk if we think it is profitable	3.57	3.63
We are more willing to take on risks now than earlier	2.57	3.13
I am eager to take risks in farming (general)	3.71	2.50
I am eager to take risks in the production	3.14	2.38
I am eager to take risks in marketing	3.57	2.50
I am eager to take risks in financial issues	2.57	2.00

Table 4.10. Results for some self-reported attitudes and perceptions towards risk

Self-reported attitudes and perceptions		Full-cycle companies		Grow-out companies	
Self-reported attitude towards risk	1. Very risk-averse	14.3%	Avg score: 3.10	0%	Avg score: 3.00
	2. Risk-averse	14.3%		25%	
	3. Neutral	28.6%		50%	
	4. Risk-seeker	28.6%		25%	
	5. Very risk-seeking	14.3%		0%	
Perception of the level of importance of analysing risks in aquaculture	1. Very low	0%	Avg score: 4.30	0%	Avg score: 3.80
	2. Low	0%		12.5%	
	3. Normal	14.3%		25%	
	4. High	42.9%		37.5%	
	5. Very high	42.9%		25%	

4.5 Conclusions

The primary goal of this study is to provide empirical insights into European aquaculture companies' perceptions of various risk sources and risk management practices through a mixed-methods approach involving online surveys and interviews and differentiating according to the type of aquaculture company in terms of their business model (full-cycle company or grow-out company). The study also examines certain company attitudes toward risk to gain a better understanding of risk behaviour in European aquaculture companies.

Based on our findings, we can conclude that the hypotheses established can be accepted. We can conclude from the first hypothesis that risk sources are rated differently depending on the type of aquaculture company. While there are similarities in the order of preferences for the types of risks, with diseases risks representing the most important risk-type for both types of companies, there are still differences, particularly in the magnitudes of the values, indicating for example that grow-out companies rated the level of risk of all the different types of risks higher. Moreover, while grow-out companies prioritize higher market and financial risks, full-cycle companies prioritize higher environmental risks. According to the types of companies, there are also some differences in the ratings of the top-three specific risks per risk category.

Concerning the second hypothesis, we discovered evidence indicating that there are differences in the rating of risk management practices based on the type of aquaculture company. For example, while preventing diseases and escapes was the most important risk management practice for full-cycle companies, it was only the sixth most important practice for grow-out companies. This distinction can also be seen in the average rating given by each type of company. Furthermore, the highest-rated risk management practice for grow-out companies was managing well the water environment/regular checking of quality of supply water, and while full-cycle companies received a similar value in terms of average score, it was only ranked fourth in terms of importance for these companies.

Concerning the third hypothesis, we found that there are differences in the risk attitudes depending on the type of aquaculture company, as it was clear that full-cycle companies were more willing to take risks than grow-out companies. However, there were some similarities, as both types of companies see aquaculture as a risky business, perceive themselves as avoiding

more risks than other farmers, agree that they are willing to take risks if they believe they will be profitable and are willing to take more risks in marketing than in other areas.

This study assists policymakers, consultants, governments, researchers, and aquaculture companies in identifying the most relevant risk sources and in the development of risk management practices that may contribute to improving European aquaculture companies' current risk management. Future research should concentrate on identifying relationships between company risk perceptions and their characteristics using more efficient statistical models such as regressions.

This study is not exempt from limitations. The sample, which only included 15 responses, might be the most significant limitation, as it does not represent the entire European aquaculture industry. However, it is important to note that due to the busy schedules of aquaculture managers, it is difficult to find people willing to participate in surveys. Furthermore, given the high level of competition in the aquaculture sector, some of them are unwilling to provide information because they are afraid that it will be used to harm their reputation, or simply because they believe that the information will benefit other companies indirectly, providing opportunities for increased competition. Given the preceding, a sample of 15 companies can be considered adequate for drawing important conclusions, especially because the information is deepened by interviewing 4 of the 15 respondents, allowing for clearer conclusions and explanations of the survey results.

Another important limitation of the present study is that the opinions of the companies were not separated according to their production process, such as conventional intensive aquaculture in cages on the open sea, organic or RAS. Considering the responses obtained in the interviews, it was clear that this factor had an important incidence in the perceptions, but unfortunately, we didn’t consider this in the first step of the study, with the surveys, as there was no previous evidence of this in the literature. As a result, future investigations should consider differentiating the opinions of the companies according to this matter.

Another significant limitation of the study is that the findings of this investigation were not tested statistically, so the results should be interpreted with caution. Nonetheless, the interviews allow us to go beyond the average scores and gain a better understanding of why and how the responses are given. Furthermore, we aimed to avoid questions that required detailed responses for the survey to keep respondents motivated to take and complete it. As a result, even though useful information could be omitted, this compromise was deemed necessary.

4.6 Appendix

The estimated Discrete Choice Models for each type of risk and company can be found in Table 4.11, Table 4.12, Table 4.13, Table 4.14, Table 4.15 and Table 4.16. The risks that have blank spaces as parameters couldn't be estimated because they were never selected as one of the most important choices in terms of consequences and likelihood of occurrence.

Table 4.11. Models 1A and 1B – Diseases risks

Risk	Model 1A - Full cycle companies				Model 1B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Severe malformations or skeletal anomalies	-2.400	0.010	-2.170	0.050	-2.570	0.000	-3.600	0.000
High death rate due to diseases	0	fixed	0	fixed	0	fixed	0	fixed
Fingerlings infected by diseases	-0.580	0.400	0.863	0.220	-1.420	0.040	-2.490	0.020
Inability to control diseases from environmental sources	-1.030	0.170	0.155	0.830	-0.340	0.590	0.679	0.350
Non-severe malformations or skeletal anomalies			-2.170	0.050	-3.280	0.000		
Model adjustment								
ρ2	0.297				0.39			
Adjusted ρ2	0.16				0.27			
Final Log-likelihood	-35.778				-35.48			
Number of observations	42				48			

Table 4.12. Models 2A and 2B – Environmental risks

Risk	Model 2A - Full cycle companies				Model 2B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Pests (Fouling organisms/Predators)	-0.461	0.51	-0.875	0.22	0.0509	0.93	-0.691	0.29
Drought	0.051	0.940	-0.667	0.340	-1.120	0.130	-2.800	0.000
Pollution	-0.127	0.850	-0.734	0.280	-0.230	0.710	-1.810	0.010
Flood	-1.240	0.150	-2.440	0.030	-2.350	0.030	-2.810	0.000
Technical failure (machinery, equipment)	0	fixed	0	fixed	0	fixed	0	fixed
Model adjustment								
ρ2	0.096				0.23			
Adjusted ρ2	-0.044				0.108			
Final Log-likelihood	-51.836				-50.446			
Number of observations	42				48			

Table 4.13. Models 3A and 3B – Market and Financial risks

Risk	Model 3A - Full cycle companies				Model 3B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Under financing by own capital, credits, loans or subsidies	-1.370	0.240	-2.190	0.050				
Price of farm equipment	-1.410	0.220			-3.750	0.000	-3.310	0.000
Price of fingerlings	-1.320	0.260	-2.150	0.060	-3.730	0.000	-3.260	0.000
Market regulation measures	-1.320	0.260			-3.700	0.000	-3.310	0.000
Price of feed	0.318	0.690	0.008	0.990	-1.840	0.020	-1.570	0.030
Future interest/exchange rate								
Taxation/Taxes	-0.197	0.810	-1.530	0.080			-3.310	0.000
Uncertainty about market access/trade policy	-0.607	0.510	-1.060	0.170	-2.590	0.000	-1.650	0.020
Fish price variability/Future fish price	0	fixed	0	fixed	0	fixed	0	fixed
Future wages of labour	-0.316	0.700	-1.530	0.080	-3.750	0.000	-3.310	0.000
Future fish demand	-0.612	0.510	-1.370	0.120	-1.990	0.010	-2.150	0.010
Model adjustment								
ρ2	0.107				0.287			
Adjusted ρ2	-0.077				0.132			
Final Log-likelihood	-77.471				-68.645			
Number of observations	42				48			

Table 4.14. Models 4A and 4B – Operational risks

Risk	Model 4A - Full cycle companies				Model 4B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
A poor or inexistent water treatment system								
Applying chemical and medicines improperly	-2.06	0.06	-1.89	0.09			-2.14	0.01
Low-quality fingerlings	-2.000	0.070	-1.950	0.080	-0.616	0.360	-1.120	0.110
Use undersize/oversize fingerlings	-2.060	0.060						
Availability of production inputs	-1.150	0.190	-1.900	0.090	-1.180	0.090	-2.070	0.010
Low quality of feed	-0.098	0.890	-0.310	0.670	-2.260	0.040	-2.890	0.010
Over (density) stocking fingerlings			-1.05	0.22	-2.34	0.03		
Accidents on the fishing vessels	-1.960	0.080	-1.210	0.160	-1.520	0.070	-2.040	0.020
Escapes	-0.544	0.440	-0.212	0.770	-0.702	0.300	-1.760	0.020
Overfeeding causing pollution and waste accumulation	-2.000	0.070	-1.950	0.080	-1.590	0.050	-2.200	0.010
Technical failure (machinery, equipment)	0	fixed	0	fixed	0	fixed	0	fixed
Model adjustment								
ρ2	0.149				0.157			
Adjusted ρ2	-0.034				0.007			
Final Log-likelihood	-74.094				-78.426			
Number of observations	42				48			

Table 4.15. Models 5A and 5B – Organizational and Human risks

Risk	Model 5A - Full cycle companies				Model 5B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Influence of middlemen or distribution organizations	-0.860	0.330	-1.110	0.210	-2.020	0.020	-2.320	0.030
Sufficient supply of competent labour	0	fixed	0	fixed	0	fixed	0	fixed
Risk of injuries/health problems among employees	0.051	0.950	-0.620	0.430	-0.190	0.740	0.233	0.700
'Moral risk': untrustworthy/corrupt employees	-0.860	0.330	-0.190	0.790	-2.700	0.010	-2.300	0.030
Risk of losing key employees	0.205	0.760	0.615	0.390	-1.480	0.050	-0.510	0.410
Logistics and transportation issues	-0.490	0.530	-0.980	0.270	-1.500	0.040	-1.140	0.110
Model adjustment								
ρ2	0.076				0.214			
Adjusted ρ2	-0.073				0.084			
Final Log-likelihood	-61.928				-60.177			
Number of observations	42				48			

Table 4.16. Models 6A and 6B – Social and Political risks

Risk	Model 6A - Full cycle companies				Model 6B - Grow out companies			
	Consequences		Likelihood		Consequences		Likelihood	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Changes in environmental policy and regulations	0	fixed	0	fixed	0	fixed	0	fixed
Uncertainty about food safety policy	-2.49	0.03						
Sufficient sea area access					-1.590	0.160	-0.400	0.610
Public view of farms (concerns about safety and sustainability)	-1.800	0.040	-1.200	0.120	0.604	0.370	-0.920	0.290
Certification systems	-2.520	0.020	-1.560	0.080	-1.590	0.160		
Changes in animal health regulations	-1.46	0.05	-1.42	0.1	-0.44	0.56	-0.1	0.89
Future changes in the licensing system	-1.24	0.11	-1.44	0.1	0.475	0.5	-0.05	0.94
Political shocks	-2.460	0.030	-2.240	0.050	-0.770	0.380	-1.670	0.140
Governmental support removal	-2.460	0.030	-1.440	0.100	-1.520	0.180	-1.640	0.150
Changes in government policy on product development strategy	-1.340	0.080	-1.520	0.090	-1.550	0.170	-1.020	0.250
Changes in work environment regulations			-1.61	0.07			-0.61	0.43
Model adjustment								
ρ2	0.116				0.114			
Adjusted ρ2	-0.068				-0.047			
Final Log-likelihood	-77.005				-88.24			
Number of observations	42				48			

5 Paper: Using the Levers of Control (LOC) framework to assist managers of European aquaculture companies in improving risk management strategy

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Abstract

Aquaculture companies are subjected to a high variety of risks. In fact, modern aquaculture is deemed as a risky business (Asche et al., 2008). Given this, risk management is a relevant element to consider by aquaculture managers. For this purpose, the Levers of Control (LOC) framework proposed by Simons can represent an interesting tool to enhance the implementation of business strategies (Simons, 1995), including those associated with risk management. Considering this, we developed a practical approach directed to aquaculture production managers for improving their management of the most significant risk sources identified, using Simons' (1995) levers of control theory. We found that for full-cycle companies, the risks of fish price variability and the price of feed could be respectively mitigated and avoided using beliefs and boundary control systems, while the risk of fingerlings infected by diseases could be avoided using boundary control systems. For grow-out companies, on the other hand, the risks of technical failure, high death rate due to diseases, inability to control diseases from environmental sources, bad weather and injuries or health problems among employees could be avoided using boundary control systems, whereas the risks of sufficient supply of competent labour and fish price variability could be avoided using beliefs control systems. The remaining risks for both types of companies should be either accepted and monitored using interactive controls systems or transferred to a third party.

Keywords: European aquaculture companies; levers of control framework; LOC; managers; risk management strategy.

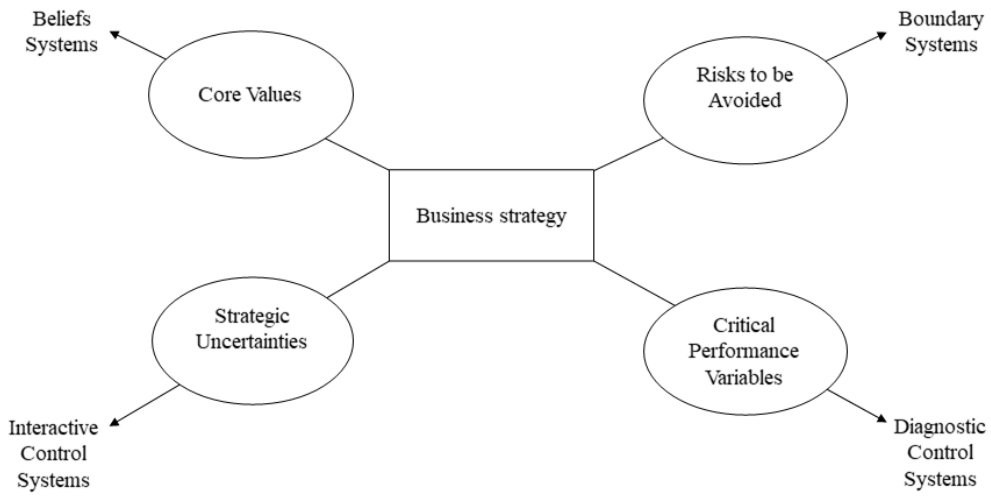
5.1 Introduction

Aquaculture is the most rapidly growing technology for food production and has already surpassed wild-caught fish production (Bronnmann and Asche, 2017; FAO, 2018). Still, modern aquaculture is considered a risky business (Asche et al., 2008), accounting for risks in the production process related to aspects such as the environment, climate conditions, and diseases (Kumbhakar, 2002; Tveterås, 1999). Also, aquaculture accounts for market risks such as volatile market prices, persistent competition with other companies and restriction of market access due to continuous changing trade regulations (Anderson, 2003). In addition, aquaculture companies, like any other company, are subject to organizational risks, as well as risks related to the personnel. Also, in some cases, they face social and political risks. Considering the high quantity of risks that aquaculture companies face, risk management is an important aspect to be considered by aquaculture managers. For this, Simons' Levers of Control (LOC) framework can represent an interesting tool to enhance the implementation of business strategies (Simons, 1995, 1994), including those associated with risk management.

Simons' levers of control are often used by both private and public organisations, despite some criticisms (Alcouffe et al., 2013; Tessier and Otley, 2012; Widener, 2007). The literature includes investigations looking to understand how the LOC are deployed in different companies or industries as case studies, such as a manufacturing company in Slovenia (Tekavčič et al., 2008), the sugar industry in Kenya (Ojera et al., 2011) and the construction industry in Malaysia (Mustapha and Hassan, 2017).

Simons constructed his theory as a system of positive and negative forces that oppose each other (see Figure 5.1). Simons states that if an organization balances those forces, its strategy can be successfully implemented. In his model, beliefs and interactive control systems are positive driving forces, whereas boundary and diagnostic control systems are negative driving forces (Simons, 1995).

Figure 5.1. Simons' levers of control



Source: Simons (1995).

Control systems, beliefs systems, boundary systems, and interactive control systems are the four LOC used by managers to maintain or alter patterns in organizational activities, according to Simons (1994). The four levers of control are combined by managers to control the achievement of organizational goals while allowing employees simultaneously to seek opportunities and resolve problems (Ahrens and Chapman, 2004; Frow et al., 2005; Mundy, 2010; Simons, 1995). When mobilized together, the four levers of control are fully capable of facilitating the implementation and completion of the strategic objectives of an organization (Bruining et al., 2004; Henri, 2006; Mundy, 2010; Widener, 2007).

Managers who use this framework effectively can elicit creativity from their employees without sacrificing control (Simons, 1995; Speklé et al., 2017). According to Speklé et al. (2017), the LOC provide tools for employees that (1) help them identify problems or opportunities that require creative action, (2) encourage them to take action, and (3) allow them to be creative up to certain limits.

Both boundary and belief systems, according to Simons (1995), create dynamic tension when they work together. While beliefs are inspiring and positive, boundaries represent constraints; thus, the action of both allows for the establishment of guidance and inspiration, as well as protection from potentially harmful opportunism. In terms of risk, Widener (2007) contends that companies use both beliefs and boundary systems to control employee behaviour, thereby reducing the risk of harm to the organization.

Beliefs systems, in particular, are formal systems that facilitate the reinforcement of an organization's fundamental beliefs and values (Simons, 1994). They enable managers to guide employees in the values and direction of their company ideas. They also motivate employees to think of new ways to add value to the company (Simons, 1995). Company value statements, mission, vision, and corporate credos are examples of belief controls (Sheehan, 2010).

Boundary systems, on the other hand, are formal systems that enable managers to establish limits and rules that employees must follow (Simons, 1994). Simons emphasizes that managers cannot dictate to their subordinates the possibilities to use, thus instead, managers can communicate different basic rules that indicate to employees what they must not do, which is accomplished with boundary systems (Simons, 1995). Some examples of boundary controls are employee codes of conduct and standard operating procedures (that make it clear to employees what is and is not acceptable behaviour so they cannot use ignorance as an excuse), rules for the use of company property, and rules for sharing confidential information (Sheehan, 2010).

Diagnostic control systems are formal systems that enable managers to monitor employee outcomes and make corrections based on that information and any deviations from organizational outcomes that may occur (Simons, 1994). These systems assure managers that their employees are meeting their objectives in a timely and effective manner (Simons, 1995). They support the actions of managers, who set goals and targets for employees in various activities, constantly monitor them to see if they are met, and reward them if they are (Sheehan, 2010). Balanced scorecards, budgets, and cash forecasts are some examples of these systems

(Sheehan, 2010). Widener (2007) adds that managers use these systems to manage risk and uncertainty when a more precise measurement is available.

Moreover, managers use interactive control systems on a regular and personal basis to participate in their employees' decision-making activities (Simons, 1994). These systems differ from diagnostic control systems in four ways: (1) they focus on potentially strategic information that changes constantly, (2) the information is important enough for operating managers at all levels of the organization to demand regular and frequent attention, (3) the data obtained by these systems can be best discussed and managed in face-to-face meetings, and (4) These systems serve as a catalyst for continuous discussion about underlying data, assumptions, and action plans (Simons, 1995).

According to Widener (2007), companies use interactive systems when they face high levels of strategic risk and uncertainty. Moreover, according to Bisbe and Otley (2004) and Simons (1991), interactive systems are effective in companies that face a variety of risks and uncertainties. Finally, Widener (2007) found that firms require both interactive and diagnostic systems in order to effectively manage operational risk.

For aquaculture literature, certain studies have investigated the importance for farmers of different risk sources and risk management strategies/practices (Ahsan, 2011; Ahsan and Roth, 2010; Alam and Guttormsen, 2019; Bergfjord, 2009; Darby and Incedursun, 2019; Elwin et al., 2020; Joffre et al., 2019, 2018; Kabir et al., 2020; Le Bihan et al., 2013; Le and Cheong, 2010, 2009; Lebel et al., 2020, 2016, 2016, 2015; Pimolrat et al., 2013; Rahman et al., 2020; Theodorou, 2015). However, we have not found any previous studies proposing a framework to assist aquaculture managers in their risk management strategy using Simons' (1995) LOC framework.

Moreover, in commercial intensive aquaculture, different types of companies emerge according to the stages of life cycles executed during fish production. Some are only hatcheries, which are in charge of processes such as the selection and the conditioning of broodstock, spawning, egg fertilization, larval, post-larval and juvenile rearing, in other words, they usually manage the reproduction of the broodstock and rear the fish until their juvenile stage. Other companies are known as grow-out companies, which mainly buy juvenile fish from hatcheries and rear them until the commercial size is reached. Lastly, other companies known as full-cycle companies, perform the full life stage of the fish from the broodstock management to the full commercial size of fish. Since the risks facing a company depend on the operations performed, it is crucial to establish different analyses for each type of company. Considering this, the present study will focus on the two the most common types of companies in commercial aquaculture: full-cycle and grow-out companies.

Given the previous, the purpose of the present research is to propose an approach to help managers improve their risk management strategy by using Simons' LOC framework based on the results of the most important risk sources identified. The remainder of the paper is organized as follows: Section 5.2 presents the data and methodology, section 5.3 explains the results and discussion, and section 5.4 offers some concluding remarks.

5.2 Data and methodology

5.2.1 Data collection

To collect the information, a survey was sent to different European fish companies by e-mail. To encourage participation, participants were told that all the information collected was going to be treated anonymously, and only if they wanted, they could leave their information. The core of the results of the present study is based on two specific sections of the mentioned questionnaire: first, a section including a Likert-scale section to rate according to the severity of the consequences and the likelihood of occurrence, different risk categories; and second, a section in which respondents had to select for each of the previous risk categories, the top three specific risks in terms of the severity of their consequences and their likelihood of occurrence. Table 5.1 shows the principal characteristics of the studied sample. A total of 14 responses were received, including 8 from European aquaculture grow-out companies and 7 from full-cycle aquaculture companies, involving both the hatchery and on-growing units.

Table 5.1. Characteristics of the sample

Type of company	**%**
Full-cycle	46.7%
Grow-out	53.3%
Number of employees	**%**
1-10 employees	53.3%
21-50 employees	33.3%
101-150 employees	6.7%
Over 150 employees	6.7%
Countries	**%**
Germany	13.3%
Switzerland	13.3%
Ireland	13.3%
Other (Cyprus, Poland, Greece, Czech rep., Portugal, Turkey, UK, Belgium, Spain)	6.7% each country
Total production (Avg of 2019 and 2020)	**%**
Less than 10 tons	20.0%
11 to 50 tons	6.7%
51 to 100 tons	13.3%
101 to 400 tons	13.3%
401 to 1000 tons	6.7%
1001 to 2000 tons	20.0%
2001 to 5000 tons	13.3%
150000 tons	6.7%
Species farmed	**%**
Trout	26.67%
Meagre	26.67%
Salmon	20.00%
Seabass	20.00%
Seabream	20.00%
Carp	13.33%

Perch	13.33%
Pike	13.33%
Sturgeon	13.33%
Other (Amberjack, Artic Char, Coregonus, Pagrus, Tench)	6.67% for each species

5.2.2 Methodology

Initially, we identified the most important risk categories, and then, we determined the most relevant specific risks for each one of the risk categories considered, according to the severity of their consequences and their likelihood of occurrence. After that, to integrate the LOC framework into the document, we followed Sheehan (2010), who proposed a practical framework that explicitly integrates risk management principles and management control systems, extending Kaplan and Norton's work (2008, 2004, 2001, 1996). This method allows managers to focus on the opportunities identified in their companies' strategic plans while minimizing the potential impact of threats. Sheehan (2010) established the following steps for the approach: (1) use Kaplan and Norton's (2004) strategic mapping tool to visualize the firm's strategy, (2) use the firm's strategy map to identify and act on important risks, (3) define how managers can use management control systems to assess the identified risks, and (4) monitor the risk continuously. Based on the previous approach, we synthesized, summarized, and adapted it in two basic steps for practical application to the European aquaculture industry:

1. Identifying the risks and defining the risk assessment

2. Designing a risk-based management control system using the LOC framework

5.2.2.1 Identifying the risks and defining the risk assessment

We have defined six different categories of risk types according to previous research on aquaculture risk management: (1) market and financial risks, (2) operational risks, (3) disease risks, (4) environmental risks, (5) organizational and human risks, and (6) political and social risks. Initially, respondents in the surveys were asked to rate each of the risk types based on the severity of their consequences (from 1 to 5) and their likelihood to occur (from 1 to 5). Following that, specific risks associated with each of the risk types were displayed, and respondents were asked to select the three most relevant risks in terms of the severity of their consequences and likelihood of occurrence. These specific risks were also extracted from the aquaculture risk preferences literature.

After that, we defined a risk response matrix, and according to the position of the risks in the matrix, one generic response was assigned: mitigate, avoid, transfer and accept (COSO, 2004).

a) Mitigate risk: When a risk has a high probability of occurrence but a low impact, the best risk response is to reduce potential loss.
b) Avoid risk: When there is a high likelihood of occurrence and significant consequences, the best response is to avoid the risk.

c) Transfer risk: When there is a low likelihood of occurrence but significant consequences, the best response is to transfer the risk completely or partially to a third party. This could be accomplished by purchasing insurance, outsourcing, or forming partnerships.
d) Accept risk: When there is a low likelihood of occurrence but a small impact, the cost of mitigating the risk is greater than the risk of accepting the risk; thus, the best response is to do nothing except keep the risk in mind and monitor it.

5.2.2.2 Designing a risk-based management control system using the LOC framework

The goal of this step is to describe how managers can use control systems to manage the identified risks. General ideas are given to managers of the aquaculture industry for each risk according to the generic responses previously described.

5.3 Results and discussion

Based on the results of the section of the survey in which respondents had to rate the different risk categories according to the severity of their consequences and their likelihood of occurrence (see Table 5.2) and the results from the section of the most relevant specific risks according to the same aspects (see Table 5.3), the different specific risks were ranked in a scale from 0 to 5 accordingly in terms of the severity of their consequences and the likelihood of occurrence (see Table 5.4). From 0 to 2.5, they were considered as "low", while those between 2.6 and 5 were considered as "high".

It is important to clarify that the results of Table 5.6 were extracted by estimating discrete choice models, whose obtained parameters were plotted on a relative scale from 0% to 100% according to each risk category, type of company and type of selection (consequences or likelihood of occurrence). The results of these models as well as those related to Table 5.5 and Table 5.6 are not detailed, as the objective of the present investigation is to improve the management of the most significant risk sources identified, using Simons' (1995) levers of control theory, rather than describing the implications of the risks, which are explained in a different paper.

Table 5.2. Average scores for the types of risk

Type of risk	Full-cycle companies		Grow-out companies	
	Severity of their consequences	Likelihood of occurrence	Severity of their consequences	Likelihood of occurrence
Diseases risks (DR)	3.43	2.71	4.00	3.63
Environmental risks (ER)	3.57	2.29	3.38	3.00
Market and financial risks (MFR)	3.00	2.57	3.75	2.75
Operational risks (OR)	2.57	2.14	3.50	2.75
Organizational and human risks (OHR)	2.29	1.86	2.88	2.88
Social and political risks (SPR)	2.29	1.43	2.50	2.13

Table 5.3. Relative scale results of the specific risks according to the severity of the consequences (C) and the likelihood of occurrence (L)

Diseases risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
High death rate due to diseases	100.0%	71.5%	100.0%	84.1%
Fingerlings infected by diseases	75.8%	100.0%	56.7%	25.9%
Inability to control diseases from environmental sources	57.1%	76.7%	89.6%	100.0%
Severe malformations or skeletal anomalies	0.0%	0.0%	21.6%	0.0%
Non-severe malformations or skeletal anomalies	N/A	0.0%	0.0%	N/A
Environmental risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Drought	100.0%	72.7%	51.2%	0.4%
Bad weather/Bio-physical shocks (storms, temperature changes, etc.)	96.0%	100.0%	97.9%	100.0%
Pollution	86.2%	69.9%	88.3%	35.6%
Pests (Fouling organisms/Predators)	60.3%	64.1%	100.0%	75.4%
Flood	0.0%	0.0%	0.0%	0.0%
Market and Financial risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Price of feed	100.0%	100.0%	50.9%	52.6%
Fish price variability/Future fish price	81.6%	99.7%	100.0%	100.0%
Taxation/Taxes	70.2%	30.0%	N/A	0.0%
Future wages of labour	63.3%	30.0%	0.0%	0.0%
Uncertainty about market access/trade policy	46.5%	51.4%	30.9%	50.2%
Future fish demand	46.2%	37.3%	46.9%	35.0%
Price of fingerlings	5.2%	1.8%	0.5%	1.5%
Market regulation measures	5.2%	N/A	1.3%	0.0%
Under financing by own capital, credits, loans or subsidies	2.3%	0.0%	N/A	N/A
Price of farm equipment	0.0%	N/A	0.0%	0.0%
Future interest/exchange rate	N/A	N/A	N/A	N/A

Operational risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Technical failure (machinery, equipment)	100.0%	100.0%	100.0%	100.0%
Low quality of feed	95.3%	84.1%	3.4%	0.0%
Escapes	73.6%	89.1%	70.0%	39.1%
Availability of production inputs	44.2%	2.6%	49.6%	28.4%
Accidents on the fishing vessels	4.9%	37.9%	35.0%	29.4%
Low-quality fingerlings	2.9%	0.0%	73.7%	61.2%
Overfeeding causing pollution and waste accumulation	2.9%	0.0%	32.1%	23.9%
Applying chemicals and medicines improperly	0.0%	3.1%	N/A	26.0%
Use undersize/oversize fingerlings	0.0%	N/A	N/A	N/A
A poor or inexistent water treatment system	N/A	N/A	N/A	N/A
Over (density) stocking fingerlings	N/A	46.2%	0.0%	N/A

Organizational and Human risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Risk of losing key employees	100.0%	100.0%	45.2%	70.9%
Risk of injuries/health problems among employees	85.5%	28.4%	93.0%	100.0%
Sufficient supply of competent labour	80.8%	64.3%	100.0%	90.9%
Logistics and transportation issues	34.7%	7.5%	44.4%	46.2%
'Moral risk': untrustworthy/corrupt employees	0.0%	53.3%	0.0%	0.8%
Influence of middlemen or distribution organizations	0.0%	0.0%	25.2%	0.0%

Social and Political risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Changes in environmental policy and regulations	100.0%	100.0%	72.5%	100.0%
Future changes in the licensing system	50.8%	35.7%	94.1%	97.0%
Changes in government policy on product development strategy	46.8%	32.1%	1.8%	38.9%
Changes in animal health regulations	42.1%	36.6%	52.4%	94.0%
Public view of farms (concerns about safety and sustainability)	28.6%	46.4%	100.0%	44.9%
Political shocks	2.4%	0.0%	37.4%	0.0%
Governmental support removal	2.4%	35.7%	3.2%	1.8%
Uncertainty about food safety policy	1.2%	N/A	N/A	N/A
Certification systems	0.0%	30.4%	0.0%	N/A
Sufficient sea area access	N/A	N/A	0.0%	76.0%
Changes in work environment regulations	N/A	28.1%	N/A	63.5%

Table 5.4. Average scores for the specific risks

Diseases risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
High death rate due to diseases	**3.4**	1.9	**4.0**	**3.1**
Fingerlings infected by diseases	**2.6**	**2.7**	2.3	0.9
Inability to control diseases from environmental sources	2.0	2.1	**3.6**	**3.6**
Severe malformations or skeletal anomalies	0.0	0.0	0.9	0.0
Environmental risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Drought	**3.6**	1.7	1.7	0.0
Bad weather/Bio-physical shocks (storms, temperature changes, etc.)	**3.4**	2.3	**3.3**	**3.0**
Pollution	**3.1**	1.6	**3.0**	1.1
Pests (Fouling organisms/Predators)	2.2	1.5	**3.4**	2.3
Flood	0.0	0.0	0.0	0.0
Market and Financial risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Price of feed	**3.0**	**2.6**	1.9	1.4
Fish price variability/Future fish price	2.4	**2.6**	**3.8**	**2.8**
Taxation/Taxes	2.1	0.8		
Future wages of labour	1.9	0.8	0.0	0.0
Uncertainty about market access/trade policy	1.4	1.3	1.2	1.4
Future fish demand	1.4	1.0	1.8	1.0
Price of fingerlings	0.2	0.0	0.0	0.0
Market regulation measures			0.0	0.0
Under financing by own capital, credits, loans or subsidies	0.1	0.0		
Price of farm equipment			0.0	0.0
Operational risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Technical failure (machinery, equipment)	**2.6**	2.1	**3.5**	**2.8**
Low quality of feed	2.4	1.8	0.1	0.0
Escapes	1.9	1.9	2.5	1.1
Availability of production inputs	1.1	0.1	1.7	0.8
Accidents on the fishing vessels	0.1	0.8	1.2	0.8
Low-quality fingerlings	0.1	0.0	**2.6**	1.7
Overfeeding causing pollution and waste accumulation	0.1	0.0	1.1	0.7
Applying chemicals and medicines improperly	0.0	0.1		
Sufficient sea area access			0.0	1.6

Organizational and Human risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Risk of losing key employees	2.3	1.9	1.3	2.0
Risk of injuries/health problems among employees	2.0	0.5	**2.7**	**2.9**
Sufficient supply of competent labour	1.8	1.2	**2.9**	**2.6**
Logistics and transportation issues	0.8	0.1	1.3	1.3
'Moral risk': untrustworthy/corrupt employees	0.0	1.0	0.0	0.0
Influence of middlemen or distribution organizations	0.0	0.0	0.7	0.0
Social and Political risks				
	Full cycle companies		Grow out companies	
Risk	C	L	C	L
Changes in environmental policy and regulations	2.3	1.4	1.8	2.1
Future changes in the licensing system	1.2	0.5	2.4	2.1
Changes in government policy on product development strategy	1.1	0.5	0.0	0.8
Changes in animal health regulations	1.0	0.5	1.3	2.0
Public view of farms (concerns about safety and sustainability)	0.7	0.7	2.5	1.0
Political shocks	0.1	0.0	0.9	0.0
Governmental support removal	0.1	0.5	0.1	0.0
Certification systems	0.0	0.4		
Sufficient sea area access			0.0	1.6

After this, we organized the various risks into matrixes based on the results of Table 5.4, assigning each one of four generic risk responses: mitigate, avoid, transfer, and accept. Table 5.5 shows the matrix for full-cycle companies, while Table 5.6 shows the matrix for grow-out companies. The results of these tables are required for developing the relationship between these risks source and the LOC, which will be discussed after.

Table 5.5. Risk matrix indicating which risks to mitigate, avoid, accept and transfer for full-cycle companies

		Consequences	
		Low	**High**
Likelihood	**High**	**Mitigate risk** - Market and financial risks • Fish price variability/Future fish price	**Avoid risk** - Market and financial risks • Price of feed - Diseases risks • Fingerlings infected by diseases
	Low	**Accept risk** - Market and financial risks • Future fish demand • Uncertainty about market access/trade policy • Taxation/Taxes • Future wages or labour • Price of fingerlings • Under financing by own capital, credits, loans or subsidies - Diseases risks • Severe malformations or skeletal anomalies • Inability to control diseases from environmental sources - Environmental risks • Flood • Pests (Fouling organisms/Predators) - Operational risks • Low quality of feed • Escapes • Availability of production inputs • Accidents on the fishing vessels • Low-quality fingerlings • Overfeeding causing pollution and waste accumulation • Applying chemicals and medicines improperly - Organizational and human risks • Risk of injuries/health problems among employees • Risk of losing key employees • Sufficient supply of competent labour • 'Moral risk': untrustworthy/corrupt employees • Logistics and transportation issues • Influence of middlemen or distribution organizations - Social and political risks • Changes in environmental policy and regulations • Future changes in the licensing system • Changes in government policy on product development strategy • Changes in animal health regulations • Governmental support removal • Public view of farms (concerns about safety and sustainability) • Political shocks • Certification systems	**Transfer risk** - Operational risks • Technical failure (machinery, equipment) - Environmental risks • Bad weather/Bio-physical shocks (storms, temperature changes, etc.) • Drought • Pollution - Diseases risks • High death rate due to diseases

Table 5.6. Risk matrix indicating which risks to mitigate, avoid, accept and transfer for grow-out companies

		Consequences	
		Low	**High**
Likelihood	**High**	**Mitigate risk**	**Avoid risk** - Market and financial risks • Fish price variability/Future fish price - Operational risks • Technical failure (machinery, equipment) - Diseases risks • High death rate due to diseases • Inability to control diseases from environmental sources - Environmental risks) • Bad weather/Bio-physical shocks (storms, temperature changes, etc.) - Organizational and human risks • Sufficient supply of competent labour • Risk of injuries/health problems among employees
	Low	**Accept risk** Diseases risks • Fingerlings infected by diseases • Severe malformations or skeletal anomalies - Environmental risks • Flood • Drought - Market and financial risks • Price of feed • Uncertainty about market access/trade policy • Future fish demand • Future wages of labour • Price of fingerlings • Market regulation measures • Price of farm equipment - Operational risks • Availability of production inputs • Accidents on the fishing vessels • Low quality of feed • Overfeeding causing pollution and waste accumulation • Escapes - Organizational and human risks • Risk of losing key employees • Logistics and transportation issues • 'Moral risk': untrustworthy/corrupt employees • Influence of middlemen or distribution organizations - Social and political risks • Future changes in the licensing system • Changes in environmental policy and regulations • Changes in animal health regulations • Changes in government policy on product development strategy • Political shocks • Governmental support removal • Sufficient sea area access • Public view of farms (concerns about safety and sustainability)	**Transfer risk** - Environmental risks • Pests (Fouling organisms/Predators) • Pollution - Operational risks • Low-quality fingerlings

5.3.1 Designing a risk-based management control system using the LOC framework for full-cycle companies

In this subsection, we discuss how full-cycle companies can use and personalize Simons' LOC framework to ensure that they mitigate, avoid, transfer and accept the above-identified risks appropriately (see Table 5.7).

Table 5.7. Managing the risks with LOC for full-cycle companies

Type of risk	Specific risk	LOC applied
Risks to mitigate		
MFR	• Fish price variability/Future fish price	Belief controls and Diagnostic controls
Risks to avoid		
MFR	• Price of feed	Boundary controls
DR	• Fingerlings infected by diseases	
Risks to transfer		
OR	• Technical failure (machinery, equipment)	Transfer risk to an insurance company or companies producing the equipment and machinery
ER	• Bad weather/Bio-physical shocks (storms, temperature changes) • Drought • Pollution	Transfer risk to an insurance company
DR	• High death rate due to diseases	
Risks to accept		
MFR	• Future fish demand • Uncertainty about market access/trade policy • Taxation/Taxes • Future wages or labour • Price of fingerlings • Under financing by own capital, credits, loans or subsidies	Monitor with interactive control systems
DR	• Severe malformations or skeletal anomalies • Inability to control diseases from environmental sources	
ER	• Flood • Pests (Fouling organisms/Predators)	
OR	• Low quality of feed • Escapes • Availability of production inputs • Accidents on the fishing vessels • Low-quality fingerlings • Overfeeding causing pollution and waste accumulation • Applying chemicals and medicines improperly	
OHR	• Risk of injuries/health problems among employees • Risk of losing key employees • Sufficient supply of competent labour • 'Moral risk': untrustworthy/corrupt employees • Logistics and transportation issues • Influence of middlemen or distribution organizations	
SPR	• Changes in environmental policy and regulations • Future changes in the licensing system • Changes in government policy on product development strategy • Changes in animal health regulations • Governmental support removal • Public view of farms (concerns about safety and sustainability) • Political shocks • Certification systems	

5.3.1.1 Mitigate risk

Companies should seek to differentiate their products from the rest, especially in terms of quality. This can be accomplished using beliefs controls applied in the mission statement of the company, which clarifies the added value of the products. With this knowledge, it is possible to enhance the quality of the products and differentiate them from others, which might be the best way to mitigate the risk of fish price variability/future fish price, as the competition would narrow.

Also, diagnostic controls can help managers reduce risk by monitoring employees' progress and rewarding them for doing their jobs well (Sheehan, 2010). Considering this, the risk of fish price variability/future fish price could be mitigated by rewarding the employees in the marketing area, if they can maintain a base of loyal customers, that would accept fix suitable price offered by the company due to the quality and service offered, reducing the possibility of being affected by the external prices of the market.

5.3.1.2 Avoid risk

Boundary controls can help managers avoid risks by making them off-limits, while beliefs systems can help employees avoid certain harmful behaviours (Sheehan, 2010). Full-cycle businesses should avoid the market and financial risk of feed price fluctuations by establishing a rule for the purchasing department to avoid relying exclusively on one feed provider company. Considering that there will be different providers that could offer a relatively better price, the risk of feed price fluctuations could be avoided. This policy should be formalized by managers through boundary controls, by including them in a mission statement.

For the disease risk of fingerlings infected by diseases, managers of full-cycle companies should use boundary controls on employees in charge of fish health to limit behaviours that may increase the possibility of disease appearance. For this, some rules that can be formalized in the company's mission statement are to strictly adhere to disease control measures such as vaccinations, grading, and the cleanliness of environments where fish are reared. A manual should be created to clarify all the behaviours that employees should follow in order to avoid actions that lead to the spread of diseases or high mortality rates.

5.3.1.3 Transfer risk

Managers can use controls to protect the company's assets by sharing risk with third parties (Sheehan, 2010). The operational risk of technical failure in machinery equipment can be transferred to either the company that manufactured the equipment/machinery or to an external insurance company. This would demand additional costs for the company, but it would also ensure the company's production stability. Similarly, managers of full-cycle companies should seek insurance for uncontrolled risks that may have an impact on production by increasing fish mortality, such as high death rate due to diseases and for environmental risks such as bad weather/biophysical shocks, drought, or pollution.

5.3.1.4 Accept risk

Because the remaining risks have a low probability of occurrence and a low impact in terms of the consequences, managers can accept them and just use interactive control systems to assess them with the assistance of other employees of the company. By using interactive control systems, managers are not directly involved in the control of these risks but can monitor them through meetings and communication with the subordinates in charge. This facilitates those managers to pay closer attention to other more pressing matters.

5.3.2 Designing a risk-based management control system using the LOC framework for grow-out companies

In this subsection, we discuss how grow-out companies can use and personalize the levers of control framework to adequately mitigate, avoid, and transfer the identified risks (see Table 5.8).

Table 5.8. Managing the risks with levers of control for grow-out companies

Type of risk	Specific risk	LOC applied
Risks to avoid		
OR	• Technical failure (machinery, equipment)	Boundary control
DR	• High death rate due to diseases	
	• Inability to control diseases from environmental sources	
ER	• Bad weather/Bio-physical shocks (storms, temperature changes, etc.)	
OHR	• Risk of injuries/health problems among employees	
	• Sufficient supply of competent labour	Beliefs controls
MFR	• Fish price variability/Future fish price	
Risks to transfer		
ER	• Pests (Fouling organisms/Predators) • Pollution	Transfer to an insurance company
OR	• Low-quality fingerlings	
Risks to accept		
DR	• Fingerlings infected by diseases • Severe malformations or skeletal anomalies	Monitor with interactive control systems
ER	• Flood • Drought	
MFR	• Price of feed • Uncertainty about market access/trade policy • Future fish demand • Future wages of labour • Price of fingerlings • Market regulation measures • Price of farm equipment	
OR	• Availability of production inputs • Accidents on the fishing vessels • Low quality of feed • Overfeeding causing pollution and waste accumulation • Escapes	
OHR	• Risk of losing key employees • Logistics and transportation issues • 'Moral risk': untrustworthy/corrupt employees • Influence of middlemen or distribution organizations	
SPR	• Future changes in the licensing system • Changes in environmental policy and regulations	

	• Changes in animal health regulations • Changes in government policy on product development strategy • Political shocks • Governmental support removal • Sufficient sea area access • Public view of farms (concerns about safety and sustainability)	

5.3.2.1 Avoid risk

For the market and financial risk of fish price variability/future fish price, managers of grow-out companies can use beliefs controls by establishing clear goals for employees on the company's vision and mission, in order to recruit the best team for the marketing area. More competent employees are expected to make fewer mistakes and be more committed to their work in the company, and as a result, they would perform better in the marketing decisions, increasing the possibility to have a more stable future fish demand and higher market access. Similarly, for the organizational and human risk of sufficient supply of competent labour, managers can use beliefs controls by clearly communicating the aptitudes required to work in the company. As a result, the company's human resources team will have clear knowledge on how to handle the personnel selection processes.

Moreover, managers of grow-out companies can use boundary controls to avoid the operational risk of a technical failure (machinery, equipment), by creating an operation manual that specifies which behaviours should be avoided. Moreover, for diseases risks such as high death rate due to diseases and inability to control diseases from environmental sources, managers of grow-out companies should use boundary controls on employees in charge of fish health to limit behaviours that may increase the possibility of disease appearance, as similarly discussed for full-cycle companies.

For the environmental risk of bad weather/bio-physical shocks (storms, temperature changes, etc.), managers must establish boundary controls by clearly communicating the safety measures that employees must follow to protect machinery and equipment during bad weather events such as lightning strikes, that could disrupt electrical devices in farms using RAS.

To reduce the organizational and human risk of injuries/health problems among employees, managers of grow-out companies should use boundary controls by establishing safety measures for employees to avoid accidents. For this case, there are technicians specialized in occupational risks that can assist managers in the construction of the safety measures.

5.3.2.2 Transfer risk

The operational risk of low-quality fingerlings have a low probability of occurrence but a significant impact on its consequences; as a result, it should be transferred to an insurance company. Similarly, as explained with full-cycle companies, managers of grow-out companies should seek insurance for uncontrolled risks that may have an impact on the production process such as the environmental risks of pests or pollution.

5.3.2.3 Accept risk

Similarly, as explained with full-cycle companies, managers of grow-out companies should accept and monitor the remaining risks using interactive control systems

5.4 Conclusions

The main objective of this study is to offer a practical approach for aquaculture managers to improve the management of risks in European aquaculture farms (full-cycle and grow-out) using the LOC framework. Our approach suggested that for full-cycle companies, the market and financial risks of fish price variability and the price of feed could be mitigated and avoided, respectively, through beliefs and boundary control systems, while the risk of fingerlings infected by diseases could be avoided using boundary control systems. Meanwhile, due to the high consequences and low probability of the risk of the high death rate due to diseases, full-cycle companies should transfer this risk to an insurance company. Similarly, the operational risk of technical failure could be transferred to third parties, as well as uncontrollable environmental risks such as bad weather, drought and pollution. The remaining risks of full-cycle companies should be accepted and monitored using interactive control systems.

In the case of grow-out companies, the risks of technical failure, high death rate due to diseases, inability to control diseases from environmental sources, bad weather and injuries or health problems among employees could be avoided using boundary control systems, while the risks of sufficient supply of competent labour and fish price variability could be avoided using beliefs control systems. On the other hand, environmental risks such as pests and pollution, and the risk of low-quality fingerlings should be transferred to an insurance company. Finally, the remaining risks of grow-out companies should be accepted and monitored using interactive control systems.

The main limitation of the study is related to the sample used to obtain the most and less relevant risks in terms of the consequences and likelihood of occurrence, as it is only based on the responses of 15 aquaculture companies, which are not representative of the whole European Aquaculture Industry. Nevertheless, considering the difficulties of finding companies willing to participate in the survey due to their busy schedules, unwillingness to reveal information that may harm their reputation or belief that the information shared might benefit other direct competitors, the collected sample can be considered relatively adequate for establishing relevant conclusions.

The results of the present study extend previous literature by providing insights into how managers can use the LOC framework to improve risk management strategy. These results may encourage managers to give more importance to the use of the LOC framework for solving issues related to strategic control. Moreover, future research should focus on a specific case study. This way, a more specific and illustrative approach can be executed by implementing the LOC framework for risk management strategy in a specific company.

Chapter III

Labelling preferences for Fishery and Aquaculture products

6 Paper: Assessing the label's mandatory information for fishery and aquaculture products in the EU28. A consumer approach based on a consistent fuzzy preference relation with geometric Bonferroni mean

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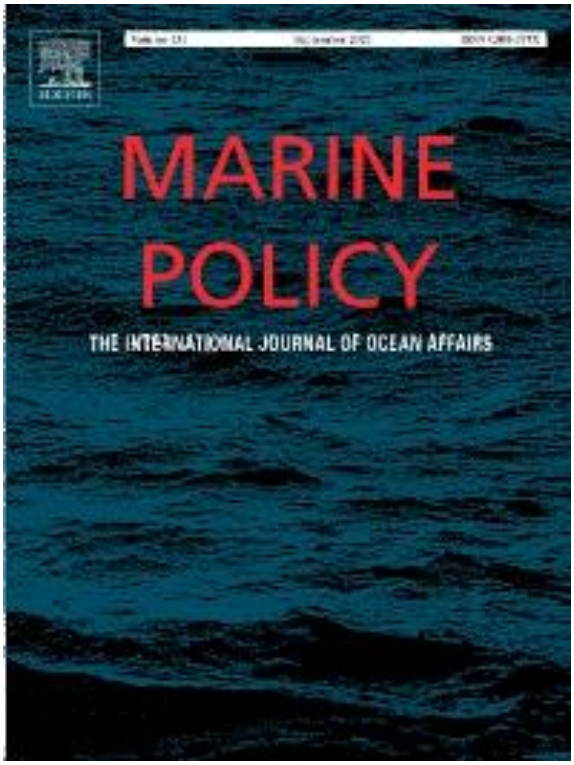
Abstract



Fishery and aquaculture products (FAPs) are a very important source of the protein intake of the European Union (EU) citizens. Despite the importance, the knowledge on labelling is still scarce. Two important issues regarding the labelling preferences of 27732 EU residents (the criteria interrelationship as well as the relationship that exists at the country level) will be assessed through a method based on a modified Consistent Fuzzy Preference Relation (CFPR) that uses the Geometric Bonferroni Mean (GBM) operator. The results show that not all the EU countries are homogeneous, so the subsidiarity principle might have been applicable. Our results also contribute to the strand of the fishery and aquaculture market. Policy implications, as well as future research studies, are discussed.

Keywords: Fuzzy preference relation; Geometric Bonferroni mean; Decision matrix; Fishery and aquaculture products; European labels' preferences.

6.1 Introduction

Food labelling can be analysed under a myriad of multiple perspectives that range from third-party or private own-label product differentiation to strict public legislation that reduces the existing asymmetrical information position that consumers have in the market (Caswell and Anders, 2011). The first practice can be considered anti-competitive if some firms are capable of exerting market power (McCorriston, 2002). The author shows that some of the important food retailers in the EU sell an increasing proportion of own-label products. On the other hand, EU food labelling legislation was first introduced in 1978 as a way to guarantee food safety for European consumers (Himmelsbach et al., 2014). Since then, some new directives and regulations have been signed until the provision of food information to consumers (EU Regulation No 1169/2011) that has the following main objectives: (1) to simplify the existing law; (2) to ensure legal certainty; (3) to reduce administrative burden; and (4) to benefit EU citizens by requiring clear, comprehensive and legible labelling of foods (European Commission, 2011).

Under the consumers' perspective on fishery and aquaculture products (FAPs), the EU regulation 1379/2013 seeks to provide information to consumers, obliging the Member States to elaborate a list of the commercial name in each respective territory with the corresponding species scientific name. Tinacci et al. (2019a) analyse the Italian national lists since 2002 assessing the evolution and accuracy. The authors find that the list published in 2017 contains a total of 1003 records and conclude that there is a decreasing trend in terms of accuracy of the species scientific name in favour of the commercial name. In addition, D'Amico et al. (2016) contend that the EU regulation 1379/2013 is the consequence of the application of the three main pillars that sustain the European Common Fisheries Policy envisaged in 1970 and reformed in 2013: traceability, sustainability and consumers' right to an informed purchase. The authors concluded that the regulation can also be seen as the evolutionary process of seventeen years of countries' negotiations on the creation of a common market in FAPs.

Article 35 of the EU regulation 1379/2013 establishes the following mandatory information to be declared in marks or labels on FAPs marketed within the Union: the commercial designation of the species and its scientific name; the production method as, for example, "caught", "caught in freshwater" or "farmed"; the area where the product was caught or farmed, and the category of fishing gear used to capture the products by fisheries; whether the product has been defrosted; and the date of minimum durability.

The regulation that assesses the mandatory information for FAPs (EU 1379/2013) has been analysed in the literature during the last years in which two main topics can be extracted: fraud and compliance. First, (Mariani et al., 2015) conclude that this regulation has marked a positive trend in getting a market with less fraud. D'Amico et al. (2016) insist that the regulation should also be applied to all the prepared and processed products based on FAPs. Similarly, Giusti et al. (2019) analyse the semi-preserved anchovies in Italy and conclude that marinated and oil anchovy products are difficult to trace as the information on scientific names and catching areas are only voluntarily made. Second, Tinacci et al. (2018) analyse the compliance of the Bulgarian seafood wholesalers with the EU regulation using the labels of 97 seafood products. The authors find that 59% and 85% of the products were not included in the official list and do not include the catching area, respectively. Tinacci et al. (2020) compare the commercial

designations (CDs) with the correspondent scientific names (SNs) of the Bulgarian official seafood designation list. The authors find that 43 out of 110 different CDs that exist in the list do not have any SN associated.

As discussed by Alfnes et al. (2018), many studies have analysed the preferences and willingness to pay for certain mandatory labels in the context of specific seafood products. For example, understanding the preferences for the origin label for German consumers of Salmon. However, according to our best knowledge, no previous investigation in the context of the EU has analysed the relative importance of the complete set of mandatory labels for all the FAPs, as a whole. As seen, the regulation that assesses the mandatory information for FAPs (EU 1379/2013) is an important regulation of the Common Fisheries Policy that can be analysed within the framework of decision analysis and decision makers (DMs) preferences.

The Consistent Fuzzy Preference Relation (CFPR) is often used to solve multi-criteria decision making (MCDM) problems due to its effectiveness in the representation of perceptions of people (Alias et al., 2019; Herrera-Viedma et al., 2004). However, the majority of CFPR methods involve a traditional aggregation process that does not identify the interrelationship among decision-making criteria, which is something that should be addressed to obtain better results (Alias et al., 2019). To cope with this, a model based on a CFPR that uses the Geometric Bonferroni Mean (GBM) operator is developed to analyse the mandatory scale proposed by the EU 1379/2013 according to the preference values related to 27732 EU residents, who will be considered as the main DMs. A final ranking of the criteria and the relationship concerning some interesting segments such as country of residence and age will be obtained. To the best of our knowledge, this is the first study that analyses the full scale proposed by the EU 1379/2013.

In sum, our paper develops a method based on a CFPR as a way to avoid the limitation of consistency that is normal in other decision-making methods. In this sense, we extend the method proposed by Alias et al. (2019) in which not only the interrelationship of information on the criteria included in the labelling scheme is dealt with as the GBM operator is also applied to the respondents as a way to aggregate the information also considering their possible interrelationship. The extended modified approach is applied to our case study as a way to analyse the consumers' preferences on the EU FAPs mandatory labelling scheme dealing with two potential interactions at the level of criteria and respondents. Thus, as the GBM is also applied to the weights obtained for each of the respondents, we denominate our model as CFPR-GGBM method –Consistent Fuzzy Preference Relation with a Grand Geometric Bonferroni Mean.

An analysis of the scale related to the mandatory information for fishery and aquaculture products is also important considering that its crucial to determine which information is relevant for consumers, especially taking into account that excessive information on labels can be confusing, while too little information can be misleading (Pieniak et al., 2013). Also, an analysis within the context of the EU is important, as Bradford (2020) contends that the EU matters and this evident fact should not undermine the narrative for further integration if the EU's role in the world is going to be persistent and relevant. A further move to build an authentic European federation will boost the interests of the EU, both within and beyond its borders,

through the Brussels Effect. Moreover, food labelling schemes of specific food products should be performed and evaluated with special attention and consideration of the cultural differences, because apart from the expectations generated by the information provided, which influence the choice of consumers and the product experience, consumers also have expectations derived by previous experiences and traditions (Altintzoglou et al., 2014).

The remainder of the paper is organized as follows: Section 6.2 offers some insights from the literature, section 6.3 describes the data section, section 6.4 details the methodology, section 6.5 presents and discusses the results, section 6.6 describes some policy implications, and section 6.7 offers some concluding remarks.

6.2 Literature review

D'Amico et al. (2016) analyse the regulation that assesses the mandatory information for FAPs (EU 1379/2013) in comparison with the previous legislative mandate regarding the labelling requirements for FAPs. The authors point out that besides the legislation advances in the right direction there are still at least two important drawbacks: the exclusion of prepared and processed derived seafood products and the existing void of the mass caterer operators. The authors suggest that these controversial problems that exist 15 years ago should be modified with new regulatory measures that extend the applicability to all the seafood products and all the economic agents of the FAPs logistic chain. As Pardo et al. (2016) acknowledge the percentage of mislabelling is 30%, and, in general, the incidental rates are more numerous in restaurants and takeaways than in retailers and supermarkets. Also, the mislabelling rate can differ according to the presentation of the product, as Miller and Mariani (2010) found that around 25% of all the products sampled were genetically different species from the indicated on the label, while it was more than 80% when the smoked fish samples were considered. According to Esposito and Meloni (2017), the mislabelling can be due to different circumstances such as unintentional or accidental vs. those that can be considered fraud –less valued species are labelled as other more valued species. Reilly (2018) contend that species mislabelling is one of the common illegal practices that affect FAPs and that FAPs are among the sectors in which food fraud is more common.

Asensio and Montero (2008) contend that FAPs labelling is essential and almost the unique source of information that consumers have about the products they consume. The authors add that the information is relevant and demanded by consumers because FAPs are very perishable and have multiple origins. The authors provide an overview of the existing regulation regarding the mandatory information: commercial designation of the species; the area of catch; the production method; and fish presentation. The authors analyse the labelling of fresh, refrigerated and chilled fish in 285 and 155 fishmongers in food markets and supermarkets, respectively in Madrid, Spain or its surrounding area. Mercamadrid is the second world largest wholesale market for FAPs. The analysis is similar to the previously commented studies regarding the compliance of the labelling concerning the mandatory information, but there is not any particular investigation on the validity and integrity of the four criteria studied in the mandatory information scale. In this sense, there is only one mention of the traceability concept as the information gathered throughout the food supply chain as a way to guarantee the quality

of the seafood product. The authors conclude that "consumers must demand a complete fish labelling with the designation of the fish species, the catch area, the production method and the fish presentation (p. 798)." Nevertheless, a critical assessment of the scale itself is missing.

Another interesting salient issue from the literature review is the scarcity of studies that analyse the economic causes of the mislabelling behaviour. Oceana (2016) overviews more than 200 published studies from 55 countries and finds that, on average, 20% of seafood products were mislabelled, and most of the economic agents of the logistic chain such as fisheries, farms, processors, distributors, retailers or caterers were involved. The scale of the problem is outstanding in developed and developing countries, and Reilly (2018) contends that the first step to combat the fraud in FAPs is to establish an agreed list of commercial names with the respective scientific denomination –the first attribute of the mandatory information requested by regulation that assesses the mandatory information for FAPs (EU 1379/2013). According to the author, national governments need to provide the list before any fraud control program can be designed.

NOAA Fisheries' FishWatch, an American database on sustainable seafood, identified three types of seafood fraud: seafood substitution, seafood short-weighting and mislabelling seafood (FISHWATCH, 2020). The first category is mostly related to the substitution of low-value species for more expensive ones, mostly on filleted and skinned presentation, in which species are difficult to differentiate. The second is related to the misrepresentation of the net weight of the seafood by using practices such as using an excess of ice or additives. Finally, the last type of fraud is related to using not suitable labels on some products, to avoid regulations or fees. Moreover, (Alfnes et al., 2018) added that a more recent version of fraud is related to the misuse of sustainability labels.

Jacquet and Pauly (2008) and Reilly (2018) contend also that fish fraud is mainly caused by the economic benefits obtained by the offenders. As commented, one of the most common examples is the substitution of low-quality-value species for high-quality-value varieties. This cause can be rooted in Akerlof (1978), in which adverse selection is seen as one important cause of market failure. It is evident that the FAPs market is characterized by important information asymmetries in which some supply participants of the food logistic chain have much better information than other agents, especially consumers. This classic asymmetric information problem is known by his seminal work as Akerlof's market for lemons. Levin (2001) revisits Akerlof's work to analyse to what extent greater information asymmetries reduce the gains from trade. The author concludes that trade gains depend on the net effects of two interaction forces: "the buyers' curse" (paying more than what an item or service is truly worth) and the shift supply effects. On the other hand, the author shows that improving buyers' information increases unambiguously trade gains. Thus, it can be concluded that the use of DNA sequencing for species identification can be considered a valid tool to improve FAPs' consumer information (Khaksar et al., 2015; Reilly, 2018; Tinacci et al., 2019b) (Khaksar et al., 2015; Reilly, 2018; Tinacci et al., 2019b) and a key element of the assessment of the regulation that assesses the mandatory information for FAPs (EU 1379/2013) compliance.

As discussed, the previous literature has mainly analysed the compliance degree of the current legislation in the EU, and the main reasons that originate the fraud of mislabelling. The directive

was seen as the derivative of seventeen years of Member States negotiations in which the labelling mandatory information pretended to protect consumers at the time of making purchases with better information. However, the current legislative labelling directive has been taken as a normative and valid regulatory status-quo that has not been critically analysed from the consumers' perspective, and as we will see in the current study, the consumers' preferences regarding the FAPs mandatory labelling are not homogeneous at country level, and this result should have had clear implications in the development of the FAPs common market in the EU. The next section will provide an overview of the mandatory information module included in the Special Eurobarometer 475 2018. Thus, the degree of importance given by consumers to each individual piece of information included in the directive will be analysed.

In addition, while other investigations have studied the importance of some of the elements of the mandatory information established for FAPs (EU 1379/2013), none of them has studied the full set, as can be noticed from Table 6.1. Most of these studies used Discrete Choice Experiments as their main methodology and focused on specific species and countries to develop their analysis. Regarding the mandatory information, the first element "the commercial designation of the species and its scientific name" is normally assumed to be something obvious to be given as part of the study, so the importance of its inclusion is never considered. From the rest of the different types of mandatory information, the importance of the harvest method (wild or farmed product) and the area of catch or production are commonly studied in the literature as shown in Table 6.1. Moreover, the information on the fishing gear used to catch the product has not been previously assessed in any of the studies listed, since most of them focus on farmed species, and this type of information is only applicable to captured species. Regarding the information about whether or not the product has been previously frozen, the studies rather focus on the preferences for product presentation and include the frozen presentation as a variable to identify differences to other types of presentations, such as fresh. Finally, the "use by" or "best before" date is assessed by only one of the investigations listed.

Table 6.1. Literature that included an analysis of the different types of mandatory information for FAPs

Investigation	Species	Country	Type of mandatory information				
			Wild or farmed product	Area of catch or production	The fishing gear used to catch the product	Presentation of the product: frozen or not	The "use by" or "best before" date
Ankamah-Yeboah et al. (2018)	Trout	Germany		X		X	
Ankamah-Yeboah et al. (2019)	Trout	Germany		X		X	
Ariji (2010)	Tuna	Japan	X	X			
Asche et al. (2015)	Salmon	Scotland	X	X		X	
Banovic et al. (2019)	Amberjack	Germany, France, Italy, Spain, UK		X			
Bi et al. (2016)	Salmon, Mahi, Grouper	US					
Bronnmann and Asche (2017)	Salmon	Germany	X			X	
Bronnmann and Hoffmann (2018)	Turbot	Germany	X			X	
Chen et al. (2015)	Cod, Salmon, Monkfish, Pangasius	France	X	X			
Darko et al. (2016)	Tilapia	Tanzania (Africa)	X			X	
Davidson et al. (2012)	Salmon, Tuna, Tilapia, Moi	US	X	X		X	
Fernández-Polanco et al. (2013)	Seabream	Spain	X	X			
Ferrer Llagostera et al. (2019)	Seabream	Spain	X				
Heide and Olsen (2017)	Cod	Norway					X
Hinkes and Schulze-Ehlers (2018)	Pangasius, Tilapia	Germany		X			
Jaffry et al. (2004)	Cod, Salmon, Tuna, Haddock, Prawns	UK	X	X		X	
Lim et al. (2018)	Tuna	US		X			
Lucas et al. (2018)	Seafood in general	France	X	X			
Mauracher et al. (2013)	Seabass	Italy		X			
McClenachan et al. (2016)	Seafood in general	US		X			
Miyata and Wakamatsu (2018)	Cod, Whitebait	Japan		X			

Investigation	Species	Country	Type of mandatory information				
			Wild or farmed product	Area of catch or production	The fishing gear used to catch the product	Presentation of the product: frozen or not	The "use by" or "best before" date
Olesen et al. (2006)	Salmon	Norway					
Olesen et al. (2010)	Salmon	Norway					
Risius et al. (2017)	Trout	Germany		X			
Risius et al. (2019)	Trout	Germany		X			
Roheim et al. (2012)	Salmon	US	X				
Rudd et al. (2011)	Salmon	Canada		X			
Sogn-Grundvåg et al. (2019)	Whitefish	Scotland		X		X	
Stefani et al. (2012)	Seabream	Italy		X			
Thong et al. (2015)	Salmon, Cod, Sole, Seabream, Saithe, Pangasius, Monkfish, Tuna	France	X	X		X	
Thong et al. (2018)	Cod, Saithe, Pangasius, Monkfish, Salmon, Sea bream, Sole, Tuna	France	X	X		X	
Uchida et al. (2014)	Salmon	Japan	X	X			
van Osch et al. (2017)	Salmon	Ireland		X			
van Osch et al. (2019)	Salmon, Seabream	Ireland, UK, Italy, Israel, Norway		X			
Wakamatsu and Miyata (2017)	Cod, Whitebait	Japan		X			
Witkin et al. (2015)	Pollock, Atlantic mackerel, Silver hake, Spiny dogfish, Haddock, Cod	US		X			
Yip et al. (2017)	Atlantic Salmon, Sockeye Salmon, King Salmon	US	X	X			
Zander et al. (2018)	Trout	Germany		X			

6.3 The questionnaire and data

The Special Eurobarometer 475 2018, for the second time, includes questions that analyse the "EU consumer habits regarding FAPs". The EU is the world largest market for FAPs in nominal terms, although the expenditure per capita on FAPs is higher in Japan. As said, the Common Fisheries Policy establishes a set of rules that "aim to secure a safe and stable supply of seafood, sustainable fisheries, healthy seas, and prosperous coastal communities for today's Europeans and future generations internal market for fishery and aquaculture products of the EU" (p. 3) (European Union, 2018a).

The Special Eurobarometer 475 2018 (European Commission, 2019) provides important insights to operators that can be used to be more competitive and to design the strategies and plans considering the EU consumers' voice. Especially relevant to the purpose of the study, it is the trust and mandatory information module that accompanies FAPs, as the labelling of the products was enforced in December 2014. The mandatory information pretends to protect consumers within the EU making a better-informed selection.

The main objectives of the questionnaire are to: (1) understand consumer habits regarding fishery and aquaculture: how frequently do consumers eat and/or buy these products? What types of products do they buy? Where do they buy them?; (2) find the factors that influence consumption; (3) explore the reasons for buying or eating FAPs, or not; (4) determine whether there is consumer preference for wild or farmed products, sea or freshwater products, processed or unprocessed products, or in terms of origin; (5) investigate what consumers think about the information accompanying FAPs and whether they trust the information provided by the government, by certified authorities or by the brand or seller; and (6) compare current figures with those from the June 2016 survey.

This survey was administered face-to-face at respondents' homes and in their native language by the Kantar Public Brussels network in the 28 Member States of the European Union in the period 23rd of June and 6th of July. The total sample was 27,734 EU citizens from different social and demographic status (Table 6.2). The survey was carried out on behalf of the Directorate-General for Maritime Affairs and Fisheries.

Table 6.2. Sample features

Country	Frequency	Percentage (%)
FR - France	1006	3.6
BE - Belgium	1055	3.8
NL - The Netherlands	1006	3.6
DE-W - Germany - West	1011	3.6
IT - Italy	1025	3.7
LU - Luxembourg	506	1.8
DK - Denmark	1020	3.7
IE - Ireland	1011	3.6
GB-UKM - Great Britain	1043	3.8
GR - Greece	1016	3.7
ES -Spain	1035	3.7
PT - Portugal	1082	3.9
DE-E Germany East	539	1.9
FI - Finland	1017	3.7
SE - Sweden	996	3.6
AT - Austria	1044	3.8
CY - Cyprus (Republic)	503	1.8
CZ - Czech Republic	1023	3.7
EE - Estonia	1004	3.6
HU - Hungary	1064	3.8
LV - Latvia	1007	3.6
LT - Lithuania	1015	3.7
MT - Malta	502	1.8
PL - Poland	1033	3.7
SK - Slovakia	1071	3.9
SI - Slovenia	1015	3.7
BG - Bulgaria	1031	3.7
RO - Romania	1021	3.7
HR - Croatia	1031	3.7
Total	27732	100.0

Question 16 of section B (QB16) was worded as follows: From which sources do you get most of your information about fishery and aquaculture products? The respondents can choose up to three different sources among Friends and family; Television, books and magazines; The internet; Public institutions; Non-governmental organisations (NGOs); Store employee or fishmonger; Advertising and other commercial information; Other (SPONTANEOUS); None (SPONTANEOUS); Do not know. The results show that at the EU level, the three most cited sources of information are: Store employee or fishmonger (44%), Television, books and magazines (32%) and Friends and family (30%). Nevertheless, in 27 of the 28 Member States, the proportion of respondents who mentioned store employees and fishmongers has decreased in comparison with the data obtained in 2016.

Table 6.3 shows the criteria and the answer format scale included in question 13 of section B of the questionnaire. The wording of the question was as follows: How important or not is it to find the following information on labels of FAPs like fresh, frozen, smoked and dried products? It can be seen that the mandatory information scale has six criteria and that the answer format

is based on a 4-point linguistic scale (Very important (4); Fairly important (3); Not very important (2) and Not at all important (1)).

Table 6.3. The importance of the mandatory information for FAPs in the EU

C1. The name of the product and the species	1	2	3	4
C2. Whether it is a wild or farmed product	1	2	3	4
C3. The area of catch or production	1	2	3	4
C4. The fishing gear (e.g., longlines, trawls) used to catch the product	1	2	3	4
C5. Whether the product was previously frozen	1	2	3	4
C6. The "use by" or "best before" date	1	2	3	4
Source: Own elaboration Very important (4); Fairly important (3); Not very important (2) and Not at all important (1)				

6.4 Methodology

All the respondents to the survey are treated as the main DMs to represent the preferences of the mandatory information for FAPs in the EU. Some MCDM methods have been developed to select the best alternative or to rank the relative importance degree of a set of criteria like in the study. For example, in the seafood context, some of the main methods used are: the analytic hierarchy process (AHP) first introduced by Saaty (Kimani et al., 2020; Korhonen and Topdagi, 2003); the elimination and choice expressing reality (ELECTRE) (Debnath et al., 2016); Value of Information (Bates et al., 2014); Multi-Attribute Utility Theory (MAUT) (Seung and Zhang, 2011; Yip et al., 2017); Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) (Ruzante et al., 2017); and Dominance Based Rough Set Approach (DRSA) (Li et al., 2019; Xu and Shuang, 2015). All these methods are based on answers given by a group of DMs over a set of criteria that serves to approximate the concept under analysis. Instead of values, the information can be obtained through pairwise comparisons that determine somehow the DMs' preferences. Orlovsky (1978) contends that the preference relation has usually a fuzzy nature and introduces the fuzzy logic as a way to handle the uncertainty associated with the preferences representation over criteria. Alias et al. (2019) assess this method as a more "simple and effective model to construct a pairwise comparison with less information needed from the DMs" (p. 2672).

The Fuzzy Preference Relations (FPRs) approach has been previously successfully applied in different fields such as management (Wang and Lin, 2009), business (Chen and Chao, 2012) and education (Chao and Chen, 2009). In our case, the study is applied to the analysis of consumers 'perceptions adapting the methods proposed by Alias et al. (2019), Alonso et al. (2008) and Herrera-Viedma et al. (2004). The adapted method resolves the inconsistency of FPRs as the decision matrix is constructed preserving the consistency of FPRs, as well as the missing preference values. Additionally, the method overcomes the limitations of some aggregated measures such as the average, using a geometric Bonferroni mean (GBM) operator (Xia et al., 2013). Thus, the potential interrelationships between the criteria are considered. And finally, as Alias et al. (2019), a method based on the fusion between the GBM and CFPRs methods is proposed to analyse the mandatory information of FAPs in the EU. The method extends Alias et al. (2019) because we also apply GBM to the weights obtained for each of the DMs in a way in which we can now denominate our model as CFPR-GGBM method –the first G for Grand.

6.4.1 The model

Orlovsky (1978) defines that *R* is an FPR on a set of criteria $A=\{a_1, a_2, \cdots, a_n\}$ if and only if $R=(r_{ij})$ is a matrix of dimension *n* that:

$$r_{ij} \geq 0, r_{ij} + r_{ji} = 1, r_{ii} = 0.5 \ for\, all\, i, j = 1, 2, \cdots, n \qquad (6.1)$$

Where r_{ij} represents the preference degree of the criteria a_i over the criteria a_j. The values of the matrix *R* have the following meaning over the preferences: if r_{ij} is equal to 0.5, then DM shows indifference between both criteria; if r_{ij} is greater than 0.5, then criteria *i* is preferred over criteria *j*; similarly, if r_{ij} is lower than 0.5, then criteria *j* is preferred over criteria *i*; if r_{ij} is equal to 1, then criteria *i* is preferred to criteria *j*; and finally, if r_{ij} is equal to 0, then criteria *j* is preferred to criteria *i.*

In MCDM problems, the information matrix over the criteria is usually based on answers given by a sample of DMs who express their preferences regarding the criteria. The preferences of the importance of each of the criteria are usually given by answers in a certain n-point Likert scale (not important at all - very important) or in the Saaty (1990) format of pairwise comparisons such as equally important (1), moderately more important (3), strongly more important (5), very strongly more important (7), extremely more important (9). In the Saaty format, the intermediate values 2, 4, 6 and 8 for intermediate judgments are also permitted.

The problem with the Saaty format is that consistency of the preferences, especially regarding the transitivity property, is not guaranteed. Herrera-Viedma et al. (2004) resolve the inconsistency problems with a method that constructs a CFPR using the following two propositions:

Proposition 1. For a reciprocal multiplicative preference relation $S = (s_{ij})$ with $s_{ij} \in [1/9, 9]$, it is possible to build a corresponding reciprocal FPR $R = (r_{ij})$ with $r_{ij} \in [0, 1]$ as follows:

$$r_{ij} = g\left(s_{ij}\right) = \frac{1}{2}\left(1 + \log_9 s_{ij}\right) \qquad (6.2)$$

In general, if $s_{ij} \in [1/n, n]$, then $log_n s_{ij}$ is used in eq. 6.2.

Proposition 2. If *R* is a reciprocal FPR, the following expressions are equivalent:

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}, \forall i, j, k \qquad (6.3)$$

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}, \forall i < j < k \qquad (6.4)$$

$$r_{i(i+1)} + r_{(i+1)(i+2)} + \cdots r_{(i+k-1)(i+k)} + r_{(i+k)i} = \frac{k+1}{2}, \forall i, k \qquad (6.5)$$

The conversion of a decision matrix that is not normalized in the interval [0,1] can be obtained through the transformation function assuming that the decision matrix values belong to some

interval [-c, 1+c] without loss of generality. The transformation function is defined as follows to create an FPR *R*:

$$r_{ij} = f\left(s_{ij}\right) = \frac{s_{ij} + c}{1 + 2c} \qquad (6.6)$$

Once the FPR is obtained, it is possible to evaluate the aggregation score u_i for each criterion as follows:

$$u_i = \frac{1}{n_c}\left(\sum_{j=1}^{n_c} r_{ij}\right) \qquad (6.7)$$

Where n_c is the number of criteria. Finally, the weight of each criterion can be calculated as:

$$w_i = \frac{u_i}{\sum_{j=1}^{n_c} u_j} \qquad (6.8)$$

Once the weights have been obtained for each criterion, it is now possible to prioritize each of them according to the weight ranking. Alias et al. (2019) contend that CFPRs are simple and efficient tools to achieve the prioritization of the criteria, meanwhile, the preservation of consistency is guaranteed.

6.4.2 The GBM operator

Xia et al. (2013) define the $GBM(p,q,a_1,a_2,\ldots,a_n)$ for $p, q>0$ and $a_i \geq 0$ as follows:

$$GBM\left(p,q,a_1,a_2,\cdots,a_n\right) = \frac{1}{p+q}\prod_{\substack{i,j=1 \\ i\neq j}}^{n}\left(pa_i + qa_j\right)^{\frac{1}{n(n-1)}} \qquad (6.9)$$

If q is equal to 0, the GBM is equivalent to the geometric mean. The implementation of the GBM operator as an aggregation method performs much better than other methods as it considers the potential interrelationships between the different criteria in the decision problems.

Based on the definitions and concepts and similarly to Alias et al. (2019), we are going to use the CFPR-GGBM method as a way to: (1) provide a decision matrix after any survey administration regarding a criteria importance analysis; (2) analyse two alternative scenarios which are built using the reduction number of criteria comparisons proposed by Herrera-Viedma et al. (2004) in the first case, and the maximum matrix explosion using all the pairwise comparisons as the second scenario; and (3) to rank the mandatory information criteria for FAPs established by the EU regulation using all the respondents to Eurobarometer 475 as DMs.

6.4.3 Steps to apply the CFPR-GGBM in the analysis of the mandatory scale proposed by the EU 1379/2013

In this subsection, we discuss the five steps needed to apply the CFPR-GGBM in the context of the analysis of the mandatory scale proposed by the EU 13/2013.

6.4.3.1 Step 1

In the first step, the information matrix obtained in the survey is transformed into linguistic evaluations that researchers had obtained surveying a la Saaty. In our case, the information matrix is based on answers given in a 4-point Likert scale, so when we make pairwise comparisons between criteria *j* and *k* subtracting the values, we can obtain for each respondent the following preference relation (PR) matrix $S = s_{jk} = imp_j - imp_k$. The matrix can have the following values: -3,-2,-1,0,1,2 and 3. When the value is equal to 0, it means that criteria *j* and *k* are equally important. When the value is 1, it means that the criterion *j* is moderately more important than *k*. When the value is 2, it means that the criterion *j* is strongly more important than *k*. And finally, when the value is 3, it means that the criterion *j* is very strongly more important than *k*. For the negative values, the corresponding meaning is straightforward. The transformation function that converts the above preference relation matrix in one Preference Relation (PR) a la Saaty matrix can be defined as follows: $g(-3,-2,-1,0,1,2,3) = (1/7,1/5,1/3,1,3,5,7)$. A neater mathematical expression can be given according to:

$$S' = s'_{ij} = (1+2|s_{ij}|)^{sign(s_{ij})}, where\ signx = 1 if\ x \geq 0, 0\ otherwise \qquad (6.10)$$

6.4.3.2 Step 2

In this step, we obtain the decision matrices. For the first scenario, CFPR propositions are used to complete the matrix, meanwhile, the second decision matrix is obtained considering all the criteria comparisons as a way to analyse the robustness of the results. To construct the CFPR *R* using propositions 1 and 2, we calculate the initial fuzzy preference ratios using eq. (6.2) using 7 as the base for the logarithm function. Thus, the r_{ij}*'s* are obtained for the upper principal diagonal of the CFPR matrix, i.e., for the elements $\{r_{12}, r_{23}, \cdots, r_{(n-1)n}\}$. . Then, we construct the complete decision matrix R with the equations of Proposition 2. The second scenario is based on the CFPR *R** matrix in which all the elements are calculated with eq. (6.2). The first matrix R is normalized whenever the values are out of the range [0,1] with the transformation function shown in eq. (6.6) if needed.

6.4.3.3 Step 3

Step 3 is characterized by the application of the GBM operator to deal with the potential interrelationships among the criteria. In the real world, it is possible that whether the product was previously frozen is related to whether the product is wild or farmed. Then, in step 3, the GBM operator as shown in eq. (6.9) is applied to both matrices considering the two scenarios. Thus, the aggregated values consider the potential interrelationships between all the criteria.

6.4.3.4 Step 4

In step 4, the priority weights of each criterion are obtained to see the most influential criterion. The priority weights for each criterion is computed using eq. (6.8) for each DM, and as previously explained, the most influential criterion for each DM is that of the maximum value.

6.4.3.5 Step 5

Finally, in Step 5 the rankings of the weights will be analysed for both scenarios as well as for some segmentation based on the country and the age. In this step, we obtain again using the GBM (GGBM –Grand Geometric Bonferroni Mean) the aggregate values of the weights for each criterion of the sample and segments of interest. Thus, it is possible to analyse whether the mandatory information is perceived more or less homogeneously by different population segments.

6.5 Results

The proposed method is applied to the module of the mandatory information for FAPs in the Eurobarometer 475 survey. As explained, there are six criteria for the analysis and 27,734 respondents that are going to be used as the DMs. In order to explain in a clearer way how we applied the CFPR-GGBM, we will initially use as an example, the responses of the first respondent in the sample, who has answered question 13 with the following values (4,3,2,2,4,4).

The linguistic evaluation of the first step is clear. Thus, the matrix of the differences is converted to one PR matrix a la Saaty [1/7,7]. Then, we can calculate the PR matrix S and convert it to S' (Table 6.4).

In the second step, we use eq. (6.2) to derive the elements $\{r_{12}, r_{23}, r_{34}, r_{45}, r_{56}\}$. In the case of the elements of the upper diagonal matrix of S', it can be easily seen that r_{12} is equal to 0.782= $1/2(1+log_7 3)$. Similarly, it can be obtained that $\{r_{12}, r_{23}, r_{34}, r_{45}, r_{56}\}$ is equal to $\{0.782, 0.782, 0.5, 0.086, 0.5\}$. Analysing now, for example, the values of r34 and r45, it can be concluded that criteria 3 and 4 are equally important, meanwhile, criterion 5 is strongly more important than criterion 4. Then, we calculate the complete matrix R using the equations of Proposition 2. For example, from eq. (6.4) it is possible to obtain r24 as $(3/2)-r_{12}-r_{45}=(3/2)-0.782-0.086=0.632$. Similarly, the rest of the values of R can be calculated according to the expansion method that uses the eqs. of Proposition 2. Thus, the matrix R is constructed (Table 6.5). In this case, it can be seen that we need to normalize the matrix as some of the values are out of the range [0,1]. Using eq. (6.6) with a c value equal to 0.064, the normalized matrix is obtained (Table 6.5) according to the following normalized function:

$$f:[-0.063, 1.0063] \rightarrow [0,1], f(r_{ij}) = \frac{r_{ij}+0.063}{1+2(0.063)}$$

Table 6.5 also shows the decision matrix *R** that uses all the pairwise comparisons to directly obtain the complete matrix without the need of Proposition 2. It can be seen that the relative preference for each of the attributes is equivalent but some of the values are different, so the robustness of the results of the expansion method can be analysed.

Table 6.4. First step PR matrices

Matrix S						
	c1	c2	c3	c4	c5	c6
c1	0	1	2	2	0	0
c2	-1	0	1	1	-1	-1
c3	-2	-1	0	0	-2	-2
c4	-2	-1	0	0	-2	-2
c5	0	1	2	2	0	0
c6	0	1	2	2	0	0
Matrix S'						
	c1	c2	c3	c4	c5	c6
c1	1.00	3.00	5.00	5.00	1.00	1.00
c2	0.33	1.00	3.00	3.00	0.33	0.33
c3	0.20	0.33	1.00	1.00	0.20	0.20
c4	0.20	0.20	1.00	1.00	0.20	0.20
c5	1.00	3.00	5.00	5.00	1.00	1.00
c6	1.00	3.00	5.00	5.00	1.00	1.00

Source: Own elaboration. The matrices are calculated with the assumption that the respondent has answered (4,3,2,2,4,4)

Table 6.5. Second step CFPR matrices

Matrix R						
	c1	c2	c3	c4	c5	c6
c1	0.5	0.782	1.064	0.914	0.5	0.5
c2	0.218	0.5	0.782	0.632	0.218	0.218
c3	-0.064	0.218	0.5	0.5	0.218	0.218
c4	0.086	0.368	0.5	0.5	0.086	0.086
c5	0.5	0.782	0.782	0.914	0.5	0.5
c6	0.5	0.782	0.782	0.914	0.5	0.5
Matrix R normalized						
	c1	c2	c3	c4	c5	c6
c1	0.500	0.750	1.000	0.867	0.500	0.500
c2	0.250	0.500	0.750	0.617	0.250	0.250
c3	0	0.250	0.500	0.500	0.250	0.250
c4	0.133	0.383	0.500	0.500	0.133	0.133
c5	0.500	0.750	0.750	0.867	0.500	0.500
c6	0.500	0.750	0.750	0.867	0.500	0.500
Matrix R*						
	c1	c2	c3	c4	c5	c6
c1	0.500	0.782	0.914	0.914	0.500	0.500
c2	0.218	0.500	0.782	0.782	0.218	0.218
c3	0.086	0.218	0.500	0.500	0.086	0.086
c4	0.086	0.086	0.500	0.500	0.086	0.086
c5	0.500	0.782	0.914	0.914	0.500	0.500
c6	0.500	0.782	0.914	0.914	0.500	0.500

Source: Own elaboration based on the S and S' Matrices shown in Table 6.4.

Step 3 aggregates the preference relation values of the decision matrices for both scenarios by using the GBM operator (eq. (6.9)). The GBM operator is applied with *p=q=5* –the standard values of this operator. The aggregate values for the first and second scenarios and the criterion c_1 are obtained as:

$$u_1 = GBM\left(p,q,c_1,c_2,\cdots,c_6\right) = \frac{1}{10}\prod_{\substack{i,j=1\\ i\neq j}}^{6}\left(5c_i + 5c_j\right)^{\frac{1}{30}} = 0.674$$

$$u_1^* = GBM\left(p,q,c_1,c_2,\cdots,c_6\right) = \frac{1}{10}\prod_{\substack{i,j=1\\ i\neq j}}^{6}\left(5c_i + 5c_j\right)^{\frac{1}{30}} = 0.674$$

Surprisingly, both values are equal. The GBM operator aggregates the preference values for each criterion considering all the potential interrelationships of all the criteria. Following a similar procedure for the rest of the criteria, the aggregated preference values are obtained (Table 6.6). Also, following steps 4 and 5, the priority weights and ranking of each criterion are obtained.

Table 6.6. Aggregated and priority weights of criteria for the CFPR matrices

Notation	First scenario		Second scenario	
	Aggregated score	Priority weight (Rank)	Aggregated score	Priority weight (Rank)
c1	0.674	0.232 (1)	0.674	0.237 (1)
c2	0.417	0.143 (4)	0.422	0.148 (4)
c3	0.268	0.092 (6)	0.214	0.075 (5)
c4	0.275	0.095 (5)	0.186	0.065 (6)
c5	0.637	0.219 (2)	0.674	0.237 (1)
c6	0.637	0.219 (2)	0.674	0.237 (1)
Source: Own elaboration using GBM for the matrices *R* and *R** shown in				

Table 6.6 shows that the two scenarios are different. The first scenario which is less demanding regarding the information asked to the DMs presents the first criterion as the most priority, followed by the fifth and the sixth criteria. In the second scenario, these three criteria have the same priority. The fourth and the third criteria are those which exhibit the least priority for both scenarios. Nevertheless, the rankings of these two criteria are inversely related in both scenarios. The third criterion shows the minimum priority in the first scenario, meanwhile, it is the fourth criterion for the second scenario.

Similarly, as above, the aggregate values are now obtained for each criterion and each scenario applying the GBM operator to the vector of aggregate values for each criterion at the individual level. Thus, we can calculate *gu1* and *gu1** as follows:

$$gu_1 = GBM\left(p,q,u_1^1,u_1^2,\cdots,u_1^n\right) = \frac{1}{10}\prod_{\substack{i,j=1\\ i\neq j}}^{n}\left(5u_1^i + u_1^j\right)^{\frac{1}{n(n-1)}} = 0.537$$

$$gu_1^* = GBM\left(p,q,u_1^{*1},u_1^{*2},\cdots,u_1^{*n}\right) = \frac{1}{10}\prod_{\substack{i,j=1\\ i\neq j}}^{n}\left(5u_1^{*i} + u_1^{*j}\right)^{\frac{1}{n(n-1)}} = 0.556$$

The extended method permits not only to calculate the aggregate values but also the weights as an average using the GBM operator, highlighting that in this case, the interrelationships that

are considered are those of the DMs. Thus, the method can also be applied to any population segment that can be of interest to researchers or practitioners according to:

$$g_s u_1 = GBM\left(p,q,u_1^{1s},u_1^{2s},\cdots,u_1^{ns}\right) = \frac{1}{10}\prod_{\substack{is,js=1\\ is\neq js}}^{ns}\left(5u_1^{is}+u_1^{js}\right)^{\frac{1}{ns(ns-1)}} \qquad (6.11)$$

$$g_s^* u_1 = GBM\left(p,q,u_1^{*1s},u_1^{*2s},\cdots,u_1^{*ns}\right) = \frac{1}{10}\prod_{\substack{is,js=1\\ is\neq js}}^{ns}\left(5u_1^{*is}+u_1^{*js}\right)^{\frac{1}{ns(ns-1)}} \qquad (6.12)$$

The super indices in eqs. 6.11 and 6.12 mean that the GBM operator is only applied to a segment subsample *s*. In the study, the following segments are analysed: countries and age group. The idea behind this approach is that it is likely that the responses by some specific group can also have somehow more interrelationship.

Finally, Table 6.7 shows the aggregate values and the weights of the criteria for the total respondents to the survey. It can be seen that both scenarios are different, as scenario one shows the following ranking for the criteria *c1> c6> c3> c5> c2> c4*. Meanwhile, the ranking for the criteria under the second scenario is *c6> c1> c5> c2> c3> c4*. It can be seen that there is only one basic agreement between both scenarios regarding the least priority criterion is observed in the information regarding "the fishing gear (e.g. longlines, trawls) used to catch the product", which is also in accordance with the study of Pieniak et al. (2007), that found that there is no interest on comprehensive information about fishing methods for Spanish and Belgian consumers. The rest of the criteria shows a very different priority. For example, the less demanding information method –first scenario- concludes that "the name of the product and the species" is the most priority criterion, meanwhile, for the second scenario, it changes to "the "use by" or "best before date" criterion, however, is interesting to note that in both scenarios, c1 and c6 are the top two ranked criteria.

Table 6.7. Aggregated and priority weights of criteria for all respondents

Notation	First scenario		Second scenario	
	Aggregated score	Priority weight (Rank)	Aggregated score	Priority weight (Rank)
c1	0.537	0.188 (1)	0.528	0.188 (2)
c2	0.474	0.166 (5)	0.459	0.164 (4)
c3	0.499	0.175 (3)	0.459	0.164 (5)
c4	0.315	0.110 (6)	0.285	0.102 (6)
c5	0.496	0.174 (4)	0.515	0.184 (3)
c6	0.534	0.187 (2)	0.556	0.198 (1)

Source: Own elaboration using GGBM for the matrices formed with the aggregated preference scores of all the respondents

6.5.1 Segmentation and results robustness

This section analyses the ranking results obtained by the CFPR-GGBM for two segmentation variables: country of residence and age. This section provides two interesting insights: regulation adequacy and robustness of the results obtained by the less demanding information method. First, we can compare for each of the scenarios whether the EU28 represents adequately the preference relations on the mandatory information for FAPs or, contrarily, some segment is not well represented. For this first analysis, the Spearman correlation coefficients

between the rankings for EU28 and each of the segments -29 countries and 7 age groups- will be calculated. And second, the Spearman correlation coefficients between the rankings for each of the segments for both scenarios will be obtained.

Spearman's rank correlation coefficient (ρ) measures the nature (positive and negative) and strength (very strong to non-existent) of association between two variables (Beatty, 2018). It is simply calculated as the Pearson correlation coefficient of the ranks of the values of the two variables. A rule of thumb to interpret the coefficient in absolute value is: very strong association for values higher than 0.8; strong association for values between 0.5 and 0.8; moderate association for values between 0.3 and 0.5; weak association for values between 0.1 and 0.3; and very weak or non-existent association for values lower than 0.1.

Table 6.8 and Table 6.9 show the Spearman correlation coefficients, the statistical coefficient and the p-value of the analysis of the positive association that exists between the preference relations for the mandatory information for FAPs in EU28 and each of the segments under analysis for both scenarios. It can be seen that for the first scenario, there are 9 countries for which the preferences are different: France, the Netherlands, Italy, Luxembourg, Ireland, Greece, Portugal, Cyprus and Malta. Noticeably, there are not any differences observed when the age of segmentation is used. It is also remarkable that for 18 segments (14 country segments and 4 age segments), the respective preference rankings coincide exactly with the ranking of the EU28. Thus, it can be concluded that European preferences are representative of the analysed segments.

Table 6.9 can be analysed similarly to Table 6.8. In this case, it can be seen that the differences are almost negligible as only two countries present a significantly different pattern than the EU (France and Italy). Interestingly now, there are only 13 segments (9 countries and 4 age segments) with the same ranking preference order as the EU28. The results show that for the second scenario the representativeness of the ranking preferences of the EU28 is much more consistent. Nevertheless, the authors do not find any possible explanation for these facts.

Table 6.8. Comparison of EU 28 with segments based on countries and age (First Scenario)

Segment	Spearman Correlation	S.coef	p-value
Countries			
FR - France	0.714	10	0.136
BE - Belgium	0.943	2	0.017
NL - The Netherlands	0.829	6	0.058
DE-W - Germany - West	0.886	4	0.033
IT - Italy	0.486	18	0.356
LU – Luxembourg	0.829	6	0.058
DK – Denmark	0.943	2	0.017
IE – Ireland	0.829	6	0.058
GB-UKM - Great Britain	1.000	0	0.003
GR – Greece	0.829	6	0.058
ES -Spain	0.943	2	0.017
PT - Portugal	0.714	10	0.136
DE-E Germany East	1.000	0	0.003
FI - Finland	1.000	0	0.003

Segment	Spearman Correlation	S.coef	p-value
SE - Sweden	1.000	0	0.003
AT - Austria	1.000	0	0.003
CY - Cyprus (Republic)	0.771	8	0.103
CZ - Czech Republic	1.000	0	0.003
EE - Estonia	1.000	0	0.003
HU - Hungary	1.000	0	0.003
LV - Latvia	1.000	0	0.003
LT - Lithuania	1.000	0	0.003
MT - Malta	0.829	6	0.058
PL - Poland	0.943	2	0.017
SK - Slovakia	1.000	0	0.003
SI - Slovenia	0.943	2	0.017
BG - Bulgaria	1.000	0	0.003
RO - Romania	1.000	0	0.003
HR - Croatia	1.000	0	0.003
Age			
15 - 24 years	1.000	0	0.003
25 - 34 years	1.000	0	0.003
35 - 44 years	1.000	0	0.003
45 - 54 years	0.943	2	0.017
55 - 64 years	0.943	2	0.017
65 - 74 years	0.943	2	0.017
75 years and older	1.000	0	0.003

Table 6.9. Comparison of EU 28 with segments based on countries and age (Second Scenario)

Segment	Spearman Correlation	S.coef	p-value
Countries			
FR - France	0.829	6	0.058
BE - Belgium	1.000	0	0.003
NL - The Netherlands	1.000	0	0.003
DE-W - Germany - West	1.000	0	0.003
IT - Italy	0.771	8	0.103
LU – Luxembourg	0.943	2	0.017
DK – Denmark	0.943	2	0.017
IE – Ireland	1.000	0	0.003
GB-UKM - Great Britain	1.000	0	0.003
GR – Greece	0.943	2	0.017
ES -Spain	0.943	2	0.017
PT - Portugal	0.943	2	0.017
DE-E Germany East	0.943	2	0.017
FI - Finland	0.943	2	0.017
SE - Sweden	0.886	4	0.033
AT - Austria	0.943	2	0.017
CY - Cyprus (Republic)	0.943	2	0.017
CZ - Czech Republic	0.943	2	0.017
EE - Estonia	0.943	2	0.017
HU - Hungary	0.943	2	0.017
LV - Latvia	1.000	0	0.003

LT - Lithuania	0.943	2	0.017
MT - Malta	1.000	0	0.003
PL - Poland	1.000	0	0.003
SK - Slovakia	0.943	2	0.017
SI - Slovenia	0.943	2	0.017
BG - Bulgaria	0.943	2	0.017
RO - Romania	1.000	0	0.003
HR - Croatia	0.886	4	0.033
Age			
15 - 24 years	1.000	0	0.003
25 - 34 years	0.943	2	0.017
35 - 44 years	1.000	0	0.003
45 - 54 years	0.943	2	0.017
55 - 64 years	1.000	0	0.003
65 - 74 years	1.000	0	0.003
75 years and older	0.943	2	0.017

Finally, the results' robustness for the method of Herrera-Viedma et al. (2004) is going to be checked. Table 6.10 shows the Spearman correlation coefficients, the statistical coefficient and the p-value of the analysis of the positive association that exists between the preference relations obtained for each segment under the two different methods. The results show that only for 16 segments (the EU28, 13 countries and 2 age segments), the preference ranking positive association is not statistically significant. The extreme cases are observed in Croatia and Sweden. A group of ten segments formed by EU28, West Germany, Denmark, United Kingdom, Spain, Latvia, Slovenia, Romania, age (15-24 years) and age (35-44 years), shows more moderate differences. The case of the EU28 was already analysed and discussed. Similar patterns are observed for the rest of the segments, as in all the cases the criterion on the information of "the fishing gear (e.g., longlines, trawls) used to catch the product" has the least priority. Outstandingly, the results that minimize the number of pairwise comparisons in surveys that assure the consistency property are robust as Table 6.10 shows that for the rest of the 21 segments the positive association between both methods is statistically significant. The result is not a surprise as CFPR is a method that is well known in the strand of the literature on MCDM analysis. In our case, CFPR requires only 5 adjacent pairwise comparisons –a figure which is lower than the total 15 pairwise comparisons which are needed on a scale of six criteria.

Table 6.10. Comparison of the First and Second Scenarios

Segment	Spearman Correlation	S.coef	p-value
Countries			
EU28	0.771	8	0.103
FR - France	0.829	6	0.058
BE - Belgium	0.886	4	0.033
NL - The Netherlands	0.943	2	0.017
DE-W - Germany - West	0.771	8	0.103
IT - Italy	0.943	2	0.017
LU – Luxembourg	0.829	6	0.058
DK – Denmark	0.771	8	0.103
IE – Ireland	0.943	2	0.017

Segment	Spearman Correlation	S.coef	p-value
GB-UKM - Great Britain	0.771	8	0.103
GR – Greece	0.829	6	0.058
ES -Spain	0.771	8	0.103
PT - Portugal	0.829	6	0.058
DE-E Germany East	0.886	4	0.033
FI - Finland	0.886	4	0.033
SE - Sweden	0.714	10	0.136
AT - Austria	0.886	4	0.033
CY - Cyprus (Republic)	0.943	2	0.017
CZ - Czech Republic	0.886	4	0.033
EE - Estonia	0.886	4	0.033
HU - Hungary	0.886	4	0.033
LV - Latvia	0.771	8	0.103
LT - Lithuania	0.886	4	0.033
MT - Malta	0.943	2	0.017
PL - Poland	0.886	4	0.033
SK - Slovakia	0.886	4	0.033
SI - Slovenia	0.771	8	0.103
BG - Bulgaria	0.886	4	0.033
RO - Romania	0.771	8	0.103
HR - Croatia	0.714	10	0.136
Age			
15 - 24 years	0.771	8	0.103
25 - 34 years	0.886	4	0.033
35 - 44 years	0.771	8	0.103
45 - 54 years	0.943	2	0.017
55 - 64 years	0.886	4	0.033
65 - 74 years	0.886	4	0.033
75 years and older	0.886	4	0.033

6.6 Policy implications

The results indicate that for European residents the most important criteria are “the name of the product and the species” and “the “use by” or “best before” date”, which means that this information should be highlighted among the rest of the criteria in the packages of the products or the information accompanying these products. Also, the fact that the “name of the product and the species” is highlighted as one of the most important criteria evidences the importance of strengthening the policies against fraud and particularly mislabelling, which has also been identified as a problem in Europe (Miller and Mariani, 2010).

On the other hand, it was found that the least priority criterion was “the fishing gear (e.g., longlines, trawls) used to catch the product”. This might be caused by the lack of knowledge that consumers have about the environmental impact of the fishing gear. Therefore, more information should be given to consumers about the different fishing gears and their impacts on the environment through labels added to the products or marketing campaigns. Investigations such as the one of Løkkeborg (2011) analysed mitigation measures for seabirds’ mortality in longline, trawl and gillnet fisheries. Further research and knowledge transfer to

society might be important to grow consumers' awareness of the environmental impacts that might be caused by the fishing gears.

Moreover, regarding the association that exists between the preference relations for the mandatory information for FAPs in EU28 and the different countries, the intersection of the two scenarios identified that in Italy and France the preferences are different from the rest of the EU. In particular, Italy can be considered the most extreme case regarding the differences observed in the first scenario. For Italian residents, the preferences over criteria can be ordered as *c5*> *c6*> *c1*> *c2*> *c3*> *c4*. So, for Italian residents, the most important criterion is to have information about whether the product was previously frozen –the fourth criterion at the European level. Italy is among the group of European countries which consumes more fish per-capita, and Italian residents are also characterized by eating out regularly (Samoggia and Castellini, 2018), so the differences might be explained by the fact that Italian residents prefer to clearly know whether the fish they are eating is fresh or refrigerated. On the other hand, the second scenario does not show so extremely different results for Italy, so it might not be necessary to apply the principle of subsidiarity of the EU.

Still, the main outcome that we can extract from the previous results is that it might be necessary to evaluate ex-ante the future mandatory information scale to find out whether some countries show several differences so the regulation can be adapted specifically for these cases throughout the application of the principle of subsidiarity. It seems evident that if the future scale contains more attributes, the differences at the country level can be greater than those observed here in the current analysis with only six attributes.

Furthermore, the preference relations for the mandatory information for FAPs in EU28 according to the age group seem to be statistically the same. These results are similar to those obtained by Pieniak et al. (2007) who found that the preferences for label information do not differ between young and old Spanish and Belgian consumers. Nevertheless, future modifications of the regulation that assesses the mandatory information for FAPs (EU 1379/2013) should also contemplate that this issue might change if another type of mandatory information more associated with the environment and climate change is finally included.

Finally, we recommend applying the model CFPR-GGBM to evaluate the degree of importance scales, as this model considers the interrelationship between both the criteria and respondents, which is an important feature that provides more consistent and accurate results than other multi-criteria methods.

6.7 Conclusions

Normally, the majority of MCDM methods consider that the criteria and the respondents are independent, i.e., they do not exhibit any type of interrelationship. However, in the real world, this is a very strong assumption difficult to assume. In most of the preferences' studies, criteria and respondents exhibit some sort of dependency. For this reason, our proposal is based on a CFPR-GGBM method that properly handles both of the commented issues.

In DM problems, researchers are usually interested in obtaining the best alternative or the most priority criterion, and sometimes, we tend to minimize the role of the rest of the criteria.

Nevertheless, this can be problematic in some cases when the analysis has to be done in the set of all the criteria as the scale has already been decided by some process that has involved multiple and different stakeholders such as regulators, policy makers, politicians, fishermen associations, aquaculture farms, retailers, intermediaries, consumers, researchers and other interested parties in the food logistic chain.

We firmly believe that interrelationship is an important feature that needs to be considered to provide more consistent and accurate results (Alias et al., 2019). For that reason, we extend the model CFPR-GBM proposed by Alias et al. (2019), considering also the possible relationship between the respondents with the model CFPR-GGBM. Thus, the GBM operator handles not only the dependency aspect between the criteria but also the respondents in the aggregation step.

Our results are more conclusive in the least priority criterion “the fishing gear (e.g., longlines, trawls) used to catch the product”. The results are less conclusive in the upper part of the priority criteria, but it can be concluded that two of the most important criteria for European citizens are “the name of the product and the species” and “the “use by” or “best before” date”.

The analysis of the segments shows that Italian residents exhibit for the first scenario a very different pattern regarding the preferences for the mandatory information. As for the second scenario, the results are not so extreme then the principle of subsidiarity of the EU might not be necessary. Nevertheless, our main conclusion in this respect is to analyse the future scale ex-ante to see if some Member State shows many differences so the regulation can be specifically adapted in some cases.

Our study is not exempt from some limitations. First, we do not intervene in the questionnaire, so a real survey based on CFPR was not administered. It would be an interesting issue for future research to compare the results obtained from this CFPR survey with traditional surveys like the one used in the study. Nevertheless, the database is very rich and contains all the countries of the EU28, and for the first time, the scale of the mandatory information for FAPs in the EU28 has been analysed.

7 Paper: A hybrid-fuzzy TOPSIS method to analyse the coverage of a hypothetical EU eco-label for Fishery and Aquaculture products (FAPs)

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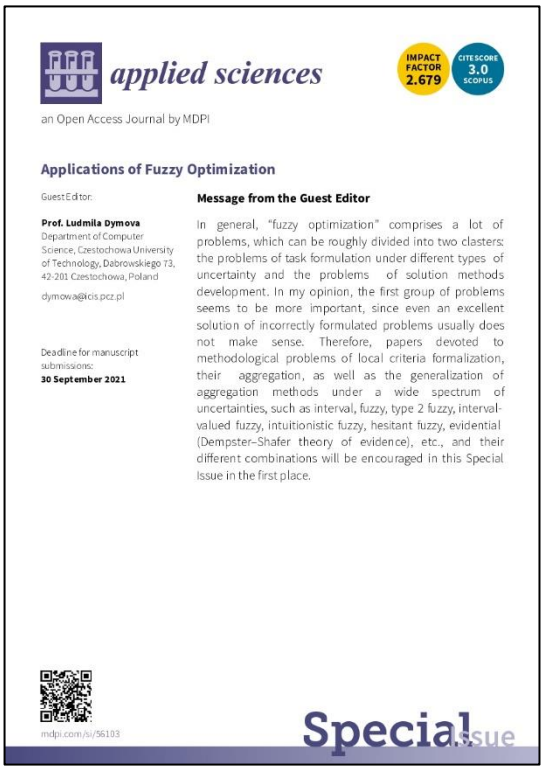
Abstract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Applications of Fuzzy Optimization

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Message from the Guest Editor

In general, "fuzzy optimization" comprises a lot of problems, which can be roughly divided into two clasters: the problems of task formulation under different types of uncertainty and the problems of solution methods development. In my opinion, the first group of problems seems to be more important, since even an excellent solution of incorrectly formulated problems usually does not make sense. Therefore, papers devoted to methodological problems of local criteria formalization, their aggregation, as well as the generalization of aggregation methods under a wide spectrum of uncertainties, such as interval, fuzzy, type 2 fuzzy, interval-valued fuzzy, intuitionistic fuzzy, hesitant fuzzy, evidential (Dempster–Shafer theory of evidence), etc., and their different combinations will be encouraged in this Special Issue in the first place.

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Special Issue

This study presents a hybrid-fuzzy TOPSIS method (FTOPSIS) to analyse 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" (European Commission, 2015a). The results indicate that Ecolabels should not only include environmental issues but also other types of information, being social and ethical issues the most relevant, followed by the animal welfare issues, the health and safety issues and the food quality issues. The findings also show that consumers, producers and stakeholders who are more interventionists and support the fact that public bodies and government should be involved in the control of eco-labelling, accept more to include additional information apart from environmental issues. Synthetic indicators (SIs) have also been found to be mostly inelastic, except for the owners of eco-labels on social and ethical issues. The implications of the future implementation of the EU Ecolabel for FAPs are discussed based on the findings.

Keywords: Fuzzy Logic; Triangular fuzzy numbers; FTOPSIS; Fishery and aquaculture products (FAPs); Ecolabels.

7.1 Introduction

The EU is the world's leading nominal trader for fishery and aquaculture products (FAPs) (FAO, 2021c). In addition, the EU has a higher average per capita consumption (24.33 kg) (European Union, 2018a) than the global average (20.3 kg) (FAO, 2021c). 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 (D'Amico et al., 2016).

The CMO ensures that the information that consumers receive from FAPs sold in Europe has the expected quality regardless of the origin of the product (European Commission, 2016a). The CMO is currently ruled by the EU regulation 1379/2013, which provides for mandatory information on the labelling of FAPs and other aspects (D'Amico et al., 2016). 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 (European Parliament, 2013). Furthermore, the EU regulation 1379/2013 requires the EU Commission to submit a report on the feasibility of a union-wide FAP eco-labelling scheme (European Commission, 2015b).

Food labelling 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 (Conte et al., 2014). Eco-labels are based on approval seals for products that are considered to have less environmental impacts than functionally or competitively similar products (Salzman, 1991). Also, 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) (Asche et al., 2015). 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 (UNCTAD. Secretariat, 1994), eco-labels 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-labelling 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 (Kirby et al., 2014). These eco-labelling schemes aim to differentiate products based on their environmental impact, thus enabling consumers to make informed purchasing decisions. Eco-labelling schemes are also designed to encourage the industry 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-labelling 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 (European Commission, 2015b). An integrated EU ecolabel for fisheries and aquaculture products might be a good alternative to surpass certain issues of current private eco-labelling schemes that have been questioned in the literature, such as their high volume of available options with conflicting messages that undermine their effectiveness (Washington and Ababouch, 2011), the anti-competitiveness environment that they might generate if some firms are capable of exerting market power (McCorriston, 2002), their lack of effectiveness and rigour (Christian et al., 2013), their inability to promote consumer demand (Washington and Ababouch, 2011) or their inability to pursue significant environmental change (Jonell et al., 2013).

The present investigation uses a hybrid fuzzy TOPSIS methodology (FTOPSIS) to analyse 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 eco-label for FAPs, considering various types of stakeholders and segments of the sample according to their opinion on whether the public bodies/governments should be involved in the control of eco-labels (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 analyses the importance of including different types of information in a hypothetical eco-label for FAPs; (2) to compare the values of the synthetic indicator by type of stakeholder and by respondents' opinion on whether the public bodies/governments should be involved in the control of eco-labels; (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 eco-label scheme.

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

The rest of the paper is organized as follows: Section 7.2 presents the relevant literature review of the eco-labels highlight more the features on FAPs, section 7.3 details the data used for the estimation of the synthetic indicators and the elasticities, section 7.4 describes the proposed methodology, section 7.5 describes the main results based on the application of the methodology, section 7.6 discusses the results, and section 7.7 offers some conclusions.

7.2 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 whole EU, apart from the report that was constructed based on the same public consultation assessed in the present investigation (European Commission, 2016b). However, the report does neither focus enough on the issues that should be assessed in the ecolabel, nor the differences of opinions between different segments about them.

In contrast, the literature is rich in assessing the impacts and importance of eco-labels 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 analyse 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 FAPs ecolabels, subdivided them according to the type of information included in the eco-labels (environmental, animal welfare, health and safety, food quality and ethical issues).

7.2.1 Environmental issues

Consumers in Europe are deeply concerned about the environmental impact of both catch and farmed fish (Schlag and Ystgaard, 2013). It is therefore not surprising that environmental conditions of the 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 lower quality in comparison (Bronnmann and Hoffmann, 2018).

Moreover, the environmental concerns of 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 (Santeramo et al., 2017), 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 (Whitmarsh and Palmieri, 2011).

On the other hand, some studies highlight that consumers are willing to pay premiums for products labelled with environmental advantages (Fonner and Sylvia, 2015; Hynes et al., 2019; Lim et al., 2018; Olesen et al., 2010, 2006; Rudd et al., 2011). Two investigations found that consumers in Norway were willing to pay a premium of around 15% for organic labelled salmon compared to conventional salmon with the same colour; however, the results show that the importance of this label is considerably low compared to salmon colour (Olesen et al., 2010, 2006). 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 seafood was harvested is healthy and sustainable and that fisheries cause minimal environmental damage (Fonner and Sylvia, 2015). Moreover, two investigations highlight that

consumers are willing to pay premiums for lower levels of contamination, evidenced in low levels of polychlorinated biphenyls (Rudd et al., 2011) or the absence of Bisphenol A (plastic) (Lim et al., 2018).

In addition, some environmental labels refer to the certification of innovative production practices that favour 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 (van Osch et al., 2019). 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 (van Osch et al., 2019) and the other in Ireland for sustainably salmon (van Osch et al., 2017).

7.2.2 Animal-welfare issues

Animal welfare can be described as the lack of suffering in animals and focuses on animal health and their needs (Dawkins, 2008). Economic considerations and state regulations on fish welfare have incorporated knowledge of fish behaviour and ecology into the aquaculture industry (Lam, 2019). 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 (Metcalfe, 2009).

In the literature, several studies have studied the possible acceptance of animal welfare labels and claims (Ankamah-Yeboah et al., 2019; Olesen et al., 2010, 2006; Zander and Feucht, 2018). In Norway, two studies identified a preference and higher WTP for animal welfare labelled salmon (Freedom Food salmon), compared to conventional salmon with the same colour (Olesen et al., 2010, 2006). However, the effect of the colour completely outweighed the effect of the label. Similarly, another investigation asked consumers from different European countries regarding additional WTPs for different sustainability claims related to seafood (Zander and Feucht, 2018). The higher animal welfare standards WTP were observed in Finland, Spain, UK, Germany and Italy, and in these last two countries, the figures were even greater than 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 labelled farmed trout products in Germany (Ankamah-Yeboah et al., 2019).

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 DCE, with a label indicating that the fish had been harvested by fisheries with high 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) (Davidson et al., 2012). Similarly, a DCE for Tuna in Mexico found that consumers who had been informed about the "dolphin-safe" eco-label were more eager to consume canned tuna (Almendarez-Hernández et al., 2017). Another study found the by-catch concern can be overcome or mitigated by the introduction of special fishing gear and methods (Gulbrandsen, 2005).

7.2.3 Health and safety issues

7.2.3.1 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 (Murray et al., 2017). 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 (Schlag and Ystgaard, 2013).

Some studies highlight that consumers are willing to pay premiums for seafood products including labels or claims supporting health benefits associated with Omega 3 (Banovic et al., 2019; Fernández-Polanco et al., 2013; Rudd et al., 2011). 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 (Rudd et al., 2011). Nevertheless, in general, attributes associated to decrease 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 Omega3 claim; however, other attributes such as the origin, the harvest method (wild or farmed), and the sustainability claim were more important (Fernández-Polanco et al., 2013). 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 (Banovic et al., 2019). However, these factors were less valued than others such as the origin, price and the Aquaculture Stewardship Council (ASC) eco-label.

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 MSC ecolabel and a BPA-free product label (Lim et al., 2018). 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, being the nutritional information more relevant (Bi et al., 2016). 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.

7.2.3.2 Safety issues

Consumption patterns may be affected by the consumers' opinions on the safety of the 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 (Lee and Nam, 2019). 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 (Santeramo et al., 2017).

Moreover, some studies indicate that consumers are willing to pay premiums for improved safety products (Fonner and Sylvia, 2015; Haghiri, 2014; Ortega et al., 2014). 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 (Haghiri, 2014). A study in the U.S. 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 (Ortega et al., 2014). A different investigation in Portland (US) for crab and salmon, found that amongst four labels related to safety, eco-labelling, quality and local products, the safety label that meets the U.S Food and Drug Administration (USFDA) standards and that declares that the seafood is low in mercury and other contaminants, was ranked third and they also identified that females had stronger preferences for safety labels (Fonner and Sylvia, 2015).

7.2.4 Food quality issues

In the literature, a DCE that took place in the UK found that 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 (Jaffry et al., 2004). 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 the labels included in the experiment such as safety, ecolabels and local products (Fonner and Sylvia, 2015).

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 (Murray et al., 2017). Another investigation also found that regular consumers of fish and shrimp in France consider important the sensory quality of the products (Thong and Solgaard, 2017). On the other hand, a different study found in Belgium that taste and health are the most important drivers for the attitude to eat fish., which is directly correlated to the frequency of fish consumption (Verbeke and Vackier, 2005).

7.2.5 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 benefits coastal communities (McClenachan et al., 2016). 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 fair trade 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 (Hinkes and Schulze-Ehlers, 2018).

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 fair-trade 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) (Loureiro and Lotade, 2005).

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 (Verbeke et al., 2007c). However, consumers refused to eat wild fish because of sustainability and ethical concerns.

7.3 Data

The database used for this investigation is based on a public consultation on options for an EU Ecolabel for FAPs (European Commission, 2015a), executed by the European Commission between April 30 and July 1 of 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 Organisation 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 organisation), retailers, and public organizations (Government, Public, Non-Governmental organisation, 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 7.1). The responses to this question were the basis for constructing the triangular fuzzy numbers, while the socio-

demographic characteristics of the respondents (Table 7.2) were used to distinguish the different segments and groups.

Table 7.1. 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: (European Commission, 2015a)

Table 7.2. 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 without considering any type of sample representativeness, methodology or control. The public consultation was widely publicised, but respondents choose to participate without any further prerogative than the interest in FAPs ecolabels framework in the EU. For that reason, the results do not necessarily reflect the opinions of the EU citizens, but the views of those who were interested in the consultation (European Commission, 2015b).

7.4 Methodology

The methodology is derived from a hybrid approach based on Fuzzy Set Theory (FST) and TOPSIS (Techniques for order preference by similarity of the ideal solution). 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 (Martín et al., 2020b). Moreover, the essence of the human ambiguity judgement when dealing with multidimensional attributes can be captured by fuzzy methods (Chang, 1996), 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 to deal not only with the uncertainty associated to the Likert scales, but also to provide the synthetic indicators and elasticity values (Martín et al., 2019).

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 are 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 Science 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 than other traditional methods (D'Urso et al., 2016; Martín et al., 2020a). Table 7.3 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, respectively, the minimum and maximum values. Thus, the first step in the methodology is to transform the responses into TFNs according to the default values shown in the table.

Table 7.3. 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 are 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 are 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 ($\tilde{A}$) 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 part of that particular segment of analysis, as shown in equation 7.1.

$$\tilde{A} = \left(a_{s,p,q}, b_{s,p,q}, c_{s,p,q}\right) = \left(\frac{\sum_{i=1}^{n} a_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} b_{s,p,q}}{n}, \frac{\sum_{i=1}^{n} c_{s,p,q}}{n}\right) \qquad (7.1)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

In the third step, we clarify 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 are calculated according to equation 7.2 for simplicity and objectivity (Chen, 1996) 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*.

$$CV_{s,p,q} = \frac{a_{s,p,q} + 2 \times b_{s,p,q} + c_{s,p,q}}{4} \qquad (7.2)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

The fourth step consists 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 7.3. While the ideal solution maximizes the level of acceptance on the inclusion of each particular issue *q*, the negative ideal solution minimizes it.

$$CV_q = \left\{CV_{1,1,q}, \ldots, CV_{s,p,q}\right\} \text{ where } CV_q^+ = \max_q\left(CV_q\right) \text{ and } CV_q^- = \min_q\left(CV_q\right) \qquad (7.3)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

The fifth step, as shown in Equation 7.4, is to calculate the Euclidean distances of each category *s* of the segment of analysis *p* respect 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 is the sixth step of the methodology and is carried out using equation 7.5, which characterizes simultaneously the distance to the ideal and negative-ideal solutions.

$$d_{s,p}^+ = \sqrt{\sum_{q=2}^{q} (CV_q^+ - CV_{s,p,q})^2} \text{ and } d_{s,p}^- = \sqrt{\sum_{q=2}^{q} (CV_{s,p,q} - CV_q^-)^2} \qquad (7.4)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

$$SI_{s,p} = \frac{d_{s,p}^-}{d_{s,p}^+ + d_{s,p}^-} \qquad (7.5)$$

Where s:1,...,s and p:1,...,p

The seventh step involves the estimation of the elasticities per segment of analysis of the SIs towards percentual changes in the response given for each issue A (equation 7.6). This

information allows the understanding of how a percentage change in each of the issues affects the SI per each of the analysed segments.

$$\eta_{s,p,q} = \frac{\Delta\% SI_{s,p}}{\Delta\% A_{s,p,q}} \qquad (7.6)$$

Where s:1,...,s; p:1,...,p and q:1,...,q

7.5 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 7.4 presents the TFNs and the CV for the total of the sample and the governmental intervention segments, while Table 7.5 presents the same information for the stakeholders' segments. Results indicate that in all cases the lowest value was assigned to include only environmental issues in the ecolabels, indicating that ecolabels should not exclusively include environmental issues, but also other types of information. Amongst them, the most important for the total of the sample surveyed was the social and ethical issues, followed in order by the animal welfare issues, the health and safety issues and the food quality issues.

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, eco-label owners, retailers or suppliers, and organizations (Government, Public, Non-Governmental organisation or Research) assigned the same rank of importance to the different issues as the total sample, however, producers ranked them differently, being the most important the health and safety issues followed very closely by the food quality issues. This result has shown that the producers are the stakeholders who value 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 analysed 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 the different issues.

Table 7.4. TFNs and Crisp values. Total and Governmental interventions segments of analysis

Attributes	Total		Gov. Intervention (No)		Gov. Intervention (DN)		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 7.5. TFNs and Crisp values. Stakeholders' segments of analysis

Attributes	Consumers		Eco-Label 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

In the fourth step, we calculate 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 7.6. Ideal and negative ideal solutions indicate which segment of analysis has given the best and worst 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 eco-label. 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 to whether or not just consider only environmental issues, which is common in current eco-labelling schemes, or, on the contrary, it should add other different issues apart from the environmental issues.

An interesting fact that can be highlighted from the results of Table 7.6 is that most of the segments of the ideal solutions are obtained at country level with the exception of the eco-label 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 eco-labels should only cover environmental issues, while Bulgarians are the segment of analysis that accept the least with 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 eco-label.

Table 7.6. Coverage of the EU ecolabels. Ideal Solutions

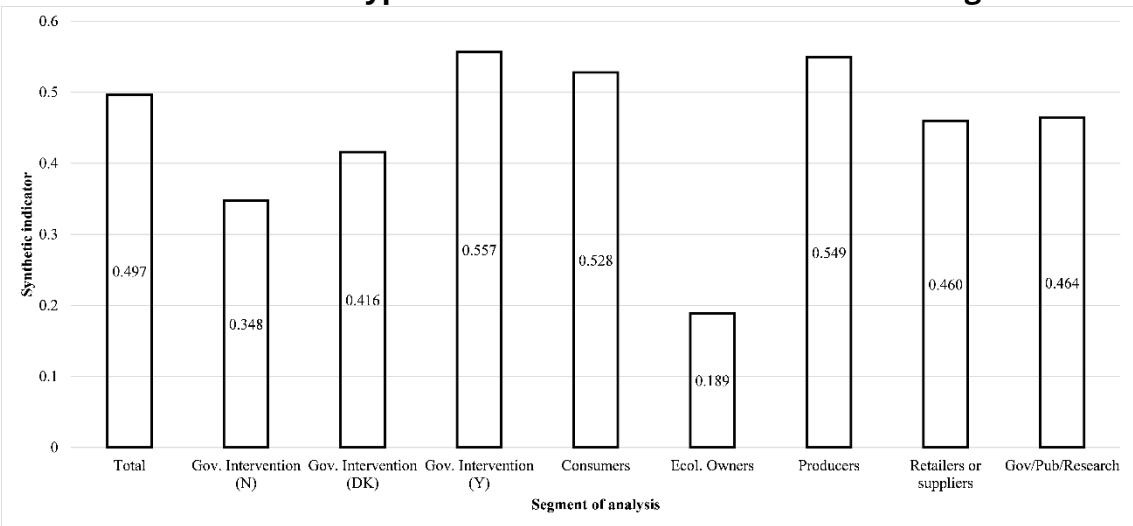
Attributes	Positive	Segment	Negative	Segment	Perc. Variation
Only Environmental issues	81.25	Croatia	7.50	Bulgaria	983%
Social and ethical issues apart from environmental issues	92.50	Cyprus	30.00	Estonia	208%
Food quality issues apart from environmental issues	92.50	Cyprus	28.75	Ecolabel owner	222%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

Following the implementation of steps 5 and 6, the SIs were calculated and are shown in Figure 7.1 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-labelling accept more to include issues that are different from environmental issues than those who do not or do not know. Similarly, from the group of stakeholders, producers and consumers have higher SIs. On the other hand, eco-label owners are the group of stakeholders that accept the least to include other types of information apart from the environmental issues.

Figure 7.1. Level of acceptance for the inclusion of additional issues apart from environmental on a hypothetic EU Ecolabel for the different segments of analysis



Finally, on the last step, we calculate the elasticities of the SIs (Table 7.7). General results indicate that the SIs are mostly inelastic with respect to all the issues and segments of analysis, except for the owners of eco-labels 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 eco-label owners regarding food quality issues.

For the total sample and most of the analysed 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 analysed segments were 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 7.7. Elasticity values of the level of acceptance for the inclusion of additional issues apart from environmental on a hypothetic EU Ecolabel for 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	Eco-Label 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

7.6 Discussion

The main outcome of the investigation is that the majority of all the analysed segments consider that FAPs 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 the social and ethical issues. The result contrasts with those obtained an extensive review of fisheries/aquaculture ecolabel schemes, which found that only a small number deals 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 (Macfadyen, 2004). In fact, for example, the MSC ecolabel, which covers about 10% of total seafood catch globally (Lim et al., 2018), strongly emphasizes environmental information over social issues. In addition, another investigation contends that although it has been widely accepted since the 1990s that 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 (Barclay, 2012).

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 (Lam, 2019). Also, 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 (Lam, 2019).

Moreover, we also found that for the majority of the segments of analysis considered, the second-highest valued issue different from the environmental type was the 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 the animal welfare and to avoid the animal suffering (Farm Animal Welfare Council, 2009). The five freedoms consist of freedom for hunger and thirst, freedom from discomfort, freedom from pain, injury and disease, freedom to express normal behaviour and freedom from fear and distress. Also, an investigation found that, according to the opinion of different stakeholders, the most relevant elements that influence fish welfare are to ensure a good physiological condition and good feed quality (Lembo et al., 2018). 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 the social and ethical issues and the 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 (Barker et al., 2019). 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 study focused on general food shopping and not on a specific type of products like FAPs.

In the same line, our finding that consumers consider animal welfare issues as 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 (Tobi et al., 2019).

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 the 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 a sub-optimal eco-labelling if producers decide to label or not FAPs 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 analysed segment, especially listening to consumers' voice (social, ethical and animal welfare), this action could reduce the interests of producers to adopt voluntarily an eco-label as their preferences are neglected or are less taken into account. Therefore, the proponents of the eco-label must analyse 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 eco-label. More consensus is needed before a formal eco-labelling 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 the most the inclusion of additional information in the EU ecolabels apart from the environmental issues. Similarly, results also show that SI 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 ecolabel's owners, indicate a low acceptance for the inclusion of other issues apart from the environmental by them, which is aligned with the idea that these two groups might not be so pro-active with the benefits of providing additional information apart from the environmental issues. This may be due to several reasons: (1) they consider more important other issues that were not considered in the analysis, (2) the inclusion of the issues despite their importance might be non-appropriate for diverse reasons in certain contexts or particular products of FAPs. Also, 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 eco-labels, they may

judge issues more strictly based on their previous experience and consider that other aspects can be more important for eco-labels apart from the issues that they should consider, for example, the administrative steps needed to establish such scheme.

Considering that it was found that the SI of ecolabel owners was elastic on social and ethical issues, eco-label promoters should make efforts in convincing eco-label 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 the environmental issues.

Finally, it is important to consider that the study is not exempt of limitations, that 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 is based on a voluntary online, which offers a lot less control over the conditions in which the respondents answer the questions. Also, the survey design used for the questions, do 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 like eco-label owners just represented by 10 respondents, which represents a risk of over-interpreting results with such a small sample for these under-represented groups.

7.7 Conclusions

This study presents a hybrid fuzzy method that analyses the coverage of a hypothetical EU ecolabel for Fishery and Aquaculture products (FAPs), by integrating a synthetic indicator that allows determining for 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 stakeholders' groups and to whether the citizens do agree or not in the eco-labelling governmental control.

The results indicate that ecolabels should not exclusively provide information on environmental issues, but also other types of information, in 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 ranked equally 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 eco-labels by public bodies or governments, have a higher level of acceptance to include other additional information apart from environmental issues. 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 eco-labels owners and social-and-ethical issues. On the other hand, the lowest elasticity value was obtained on food-quality issues for eco-label 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 analysed 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-labelling 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 related to organic production in certain member states (European Parliament, 2007). In addition to this, the lack of transparency in the market exists because consumers do not have enough knowledge about the term (van Amstel et al., 2007). Another concern that was highlighted is the need 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 many citizens pointed out that there are already many eco-labels 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-labelling 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 eco-labels.

Li (2020) analysed the eco-labelling competition issue theoretically through a dynamic Bertrand duopoly in which two eco-labelling programs (sponsored by the industry or by an environmental NGO) compete strategically in setting the eco-label features. The author found that competition between the programs may lead to the same high environmental benefits in comparison to when there exists only the NGO program, and that competition may yield a higher social welfare

Conclusions

a General discussion

a.1 Contribution to the scientific literature

a.1.1 Contributions to understanding the consumers' segment of FAPs

Regarding the understanding of the preferences for FAPs for European consumers the present investigation contributes to the following aspects:

- The investigation proposes a better understanding of FAPs' consumption across the EU in comparison to previous studies, which are more limited in several aspects such as the sample representativeness, the number of determinants studied and the geographical context in which it is focused. This better understanding allows to propose updated EU policies related to FAPs, customize the information accompanying the products and the marketing and educational campaigns to the preferences and attitudes of consumers to increase FAPs consumption, and accurately develop and implement changes to EU regulations in the context of FAPs such as the Common Fisheries Policy (CFP) and Common Market Organisation (CMO). A better understanding of the internal market of FAPs also enables operators to raise competitiveness by adopting or modifying their present strategies based on the demands of consumers. In addition, The marginal effects results can be useful for suggesting policy lessons or guiding the scope of future investigations to scientists, academics, and public authorities. Finally, the use of an adequate representative database enhances the robustness and credibility of the results.
- Limited studies are identifying the determinants of away-from-home consumption for FAPs. Additionally, they usually involve just a particular country, region and/or fish species, and the set of determinants are also limited in number and scope. Thus, the obtained results with previous investigations are not easily generalizable and the value for policies that could involve supranational entities such as the EU is also narrow. Meanwhile, the results of the present investigation provide a better understanding of the determinants of away-from-home consumption in the EU context, with more generalizable results to the complete EU region, facilitating the EU policy implementation. Also, a better understanding of the determinants of away-from-home consumption allows restaurant owners and the rest of the stakeholders of the supply chain to design and implement commercial strategies that improve the FAPs' logistic value. Furthermore, the results of the marginal effects can also provide useful insights to draw policy lessons or guide researchers and authorities in the extent of future research.

Regarding the understanding of the preferences for consumers of seabream and seabass products in Gran Canaria, the present investigation contributes to the following aspects:

- For the first time, there is a study analysing the attitudes towards seabream and seabass species in Gran Canaria. These findings facilitate the execution of strategies to improve the consumption of these two species based on consumer demand. Further, the results could also guide the scope of future studies by researchers, academics, and institutions.

- BWS Methodology and Importance-Satisfaction Analysis have been used to examine attitudes towards the consumption of fish for the first time.
- The results of the study do not only contribute to the understanding of attributes that consumers believe are the most significant and satisfied with, but also help to comprehend how the two levels (importance and satisfaction) interact together to identify the attributes that need to be approached to better improve the quality of seabream and seabass products in Gran Canaria.

a.1.2 Contributions to understanding the producers' segment of FAPs

The present investigation contributes to the risk and management of risk in aquaculture to the following aspects:

- Increase the understanding of the risk attitudes, risk sources and risk management practices of European aquaculture companies, allowing policymakers, advisors, governments, researchers, and aquaculture firms to develop strategies for improving existing risk management strategies.
- Use for the first time a mixed-methods approach with quantitative and qualitative information, to identify the main risk sources and risk management practices of European aquaculture firms.
- First attempt to understand if there is a difference between full-cycle and grow-out aquaculture companies in risk management and risks attitudes.
- Propose for the first time a practical approach using Simons' (1994) four levers of control framework, to assist aquaculture production managers in the management of the most significant risk sources identified.

a.1.3 Contributions to understanding the labelling preferences (interaction between consumers and producers) for FAPs

The understanding of the interaction between consumers and producers is obtained through the analysis of the labelling preferences of different stakeholders, especially consumers. The investigation contributes to these aspects as follows:

- This is the first research that analyses the relative importance, as a whole, of all FAPs' compulsory labels in the EU (EU Regulation 1379/2013). With this, it is possible to determine which information is important for consumers, considering excessive label information can be confusing while too little information can be misleading (Pieniak et al., 2013).
- It is the first investigation analysing the coverage of a hypothetical EU ecolabel for FAPs for different stakeholders using a hybrid fuzzy TOPSIS methodology (FTOPSIS), and that identifies differences of perspectives in acceptability to include different issues apart from environmental issues in an EU ecolabel such as animal welfare, social and ethical, food quality and health and safety.

a.1.4 Contributions to methodological aspects

The present research contributes to the following methodological aspects:

- For the first time in the context of FAPs consumption, heteroscedastic ordered probit models are estimated.
- Evaluation of alternative ways of surveys' response mechanisms by comparing the results of commonly used Likert-Scale responses with those from best-worst scaling (BWS) methods.
- Propose a similar Importance-Performance Analysis (IPA) approach (Martilla and James, 1977), but with a satisfaction dimension (Importance-Satisfaction Analysis -ISA-).
- For the first time, it is proposed a method based on a CFPR, that identifies the interrelationship among decision-making criteria and respondents, using the GBM operator (CFPR-GGBM method –Consistent Fuzzy Preference Relation with a Grand Geometric Bonferroni Mean).
- First attempt to propose a methodology that jointly analyses the importance of including different types of information in a hypothetical eco-label for FAPs.

a.2 Main Results of the investigation

In this subsection, there is a summary of the main findings of the investigation.

a.2.1 Understanding the consumers' segment for FAPs

- *Consumption at home*

The results indicate that the highest frequency of consumption at home of FAPs is related to considering these products as healthy, less expensive than other food and tasty. In addition, among the nationalities, Spaniards are more likely to consume these products at home more frequently in the EU28. Also, the consumers who are more likely to consume more frequently FAPs are those that are older than 55 years old, have a good financial situation, live in larger households, and live in towns/suburbs or small urban areas. Similarly, there is a higher frequency of consumption at home for those consumers that are satisfied with their lives and prefer wild-caught products over farmed products. Moreover, some attitudes that increase considerably the frequency of consumption of these products at home are to consider them easy to digest, quick and easy to prepare and contain little fat. Meanwhile, other less important attitudes that increase the consumption of these products, are to buy or eat them because of their origin, appearance, brand, or quality labels, and the environmental, social or ethical impacts. On the other hand, the lowest frequency of consumption at home was related to consumers who do not understand the information that accompanies the products.

- *Consumption away-from-home*

The results showed that the highest frequency of consumption away-from-home of FAPs is related to considering these products less expensive than other foods. Additionally, there is a higher frequency of consumption away-from-home at least once a week for British and Spaniards, and at least once a month for Portuguese and Belgians, in the EU28 context. However, more generally speaking, the countries located in the western part of the EU28 tend to have higher frequent consumption. In addition, the profile of the consumer that eats FAPs away-from-home more frequently are those who are between 24 and 54 years old, have a good financial situation, live alone or with just another person, and do not live in rural areas. Similarly, there is a higher frequency of consumption at home for those consumers that are satisfied with their lives, have good expectations, and have a preference for wild-caught, local and sea products. Other attitudes that increase considerably the frequency of consumption of these products away-from-home are to consider them healthy, tasty, easy to digest, for special occasions and with low fat.

- *Attitudes towards the consumption of seabream and seabass products in Gran Canaria*

The results of the study showed that the attributes of products' hygiene and safety, health issues, freshness, flavour, and nutrients it contains were the most important as well as those that consumers were more satisfied with. On the other hand, the least important attributes

were related to the influence of family or close friends eating the products, the availability the 365 days of the year and the inconvenience of the bones.

The outcome of the Importance and Satisfaction analysis showed that all the important aspects had also a high satisfaction level, which does not indicate critical issues to address with greater priority. However, in some cases the magnitudes of the values for the satisfaction and importance perceptions differed, indicating that measures should be adopted for improvements, such as for the case of the hygiene and food safety attributes.

a.2.2 Understanding the producers' segment for FAPs

- *Risk attitudes in European Aquaculture companies*

It was found that aquaculture in Europe is a risky business for companies. The study also found that European aquaculture companies consider themselves to avoid more risks than other farmers. In addition, both full cycle and grow-out companies agreed that they are willing to take risks when they believe that they are profitable and are prepared to take more risks in marketing than in other areas. Overall, full-cycle companies are more willing to take risks than grow-out companies.

- *Risk sources and risk management practices in European Aquaculture companies*

It was found different ratings of risk sources according to the type of aquaculture company. Although the order of preferences for risk types are similar, with the risk of diseases being the most relevant for both companies, there are still differences, especially in the magnitudes of values, which show, for instance, higher values for grow-out companies. In addition, while grow-out companies give higher priority to market and financial risks, full-cycle companies give higher priority to environmental risks.

It was also found evidence that the rating of risk management practices differs based on the type of aquaculture company. For example, while the prevention of diseases and escapes were the most important management practice for full-cycle companies, it was only the sixth most important for grow-out companies. Moreover, for grow-out companies, the most highly rated risk management practice was managing well the water environment/regular checking of quality of supply water and, while full-cycle companies assigned a similar value in average, it was only the fourth-ranked in terms of its importance.

- *Assessing the main risk sources using Simons' levers of control framework*

It was established a strategy to manage the main risks identified using the Simons' LOC framework for each company type. Results indicate that Market and financial risks for full-cycle companies should be mitigated or avoided using diagnostic, boundary, and beliefs controls, while disease risks should be avoided using boundary controls. Likewise, operational and environmental risks should be transferred to third parties while organisational, social and political risks should be accepted and monitored by interactive control systems. On the other hand, for grow-out companies, most risks should be avoided by either using beliefs or boundary controls, except for the risks of losing key workers, which should be mitigated by diagnostic

controls, or the risk of future fish demand which should be transferred, or social and political risks that should be monitored by interactive control systems.

a.2.3 Understanding the interaction between consumers and producers' segments of FAPs

As described before, the analysis of the labelling preferences of stakeholders and consumers leads to an understanding of the interaction between consumers and producers. In the following subsection, the main findings on the labelling preferences are described.

- *Preferences of consumers for the label's mandatory information of fishery and aquaculture products in the EU28*

The findings are more unquestionable in the least priority criterion "the fishing gear (e.g., longline, trawls) used to fish the product". In the upper section of the priority criteria, the results are less conclusive, but it can be established that more important criteria are "the name of the product and the species" and "the "use by/best before date". Moreover, the preference relations for the mandatory information for FAPs in EU28 according to the age group seem to be statistically the same.

The principle of subsidiarity could have been implemented in the first scenario, because the results indicate that not all countries of the EU are uniform, especially Italy. However, the results of the second scenario are not so extreme, thus the EU's subsidiarity principle is probably not required. Given this, the main outcome that can be extracted from the results is that it might be necessary to evaluate ex-ante the future mandatory information scale to find out whether some countries show several differences so the regulation can be adapted specifically for these cases throughout the application of the principle of subsidiarity.

- *A hypothetical EU ecolabel for FAPs including other issues apart from environmental information*

The analysis shows that the EU Ecolabel should include not only environmental but other information, such as social and ethical issues which is the most relevant, followed by animal welfare issues, health and safety, and food quality issues. Nearly all the segments of analysis ranked the issues in the same order, excluding producers to whom information on health and safety and food quality issues are more important than social and ethical issues and animal welfare issues. The results also show that producers and stakeholders who are more interventionists and support the fact that public bodies and government should be involved in the control of eco-labelling, are more in accordance to include additional information aside from environmental issues. The results indicate that the synthetic indicator is largely inelastic for all issues and segments analysed, except for eco-label owners and social-ethical issues.

a.2.4 Methodological findings

- *BWS vs Likert scale*

The magnitude of the importance and satisfaction values in the Likert scale task were greater than the BWS task, suggesting that the importance and satisfaction of products could be overestimated in the Likert scale. Meanwhile, the BWS forced consumers to select the best and worst options in each scenario, which prevented consumers from identifying each item as very important and highly satisfactory. Thus, it can be concluded that the BWS is more reliable and precise.

a.3 Managerial and Policy implications

In this subsection, different managerial and policy implications are discussed based on the previous results. The policies are ordered from the most global to the more specific, rather than by the order of the previous chapters.

a.3.1 Policies directed to improve the aquaculture market and industry in Europe

- *Authorities and stakeholders should invest in marketing campaigns that contribute to changing the current negative image of aquaculture products.*

Regarding the difference between farm and wild products, consumers who prefer wild-caught products have an increased probability of 10.8% to eat them at home at least once a week. This finding shows a handicap that aquaculture producers and authorities must correct by drawing up plans that can alter the current negative image of aquaculture products (Bronnmann and Hoffmann, 2018). Indeed, several studies show that consumers describe farmed fish as less healthy and with less quality than wild fish (Claret et al., 2014; Verbeke et al., 2007b).

Likewise, the study found that those who prefer wild-caught products are more likely to consume FAPs away from home. Indirect information on the harvest method (wild or farmed) may be gathered by consumers when eating at restaurants in proximity to the water (such as the beach or river), where they would wild-caught products. This finding reaffirms that aquaculture producers, authorities and promoters should continue to work on plans to change the negative image of aquaculture products.

- *Government and aquaculture institutions should increase efforts in finding strategies to avoid the risk of diseases, the most relevant of the aquaculture industry.*
- *Aquaculture companies should be able to anticipate how to respond to large price fluctuations by using methodologies such as simulations and discrete choice models based on collected data. The results should allow them to define strategies in the face of changing market conditions.*

Market risks were identified as one of the most important types of risk. The corporate financial departments of large-scale farmers need to address this type of risk developing simulations and discrete choice models based on collected data. Thus, they will be able to anticipate how to respond to large price fluctuations in the face of changing market conditions.

- *The LOC framework (Simons, 1994) can be used to assist managers in the risk management assessment of the company.*

a.3.2 Policies directed to improve the labelling schemes of FAPs

- *The "name of the product and species" and the "best before date" should be highlighted amongst the rest of the mandatory information accompanying FAPs.*

The findings show that " the name of the product and the species" " and "best before date" are the most important criteria amongst the mandatory information accompanying FAPs for European residents, meaning that this information should be highlighted over the rest in the packages of the products.

- *More efforts should be put by authorities to make consumers about the fishing gear in fisheries products.*

Most probably due to the lack of understanding of consumers regarding the environmental impacts of the fishing gear (e.g., longlines, trawls, etc.) used to catch the product, it was selected as the least priority criterion amongst the mandatory information accompanying FAPs, although it is well known that in reality, the fishing gear is very important considering that many of them are nonselective, causing bycatch of weak stocks. This finding suggests that it is important to educate consumers about production aspects, as consumers value as important animal-friendly labels, but show a lack of knowledge on how some fishing gears could cause problems such as bycatch. As a result, more information on the different fishing gears and their environmental effects should be provided to consumers through marketing campaigns or labels attached to the products. Also, further research and knowledge transfer to society might be important to grow consumers' awareness of the environmental impacts that might be caused by the fishing gears.

- *It might be necessary to evaluate ex-ante the future mandatory information scale to find out whether some countries show several differences so the regulation can be adapted specifically for these cases throughout the application of the principle of subsidiarity.*

The results indicate that in both scenarios evaluated with the fuzzy preference relations, the preferences for the mandatory information accompanying FAPs were different for Italian and French consumers in comparison to the rest of the EU. Italy can be regarded as the most extreme case in the first scenario. The most important criterion, for Italian residents, is to find out whether the product was previously frozen, which was only the fourth criterion in rank for Europeans. The second scenario, on the other hand, did not have a different result for Italy, so the principle of subsidiarity of the EU may not be required. Given this, the main outcome from previous findings may be that the future mandatory information scale may need to be evaluated ex-ante to see if several countries show some differences so that the regulation can be adjusted specifically for these cases using the subsidiarity principle. If the future scale has more attributes, then the country-level differences can be larger than those observed with only six attributes in the current analysis.

- *The union-wide EU ecolabel for FAPs should include other issues apart from environmental information in the following order of importance: social and ethical issues, animal welfare issues, health and safety issues, and food quality issues.*
- *Eco-label promoters of the union-wide EU ecolabel for FAPs should make efforts in convincing eco-label owners about the benefits of including social and ethical issues in the ecolabel.*

Given that the SI of ecolabel owners was found to be elastic on social and ethical issues were detected, ecolabel promoters should persuade ecolabel owners about the benefits of including these issues in the ecolabel, considering that it would increase the acceptance of include additional information that is different from environmental issues.

- *Proponents of the eco-label must analyse why producers had a different ranking of the issues in comparison to the total sample, to propose actions and strategies that might not lead producers to lose interest in the union-wide eco-label for FAPs.*

It has been found that the only group that showed a different ranking of the issues were the producers, whose elasticity values showed higher importance for health and safety issues as well as food quality issues. This indicates that there is a significant difference between the preferences of others and the producers, which might reduce producers' interests in the ecolabel, in case of ecolabel promoters decide to put more importance on the preferences of the majority of stakeholders. Given this, further analysis is needed as there must be more consensus before a formal regulation on the ecolabel can be established.

a.3.3 Policies directed to improve FAPs' market and presentation in Europe according to consumers' preferences

- *Making clearer the information accompanying FAPs might increase their consumption at home.*

The results showed that consumers who do not understand at all the information accompanying the products are less likely than average consumers to eat FAPs at least once a week (around 20% less likely). Consequently, an appropriate policy that can increase the consumption of these products in the EU28 is to simply provide more clearly and easily understandable information, especially considering that around 3% of the respondents surveyed mentioned that the information accompanying the FAPs was not entirely clear or easy to understand (European Union, 2018).

- *Highlighting the healthiness, fair cost, tastiness and digestibility of FAPs might increase the possibility of a higher frequency of consumption of FAPs at home.*

Consumers were found to be more likely to eat FAPs at least once a week if they consider that major causes of buying FAPs are their healthiness, fair cost and good taste (between 17% to 20% more probability to consume the products). Similarly, there is a higher probability of consumption at least once a week at the home of around 11%, for consumers that considered that FAPs are easy to digest. The stakeholders, mainly retailers, manufacturers, and policymakers, can use these findings to enhance EU consumption of FAPs, by highlighting the previous features of the products.

- *Quick and easy to prepare FAPs might be a suitable alternative to increase their consumption at home.*

Results show that the probability of consuming FAPs at least once a week is increased by at least 11% if a product is easy or quick to prepare. For that reason, ready-to-cook FAPs can be seen as a suitable strategy to promote their consumption in the EU28 (Husein et al., 2020). The retailers and food industry should offer easy and quick to prepare products, since this strategy, compared to other food products, currently is not so common on the market.

- *The improvement of the appearance of the products as well as the provision of clearer information regarding the origin, quality labels, and environmental, social, and ethical impacts, might increase the frequency of consumption of FAPs at home*

There is an increase in the likelihood of consuming FAPs at home at least once a week for consumers who consider that one of the main reasons to buy or eat them is because their low fat (9.0%), freshness and presentation (7.0%), brand and labelling (4.6%), origin (4.6%) and environmental, social, or ethical impacts (4.4%). It is significant to mention that if it meets Art. 39 of 1379/2013 EU regulation, information on product quality, environmental, social, and ethical impacts can be added as voluntary labels.

- *The industry of FAPs must provide attractive products for younger generations to increase their consumption at home.*

Product differentiation, online purchases, and ready-to-eat or ready-to-cook FAPs might increase young people's interest in FAPS products and improve their lower home consumption rate in comparison to older generations.

a.3.4 Policies directed to increase the away-from-home consumption of FAPs in Europe according to consumers' preferences

- *Stakeholders should look for strategies to attract older customers.*

Customers aged over 75 were less likely to consume FAPs away from home more frequently. This may be because of the preference and availability of more time to cook their own meals because this group usually doesn't work. It may also relate to dietary restrictions which make it hard to find suitable products to be eaten away from home. In this regard, it is possible to implement a marketing strategy to emphasize the benefits that FAPs can offer in the nutrition and health aspects.

- *Providing more healthy recipes with FAPs might be a good option for increasing the frequency of consumption of FAPs at home.*

The health and nutritional benefits of FAPs play a major role for consumers. The frequency of FAPs being eaten or purchased away from home increases if consumers consider that they can be easily digested, healthy or low-fat products. This is not unexpected given that seafood products are recognized as healthy and nutritious for benefits like high omega 3 content and low-fat content (Birch and Lawley, 2012; Verbeke et al., 2007d). Vitamins A and D3, digestible proteins and minerals such as iodine and selenium are other important nutrients found in FAPs (Ramalho Ribeiro et al., 2019). The emphasis on these benefits and additional options for healthier dishes could be a good way for restaurants to increase their customers base and sales.

a.3.5 Policies directed to improve the seabass and seabream products' market and industry in Gran Canaria

- *The aquaculture industry producing seabream and seabass products should look for strategies to increase the hygiene and food safety of the products to increase the satisfaction of consumers and as a result, be able to increase customers' WTP and frequency of consumption.*

The findings reveal a relatively lower level of satisfaction with the attribute of the "hygiene and food safety of the product" in comparison with its assigned importance given. Based on this,

strategic plans for improving customer satisfaction with the health and safety of these products are very important, in particular, because other investigations have shown that consumers are willing to pay premiums for claims that improve the products' safety (Fernández-Polanco et al., 2013; Fonner and Sylvia, 2015). The Seabream and seabass industry can take the salmon industry as an example, where stakeholders have incorporated new safety methods in the various phases of production, processing, distribution, wholesale, and retail sales in order to satisfy the increased demand for safe farmed Atlantic salmon (Haghiri, 2011). A study also found that for safety reasons and despite the increasing cost of the product, consumers agreed on the idea of using traceability methods and quality control systems in the salmon industry (Haghiri, 2014), consistent with another study that showed that the product safety is generally more important than the price for those with a higher frequency of consumption, thus, promotional activities emphasizing on fish safety can play a significant role in increasing fish consumption (Lee and Nam, 2019).

- *Stakeholders and authorities should invest in marketing campaigns that focus on highlighting the health benefits of seabream and seabass consumption.*

The findings of the study indicate that one of the most important attributes concerned the healthiness. In this context, fish and seafood products are usually considered to be healthy, because of health and nutritional benefits such as high omega-3, proteins, and low-fat content. Health benefits have a positive impact on the behaviour of fish consumption due to nutritional values and lower risk of disease (Arsil et al., 2019). In this context, marketing campaigns should focus on highlighting the health benefits of the consumption of fish, especially considering that multiple studies have shown that consumers are willing to pay premiums for products that highlight health benefits, such as heart function improvement (Banovic et al., 2019; Lim et al., 2018) and brain function (Banovic et al., 2019).

- *Producers are encouraged to invest in products with fortified nutrients.*

The findings of the study indicate that one of the most important attributes concerned the nutrients of the products. In this context, another study found that the nutritional value of fish products is a significant driver of their consumption (Olsen, 2004). The nutrients found in fish include digestible proteins, vitamins A and D3, trace minerals such as iodine and selenium and n-3 long-chain polyunsaturated fatty acids (Ramalho Ribeiro et al., 2019). A study has shown that consumers are willing to pay premiums for fortified products with beneficial and healthy compounds (Ramalho Ribeiro et al., 2019); thus, producers and sellers are encouraged to invest in such products.

- *Stakeholders and authorities should invest in marketing campaigns that highlight different novel recipes to cook seafood as an alternative to increase the satisfaction of consumers for the flavour of seabream and seabass products.*

The findings of the study indicate that one of the most important attributes concerned the flavour of the products, however, the satisfaction was not found to be at the same level with the importance assigned. A strategy to increase satisfaction with the flavour of the product can be found in marketing campaigns that highlight various recipes that could make seafood more pleasant in terms of flavour for certain segments of the market.

- *Stakeholders and authorities should invest in marketing campaigns that guide consumers on how to evaluate the freshness of fish products to increase the satisfaction of consumers of seabream and seabass products.*

The results of the study indicate that one of the most important attributes is related to the freshness of the products. In this context, numerous studies have shown that fresh products have an overall preference and greater willingness to pay for than other presentations (Ankamah-Yeboah et al., 2019, 2018; Bronnmann and Asche, 2017; Bronnmann and Hoffmann, 2018; Darko et al., 2016; Davidson et al., 2012). This preference for fresh products requires efforts to optimize the supply chain, to make sure that fresh products are placed on the market (Cantillo et al., 2020a). However, not being able to assess whether or not fish are fresh can be a limitation to the consumption (Birch and Lawley, 2012); so, marketing campaigns should offer consumers a guide on the assessment of products' freshness.

b Main concluding remarks

b.1 Elements validated (theories and hypothesis)

Table C.1 includes the outcomes obtained from all the presented hypotheses.

Table C.1. Results of the hypotheses

Hypothesis	Result	Main outcome	Comments supporting the outcome
H1a	Accepted	There are differences in the frequency of consumption at home of FAPs according to demographic factors such as the country of residence, age, household size and place of living.	• The marginal effects indicate that the highest consumption of FAPs at home is related to Spain, while the lowest is related to Hungary. • The older generations of residents, especially those over 55 years old, are more eager to consume FAPs more frequently at home, as well as those living together with other people and in areas such as towns/suburbs in small urban areas.
H1b	Accepted	There are differences in the frequency of consumption at home of FAPs according to economic factors such as the class of society and the economic difficulties.	• There are higher consumption rates for consumers who are part of higher social classes. • Those who rarely or never had difficulties paying their bills have a higher frequency of consumption of FAPs at home.
H1c	Accepted	There are differences in the frequency of consumption at home of FAPs according to attitudes towards the characteristics of the product such as the main reasons or aspects for consuming/buying them and the preference for wild-caught or farmed products.	• The highest positive impact on the frequency of consumption is related to considering that fish products are healthy, while other less important but also significant attitudes are related to consider the products as less expensive than other foods, tasty, easy to digest, and quick and easy to prepare. In addition, less important factors are related to the product's appearance, brand or quality labels, origin, and environmental, social or ethical impacts. • Consumers who have a clear preference for wild products are more eager to consume FAPs at home more frequently.
H1d	Accepted	There are differences in the frequency of consumption at home of FAPs according to psychological factors related to living conditions and satisfaction.	Consumers who are not satisfied with their lives or to are not optimistic about future life conditions expectations are less likely to consume FAPs at home.
H1e	Accepted	There are differences in the frequency of consumption at home of FAPs according to the easiness to understand the information accompanying the products.	The most negative impact on the consumption of the products at home is related to not understanding at all the information accompanying the products.
H2a	Accepted	There are differences in the frequency of consumption away-from-home of FAPs according to sociodemographic factors such as the country of residence, age, household size and place of living.	• There is a higher frequency of consumption away-from-home at least once a week for British and Spaniards, and at least once a month for Portuguese and Belgians, in the EU28 context. • Consumers between 25 and 54 years of age, who live in smaller households not located in rural areas are more likely to consume FAPs away-from-home.

Hypothesis	Result	Main outcome	Comments supporting the outcome
H2b	Accepted	There are differences in the frequency of consumption away-from-home of FAPs according to economic factors such as the class of society and the economic difficulties.	Consumers belonging to the higher class of society and who have fewer financial difficulties are more likely to consume FAPs away-from-home.
H2c	Accepted	There are differences in the frequency of consumption away-from-home of FAPs according to the preferences on the main reasons for buying or eating them, the preference for wild-caught or farmed products and the origin of the product (local or not and from the sea or not).	• Certain attitudes that increase the frequency of consumption of FAPs are to consider important the following reasons to buy or eat them: less expensive than other foods, easy to digest, healthy, tasty, low-fat and for special occasions. • Consumers who prefer wild, local and marine products consume FAPs away-from-home more frequently.
H2d	Accepted	There are differences in the frequency of consumption away-from-home of FAPs according to psychological factors related to living conditions and satisfaction.	Consumers who are more satisfied with life and optimistic about future living conditions have a higher probability to consume FAPs more frequently away-from-home.
H3a	Partially accepted	There are differences only in the magnitudes of the measurement of attitudes towards the purchase of seabream and seabass in Gran Canaria by consumers according to their valuation of the level of importance and satisfaction. The differences are not observed in the rankings.	The results indicate that the most important attributes were also ranked as those which satisfy consumers the most. However, the magnitude of the importance and satisfaction results differed.
H3b	Accepted	The results obtained from the best-worse scaling (BWS) methods are more robust than those obtained with the traditional widely-used Likert-scale responses.	The results suggest that, in the Likert-scale task, respondents might be overstating the importance and satisfaction of the attributes; while in the BWS, consumers were forced to evaluate a trade-off in the selection of the best and worst attributes in each scenario, so the task impeded in principle to define every attribute as very important and providing a high satisfaction.
H4a	Accepted	Risks sources are rated differently according to the type of aquaculture company.	While there are similarities in the order of preferences for the types of risks, with diseases risks representing the most important risk-type for both types of companies, there are still differences, particularly in the magnitudes of the values, indicating for example that grow-out companies rated the level of risk of all the different types of risks higher. Moreover, while grow-out companies prioritize higher market and financial risks, full-cycle companies prioritize higher environmental risks.
H4b	Accepted	Risks management strategies are rated differently according to the type of aquaculture company.	While preventing diseases and escapes was the most important risk management strategy for full-cycle companies, it was only the sixth most important choice for grow-out companies. This distinction can also be seen

Hypothesis	Result	Main outcome	Comments supporting the outcome
			in the average rating given by each type of company. Furthermore, the highest-rated risk management strategy for grow-out companies was managing well the water environment/regular checking of quality of supply water, and while full-cycle companies received a similar value in terms of average score, it was only ranked fourth in terms of importance for these companies.
H4c	Accepted	There are differences in the attitudes towards risks according to the type of aquaculture company.	Full-cycle companies were more willing to take risks than grow-out companies.
H5	Accepted	The levers of control framework are an appropriate tool to assist aquaculture managers in risk management assessment.	A strategy has been established to manage the main risks identified using the Simons' LOC framework for each company type. Market and financial risks for full-cycle companies should be mitigated or avoided using diagnostic, boundary, and beliefs controls, while disease risks should be avoided using boundary controls. Also, operational and environmental risks should be transferred to third parties while organisational, social and political risks should be accepted and monitored by interactive control systems. On the other hand, for grow-out companies, most risks should be avoided by either using beliefs or boundary controls, except for some particular risks.
H6a	Accepted	The preferences for the mandatory information of FAPs differ according to the scenario used to obtain the decision matrices following the application of a fuzzy preference relations method.	In particular, Italy can be considered the most extreme case regarding the differences observed in the first scenario. For Italian residents, the most important criterion is to have information about whether the product was previously frozen –the fourth criterion at the European level. On the other hand, the second scenario does not show so extremely different results for Italy.
H6b	Partially accepted	The preferences for the mandatory information of FAPs differs according to the country of residence of the consumers, but only for the first scenario.	For the first scenario, there are 9 countries for which the preferences are different: France, the Netherlands, Italy, Luxembourg, Ireland, Greece, Portugal, Cyprus and Malta. However, it is also remarkable that for 14 country segments, the respective preference rankings coincide exactly with the ranking of the EU28. Moreover, in the second scenario, the differences are almost negligible as only two countries present a significantly different pattern than the EU (France and Italy). Interestingly now, there are only 9 country segments with the same ranking preference order as the EU28.
H6c	Not enough evidence to accept the hypothesis	The preferences for the mandatory information of FAPs seems to be statistically the same according to the age of the consumers.	The preference relations for the mandatory information for FAPs in EU28 according to the age group seem to be statistically the same.

Hypothesis	Result	Main outcome	Comments supporting the outcome
H7a	Accepted	Stakeholders welcome the idea of a hypothetical EU ecolabel for FAPs that includes different types of information apart from environmental issues.	The majority of all the analysed segments consider that FAPs ecolabels in the EU should not only include environmental issues, but also other types of information, in which, social and ethical issues are the most relevant, followed in order by animal welfare, health-and-safety and food-quality issues.
H7b	Partially accepted	There are differences in the preferences for different types of information apart from environmental issues in a hypothetical EU ecolabel for FAPs for producers in comparison to the other stakeholders.	Almost all the segments of analysis ranked equally the issues with the exception of producers, who find more important information on health-and-safety and food-quality issues.
H7c	Accepted	There are differences in the preferences for different types of information apart from environmental issues in a hypothetical EU ecolabel for FAPs according to the preference of stakeholders for the governmental intervention in the control of ecolabelling.	Citizens who support the control of eco-labels by public bodies or governments, have a higher level of acceptance to include other additional information apart from environmental issues

b.2 Future research

b.2.1 Future Research on consumers' segment for FAPs

- *Consumption at home and away-from-home of FAPs*

One of the principal findings of the research analysing the determinants for the frequency of at-home consumption of FAPs was that the main negative marginal effect corresponds to a lack of understanding of the information accompanying the products. Regarding this, further analysis is needed to confirm whether this result is because the mandatory information provided is not being read, rather than not being understood properly. For instance, some consumers may never read the labels because they consider to already have good knowledge of FAPs or because they prefer to listen to the opinions of local fishmongers. Further studies are therefore required to understand how to provide the information more attractively, more clearly and easily.

In addition, the study analysing the determinants of at-home consumption revealed that the attitude towards the importance of the cost as one of the main reasons for buying the products was not significant. As a result, producers should risk looking for better quality products, which, even with higher costs, might be more attractive for some consumers. However, to understand the market viability and the population interested in these new products, further research is required to estimate the consumers' willingness to pay for them.

Future studies analysing FAPs' consumption determinants for both home and away-from-home consumption should focus on similar analyses for specific species to get accurate results for them, particularly, for those species that are important for away-from-home consumption, in

which the literature is more limited. Furthermore, it may be relevant for future research on the determinants of FAPs away from home consumption to consider the interviewee's spatial location to see if poor FAPs' away home consumption could be caused by the lack of specialized seafood restaurants in the area, rather than to consumers' preferences.

Furthermore, the results revealed that higher-income consumers have a higher frequency of away from home consumption of FAPs, but this might be simply the result of their higher presence in restaurants, regardless of the product they consume. In consequence, future studies should be able to compare the real propensity of higher earners to choose fish in restaurants rather than other food products. Although some research has shown that wealthy consumers are more likely to eat fish than meat products (Cavaliere et al., 2019; Islam et al., 2018), the outcomes cannot be generalized for the away-from-home consumption.

- *Attitudes towards the consumption of seabream and seabass products in Gran Canaria*

One of the major considerations for future research of the study assessing the consumption behaviour towards seabream and seabass products in Gran Canaria is to extend the sample to more population segments in Gran Canaria and more regions in the EU and the world. In addition, future research should set up separate analyses for farmed and wild products, as consumer safety attributes could be evaluated differently according to the harvest method. The reliability of the results from the relationship between importance and satisfaction for the various attributes should also be evaluated in further investigations since some attributes for respondents may be of little importance once the satisfaction level has been reached. An example of this situation is found in the automobile sector of some countries where safety is becoming less important since every vehicle sold must meet the minimum safety standards and are consequently considered safe (Beck and Rose, 2016). Some of the attributes listed in this study could lead to a similar situation.

Moreover, the study could be further extended to analyse specific product formats, selling establishments or even consumer characteristics that could determine market segmentation. The model could be enriched by new covariates with adequate data, which will provide stakeholders with greater insight.

b.2.2 Future Research on producers' segment for FAPs

Considering the studies evaluating risk preferences and assessment by European companies in aquaculture, future research should focus on finding relations between risk perceptions and companies' characteristics, using better statistical models such as regressions. Furthermore, by focusing on a specific case study, a more precise approach to applying the LOC framework for risk management in an aquaculture company can be obtained.

b.2.3 Future research on labelling for FAPs

- *Preferences of consumers for the label's mandatory information of fishery and aquaculture products in the EU28*

As regards the labelling preferences results, future research should assess the future mandatory information scale ex-ante to find out if some countries have differences in those preferences and, throughout the implementation of the subsidiarity principle, the regulation can be modified exclusively to those situations.

- *A hypothetical EU ecolabel for FAPs including other issues apart from environmental information*

The outcomes of this investigation are based on a public European Union consultation, in which the participants expressed many concerns about the EU ecolabel proposal that should be addressed in future investigations to ensure the overall success of the future EU ecolabel for FAPs. One of the concerns is with the word 'ecolabel', because according to Regulation 834/2007, in some member states the 'eco' abbreviation is associated with food products linked to organic production (European Parliament, 2007). Another concern outlined is the need to develop independent EU ecolabels for each FAPs' species. The most important concern in the public consultation is that there are already many eco-labels on the market and many citizens have indicated that they see no advantages in adding another because it would create even more confusion to the consumer. They therefore strongly suggest improving the existing regulations on the current eco-labelling schemes. On the other hand, curiously, other citizens indicated that adding a label that contains EU standards can help consumers reduce confusion and reduce the lack of credibility of current existing eco-labels on the market. It is important to clarify here that the idea of the lack of credibility of ecolabels appeared in the comments section of the public consultation made by the European Union, which was pointed out by several consumers who answered the questionnaire.

b.2.4 Methodological improvements for future research

One of the limitations of the studies analysing the determinants of FAPs at home and away-from-home consumption is that the models used do not account for unobserved heterogeneity. To improve the feasibility of the results, unobserved heterogeneity could be considered, for example, by using the zero-inflated ordered probit model with its two-steps structure of a binary probit component and an ordered probit component could be proposed to analyse the two underlying states (no fish consumption vs. fish consumption). Furthermore, the systematic variation can also be analysed with subsamples of consumers (grouped effects). the effects of countries or other systematic geographical effects are likely to occur because consumers can share some cultural background regarding fish consumption. In this context, a grouped latent class ordered probit model with class-probability functions can be used to examine determinants affecting fish home consumption in the EU.

Also, another limitation of the studies analysing the determinants of FAPs at home and away-from-home is that they are based on a survey that is not specific to the consumption of seafood at-home and away-from-home, respectively, but the consumption of seafood in general. Furthermore, another limitation is that the attitudes measured in the survey describe only positive characteristics of fish, so those who eat fish are likely to find FAPs more positively. Therefore, the results of these investigations are restricted to the available data, which is a good

base but needs improvements for more meaningful and precise results. The design of specific surveys should be considered for further research, where respondents are advised that all the issues addressed fall within the context of at-home or away-from-home consumption, depending on the context.

To conclude, a discrete choice experiment could be used in further studies to analyse a hypothetical EU ecolabel for FAPs. This way, it will be possible to evaluate simultaneously different scenarios with various types of issues, minimizing the risk of overrating the importance of some of the issues presented.

Resumen en español

El consumo mundial de pescado ha aumentado notablemente en los últimos 60 años, pasando de 9 kg/habitante en 1961 a 20.5 kg/habitante en 2018, lo que supone más del doble del crecimiento medio anual de la población en el mismo periodo (FAO, 2020a). El aumento de los patrones de consumo puede atribuirse a varios factores, de los cuales el más notable es el aumento significativo de la producción acuícola. Durante los últimos 40 años, la productividad anual de la acuicultura ha aumentado de unos 10 millones a 82 millones de toneladas, mientras que la producción pesquera se ha mantenido estable en torno a los 87 millones a 96 millones de toneladas (FAO, 2020a). De hecho, la acuicultura se considera la tecnología de producción de alimentos de más rápido crecimiento y ha superado a la industria pesquera como fuente de alimentos marinos (Bronnmann and Asche, 2017). No obstante, la acuicultura moderna es uno de los negocios más arriesgados para aventurarse como empresario, acuicultor o inversor (Asche et al., 2008).

Según la FAO (2020a), la producción mundial de pescado en 2018 fue de unos 179 millones de toneladas, de las cuales la acuicultura representó 82 millones de toneladas. En cuanto a las regiones, la Unión Europea (UE) es el mayor mercado mundial en términos nominales de productos de la pesca y la acuicultura, lo cual no es sorprendente debido a los beneficios del consumo de pescado, que no solo es una fuente de proteínas y grasas saludables, sino también una fuente excepcional de nutrientes, ácidos grasos, yodo, vitamina D y calcio (FAO, 2020b). Teniendo en cuenta lo anterior, un mejor conocimiento del mercado interior de los productos de la pesca y la acuicultura permitirá a los interesados, a partir de la demanda de los consumidores, mejorar su competitividad y adoptar o modificar sus estrategias actuales para fortalecer y ampliar el mercado interior, promoviendo así la creación de empleo (European Union, 2018a).

Dada la importancia de los productos de la pesca y la acuicultura, el presente estudio tiene como objetivo: (1) analizar los principales determinantes que explican la frecuencia de consumo de los productos de la pesca y la acuicultura por parte de los residentes europeos en el hogar y fuera de él (Capítulo I - Apartados 1 y 2); (2) medir el nivel de importancia y satisfacción de ciertas actitudes de los consumidores hacia la compra de dorada y lubina en Gran Canaria - España- (Capítulo I - Apartado 3); (3) Comprender las ideas clave sobre las actitudes de riesgo de las empresas acuícolas, identificar las fuentes de riesgo y las estrategias de gestión del riesgo más significativas, y determinar si la gestión del riesgo y las preferencias de riesgo difieren entre las empresas acuícolas de ciclo completo y las de engorde (Capítulo II - Sección 4); (4) Determinar cómo los gestores de las empresas acuícolas pueden evaluar las fuentes de riesgo más importantes utilizando el marco de las palancas de control de Simons (capítulo II - sección 5); (5) analizar la escala relacionada con la información obligatoria del etiquetado de las productos de la pesca y la acuicultura propuesta por el reglamento de la UE 1379/2013 (capítulo III - sección 6); y (6) comprender la aceptación de diferentes segmentos de una hipotética etiqueta ecológica de la UE que incluya otra información además de las cuestiones medioambientales -bienestar animal, salud y seguridad, calidad de los alimentos y cuestiones ético-sociales- (capítulo III - sección 7).

En cuanto a los determinantes, las preferencias y las actitudes de los consumidores hacia el consumo de productos de la pesca y la acuicultura (capítulo I), se identificaron los principales determinantes de la frecuencia de consumo de estos productos casa y fuera de ella mediante modelos probit ordenados. Los resultados para el consumo en casa (Capítulo I - Sección 1) muestran que la mayor probabilidad de consumir con más frecuencia estos productos está asociada a los consumidores que creen que una de las principales razones para comprarlos o comerlos es que son saludables, mientras que la mayor probabilidad de consumirlos con menos frecuencia está relacionada con los consumidores que no entienden ninguna de las informaciones que acompañan a los productos. Asimismo, el buen sabor y el bajo precio relativo de estos productos son razones importantes para aumentar su consumo. Además, los resultados muestran que los consumidores de más de 55 años, con buen poder adquisitivo, que prefieren los productos silvestres, que viven en un hogar de tres o más personas y que están muy satisfechos con su vida consumen estos productos con mayor frecuencia. Por el contrario, en lo que respecta al consumo fuera de casa (capítulo I - sección 2), descubrimos que las personas de las clases altas de la sociedad son más propensas a consumir productos de la pesca y la acuicultura fuera de casa con mayor frecuencia. Además, las principales razones para consumir estos productos con más frecuencia fuera de casa son su bajo costo en comparación con otros alimentos, su buen sabor, y que son saludables y fáciles de digerir. Además, los consumidores británicos son más propensos que los de otras nacionalidades a consumir productos de la pesca y la acuicultura fuera de casa. También se observó que los consumidores de entre 25 y 54 años, que no viven en zonas rurales, que prefieren los productos silvestres, locales y marinos, y que están muy satisfechos con su vida, tienen una mayor frecuencia de consumo de estos productos fuera de casa.

Para entender mejor las actitudes de los consumidores hacia el consumo de productos de dorada y lubina en Gran Canaria (Capítulo I - Sección 3), se usaron dos metodologías (escalas tradicionales de Likert y escalas *Best-Worst*). Según los resultados, los atributos más importantes identificados fueron la higiene y seguridad del producto, los beneficios para la salud, la frescura, el sabor y los nutrientes. Al mismo tiempo, estos atributos fueron calificados como los más satisfactorios para los clientes. Además, observamos que la metodología *Best-Worst* produce resultados más consistentes y claros que los experimentos tradicionales con escala Likert.

En el capítulo II, que trata sobre la gestión de riesgos en las empresas acuícolas europeas, utilizamos un enfoque de métodos mixtos para examinar las percepciones de las empresas acuícolas europeas sobre las fuentes de riesgo y las prácticas de gestión de riesgos (capítulo II - sección 4). Los resultados muestran que las enfermedades son el tipo de riesgo más importante tanto para las empresas de ciclo completo como para las de engorde; sin embargo, siguen existiendo diferencias en las magnitudes y el orden de las calificaciones de los distintos tipos de riesgos entre los dos tipos de empresas. Del mismo modo, los resultados muestran que las calificaciones de las prácticas de gestión de riesgos difieren según el tipo de empresa. Los resultados también revelan que las empresas de ciclo completo están más dispuestas a asumir riesgos que las empresas de engorde, aunque ambos tipos de empresas perciben la acuicultura como un negocio arriesgado.

Utilizando las Palancas de Control de Simons (1995), se desarrolló un enfoque práctico dirigido a los directores de producción acuícola para mejorar su gestión de las fuentes de riesgo más significativas identificadas (Capítulo II - Sección 5). Los resultados indican que, en el caso de las empresas de ciclo completo, los riesgos de la variabilidad del precio del pescado y del precio de los piensos podrían mitigarse y evitarse, respectivamente, utilizando sistemas de control de creencias y de límites, mientras que el riesgo de que los alevines se infecten por enfermedades podría evitarse utilizando sistemas de control de límites. Por otro lado, en el caso de las empresas de engorde, los riesgos de fallo técnico, alta tasa de mortalidad por enfermedades, incapacidad para controlar las enfermedades de origen ambiental, mal tiempo y lesiones o problemas de salud entre los empleados podrían evitarse utilizando sistemas de control de límites, mientras que los riesgos de suministro suficiente de mano de obra competente y la variabilidad del precio del pescado podrían evitarse utilizando sistemas de control de creencias. Los riesgos restantes para ambos tipos de empresas deberían aceptarse y supervisarse mediante sistemas de control interactivos o transferirse a un tercero.

Se encontró que los controles de diagnóstico, los controles de límites y los controles de creencias pueden utilizarse para mitigar o evitar los riesgos financieros y de mercado de las empresas de ciclo completo, mientras que los controles de límites pueden utilizarse para evitar los riesgos de enfermedad. Del mismo modo, los riesgos organizativos, sociales y políticos pueden supervisarse mediante sistemas de control interactivos, y los riesgos operativos y medioambientales pueden transferirse a terceros a través de los seguros. A excepción de algunos casos concretos y de los riesgos sociales y políticos, que pueden supervisarse mediante sistemas de control interactivos, la mayoría de los riesgos de las empresas de engorde pueden evitarse utilizando los sistemas de creencias o los controles de límites.

En cuanto a las preferencias de etiquetado de los productos de la pesca y la acuicultura en la UE (capítulo III), se evaluaron dos cuestiones críticas (la interrelación de los criterios, así como la relación que existe a nivel de país) mediante un método basado en una Relación de Preferencia Difusa Consistente modificada que emplea el operador de la Media Geométrica de Bonferroni (capítulo III - sección 6). Los resultados indican que no todos los países de la Unión Europea son homogéneos, lo que implica que el principio de subsidiariedad puede haber sido aplicable.

Además, en la sección 7 del capítulo IIII se propone un método TOPSIS híbrido y difuso (FTOPSIS) para evaluar la cobertura de una hipotética etiqueta ecológica de la UE para los productos de la pesca y la acuicultura. Según los resultados, las ecoetiquetas deberían incluir no sólo cuestiones medioambientales, sino también otros tipos de información, siendo las cuestiones sociales y éticas las más importantes, seguidas de las cuestiones de bienestar animal, las de salud y seguridad y, por último, las de calidad de los alimentos. Los resultados también muestran que los consumidores, productores y partes interesadas que son más intervencionistas y creen que los organismos públicos y el gobierno deberían participar en el control del etiquetado ecológico, están más dispuestos a incluir información adicional a las cuestiones medioambientales.

Además, se propusieron varias implicaciones de gestión basadas en los resultados. En cuanto a las implicaciones dirigidas a mejorar el mercado de los productos de la pesca y la acuicultura en función de las preferencias de los consumidores, se descubrió que algunos aspectos que pueden aumentar el consumo de los productos de la pesca y la acuicultura en el hogar incluyen hacer más clara la información que los acompaña y hacer hincapié en su salubridad, coste justo, sabor y digestibilidad. Además, los productos de la pesca y la acuicultura rápidos y fáciles de preparar pueden ser una alternativa adecuada para aumentar el consumo en el hogar, así como mejorar la apariencia del producto. Por último, se descubrió que la industria de los productos de la pesca y la acuicultura debe ofrecer productos atractivos para las generaciones más jóvenes con el fin de aumentar su consumo en el hogar.

En cuanto a las implicaciones de los resultados para el consumo de productos de la pesca y la acuicultura fuera de casa en Europa, las pruebas empíricas mostraron que, para aumentarlo, las partes interesadas deberían buscar estrategias para atraer a los clientes de más edad y ofrecer recetas y platos más saludables.

En cuanto a las políticas destinadas a mejorar el mercado y la industria de la acuicultura en Europa, se constató que las autoridades y las partes interesadas deberían invertir en campañas de marketing para ayudar a cambiar la actual imagen negativa de los productos acuícolas. Del mismo modo, para mejorar la gestión de riesgos, el gobierno y las instituciones acuícolas deberían aumentar sus esfuerzos en el desarrollo de estrategias para reducir el riesgo de enfermedades, que son especialmente relevantes para la industria acuícola. Además, las empresas acuícolas deben ser capaces de anticipar cómo responder a grandes fluctuaciones de precios utilizando diversas metodologías basadas en simulación y modelos de elección discreta mediante recogida de datos. Los resultados permitirán que las empresas puedan definir estrategias ante las cambiantes condiciones del mercado. Además, el enfoque de las Palancas de Control de Simons (1994) pueden utilizarse para ayudar en la gestión de riesgos de las empresas.

Para el caso concreto de los productos de dorada y lubina en Gran Canaria, las industrias implicadas deberían buscar formas de mejorar la higiene y la seguridad alimentaria de los productos para aumentar la satisfacción de los consumidores y, en consecuencia, aumentar la disposición al pago y la frecuencia de consumo de los clientes. Del mismo modo, se anima a los productores a invertir en el desarrollo de productos enriquecidos con nutrientes. Además, las partes interesadas y las autoridades deberían invertir en campañas de marketing que destaquen los beneficios para la salud del consumo de dorada y lubina, en nuevas recetas para cocinar el marisco que realcen el sabor de los productos y en cómo evaluar la frescura de los productos.

En cuanto a los resultados de las preferencias de etiquetado para la información obligatoria que acompaña a los productos de la pesca y la acuicultura, encontramos que el "nombre del producto y la especie" y la "fecha de consumo preferente" deberían destacarse por encima de todo; mientras que las autoridades deberían hacer más esfuerzos para educar a los consumidores sobre la importancia del equipo de pescado en los productos pesqueros. Y lo que es más importante, puede ser necesario evaluar la futura escala de información obligatoria

ex-ante para determinar si algunos países presentan diferencias significativas, de modo que la normativa pueda adaptarse específicamente para estos casos a través del principio de subsidiariedad.

Para concluir, se encontró que, además de la información medioambiental, una etiqueta ecológica de la UE para los productos de la pesca y la acuicultura debería incluir, en el siguiente orden de importancia: cuestiones sociales y éticas, cuestiones de bienestar animal, cuestiones de salud y seguridad, y cuestiones de calidad alimentaria. Asimismo, los promotores de la etiqueta ecológica comunitaria para los productos de la pesca y la acuicultura deberían esforzarse por persuadir a los propietarios de la etiqueta ecológica, en particular, de las ventajas de incluir las cuestiones sociales y éticas en la etiqueta ecológica. Además, los promotores de la etiqueta ecológica deben investigar por qué los productores clasificaron las cuestiones de forma diferente a la muestra general para proponer acciones y estrategias que no hagan que los productores pierdan el interés por la etiqueta ecológica.

Résumé en français

La consommation mondiale de poisson a considérablement augmenté au cours des 60 dernières années, passant de 9 kg/habitant en 1961 à 20,5 kg/habitant en 2018, soit plus du double de la croissance démographique annuelle moyenne sur la même période (FAO, 2020a). L'augmentation des habitudes de consommation peut être attribuée à plusieurs facteurs, dont le plus notable est l'augmentation significative de la production aquacole. Au cours des 40 dernières années, la productivité annuelle de l'aquaculture est passée d'environ 10 millions de tonnes à 82 millions de tonnes, tandis que la production de poisson est restée stable, entre 87 et 96 millions de tonnes (FAO, 2020a). En fait, l'aquaculture est considérée comme la technologie de production alimentaire qui connaît la croissance la plus rapide et a dépassé l'industrie de la pêche comme source de fruits de mer (Bronnmann et Asche, 2017). Cependant, l'aquaculture moderne est l'une des activités les plus risquées dans laquelle s'aventurer en tant qu'entrepreneur, aquaculteur ou investisseur (Asche et al., 2008).

Selon la FAO (2020a), la production mondiale de poisson en 2018 était d'environ 179 millions de tonnes, dont 82 millions de tonnes pour l'aquaculture. En termes de régions, l'Union européenne (UE) est le plus grand marché mondial en termes nominaux pour les produits de la pêche et de l'aquaculture, ce qui n'est pas surprenant en raison des avantages de la consommation de poisson, qui est non seulement une source de protéines et de graisses saines, mais aussi une source exceptionnelle de nutriments, d'acides gras, d'iode, de vitamine D et de calcium (FAO, 2020b). Compte tenu de ce qui précède, une meilleure compréhension du marché intérieur des produits de la pêche et de l'aquaculture permettra aux parties prenantes, sur la base de la demande des consommateurs, d'améliorer leur compétitivité et d'adopter ou de modifier leurs stratégies actuelles pour renforcer et élargir le marché intérieur, favorisant ainsi la création d'emplois (Union européenne, 2018a).

Compte tenu de l'importance des produits de la pêche et de l'aquaculture, cette étude vise à : (1) analyser les principaux déterminants expliquant la fréquence de consommation des produits de la pêche et de l'aquaculture par les résidents européens à domicile et hors domicile (Chapitre I - Sections 1 et 2) ; (2) mesurer le niveau d'importance et de satisfaction de certaines attitudes des consommateurs à l'égard de l'achat de daurade et de bar à Gran Canaria - Espagne- (Chapitre I - Section 3) ; (3) Comprendre les éléments clés de l'attitude des entreprises aquacoles face au risque, identifier les sources de risque les plus importantes et les stratégies de gestion du risque, et déterminer si la gestion du risque et les préférences en matière de risque diffèrent entre les entreprises aquacoles à cycle complet et celles en phase de grossissement (chapitre II - section 4) ; (4) déterminer comment les gestionnaires d'entreprises aquacoles peuvent évaluer les sources de risque les plus importantes à l'aide du cadre des leviers de contrôle de Simons (chapitre II - section 5) ; (5) analyser l'échelle liée aux informations obligatoires sur l'étiquetage des produits de la pêche et de l'aquaculture proposées par le règlement de l'UE 1379/2013 (chapitre III - section 6) ; et (6) comprendre l'acceptabilité des différents segments d'un hypothétique label écologique de l'UE comprenant d'autres informations en plus des questions environnementales - bien-être animal, santé et sécurité, qualité des aliments et questions socio-éthiques - (chapitre III - section 7).

En ce qui concerne les déterminants, les préférences et les attitudes des consommateurs vis-à-vis de la consommation de produits de la pêche et de l'aquaculture (chapitre I), les principaux déterminants de la fréquence de consommation de ces produits à domicile et hors domicile ont été identifiés à l'aide de modèles probit ordonnés. Les résultats concernant la consommation à domicile (chapitre I - section 1) montrent que la plus forte probabilité de consommer ces produits plus fréquemment est associée aux consommateurs qui pensent que l'une des principales raisons d'acheter ou de manger ces produits est qu'ils sont sains, tandis que la plus forte probabilité de les consommer moins fréquemment est liée aux consommateurs qui ne comprennent aucune des informations accompagnant les produits. De plus, le bon goût et le prix relativement bas de ces produits sont des raisons importantes pour augmenter leur consommation. En outre, les résultats montrent que les consommateurs de plus de 55 ans, ayant un bon pouvoir d'achat, qui préfèrent les produits sauvages, qui vivent dans un ménage de trois personnes ou plus et qui sont très satisfaits de leur vie consomment plus fréquemment ces produits. En revanche, en ce qui concerne la consommation hors du foyer (chapitre I - section 2), il a été constaté que les personnes appartenant aux classes supérieures de la société sont plus susceptibles de consommer plus fréquemment des produits de la pêche et de l'aquaculture hors du foyer. En outre, les principales raisons pour lesquelles ces produits sont consommés plus fréquemment hors du domicile sont leur faible coût par rapport à d'autres aliments, leur bon goût et le fait qu'ils sont sains et faciles à digérer. En outre, les consommateurs britanniques sont plus susceptibles que les consommateurs d'autres nationalités de consommer des produits de la pêche et de l'aquaculture hors de chez eux. Il a également été constaté que les consommateurs âgés de 25 à 54 ans, qui ne vivent pas dans des zones rurales, qui préfèrent les produits sauvages, locaux et les fruits de mer, et qui sont très satisfaits de leur vie, sont plus susceptibles de consommer ces produits hors de chez eux.

Pour mieux comprendre les attitudes des consommateurs à l'égard de la consommation de produits à base de daurade et de bar à Gran Canaria (Chapitre I - Section 3), deux méthodologies ont été utilisées (échelles de Likert traditionnelles et échelles *Best-Worst*). D'après les résultats, les attributs les plus importants identifiés sont l'hygiène et la sécurité du produit, les avantages pour la santé, la fraîcheur, le goût et les nutriments. Dans le même temps, ces attributs ont été jugés comme étant les plus satisfaisants pour les clients. En outre, il a été observé que la méthodologie *Best-Worst* produit des résultats plus cohérents et plus clairs que les expériences traditionnelles sur l'échelle de Likert.

Dans le chapitre II, qui traite de la gestion des risques dans les entreprises aquacoles européennes, a été utilisé une approche à méthodes mixtes pour examiner la perception qu'ont les entreprises aquacoles européennes des sources de risques et des pratiques de gestion des risques (chapitre II - section 4). Les résultats montrent que la maladie est le type de risque le plus important, tant pour les entreprises en cycle complet que pour les entreprises en phase de croissance ; toutefois, il existe encore des différences dans l'ampleur et l'ordre de classement des différents types de risques entre les deux types d'entreprises. De même, les résultats montrent que les évaluations des pratiques de gestion des risques diffèrent selon le type d'entreprise. Les résultats révèlent également que les entreprises en cycle complet sont

plus disposées à prendre des risques que les entreprises en phase de croissance, bien que les deux types d'entreprises perçoivent l'aquaculture comme une activité risquée.

En utilisant les leviers de contrôle de Simons (1995), une approche pratique a été développée pour les gestionnaires de la production aquacole afin d'améliorer leur gestion des sources de risque les plus importantes identifiées (Chapitre II - Section 5). Les résultats indiquent que pour les entreprises à cycle complet, les risques de variabilité du prix du poisson et du prix de l'alimentation peuvent être respectivement atténués et évités en utilisant des systèmes de contrôle des croyances et des limites, tandis que le risque d'infection des alevins par des maladies peut être évité en utilisant des systèmes de contrôle des limites. En revanche, pour les entreprises de grossissement, les risques d'échec technique, de taux de mortalité élevé dû aux maladies, d'incapacité à contrôler les maladies d'origine environnementale, de mauvaises conditions météorologiques et de blessures ou de problèmes de santé parmi les employés pourraient être évités à l'aide de systèmes de contrôle des limites, tandis que les risques de disponibilité suffisante de main-d'œuvre compétente et de variabilité du prix du poisson pourraient être évités à l'aide de systèmes de contrôle des croyances. Les risques restants pour les deux types d'entreprises devraient être soit acceptés et surveillés à l'aide de systèmes de contrôle interactifs, soit transférés à un tiers.

En ce qui concerne les préférences d'étiquetage pour les produits de la pêche et de l'aquaculture dans l'UE (chapitre III), deux questions critiques (l'interrelation des critères ainsi que la relation qui existe au niveau des pays) ont été évaluées à l'aide d'une méthode basée sur un rapport de préférence cohérent flou modifié utilisant l'opérateur de moyenne géométrique de Bonferroni (chapitre III - section 6). Les résultats indiquent que tous les pays de l'UE ne sont pas homogènes, ce qui implique que le principe de subsidiarité a pu être appliqué.

En outre, une méthode TOPSIS floue hybride (FTOPSIS) pour évaluer la couverture d'un hypothétique écolabel européen pour les produits de la pêche et de l'aquaculture est proposé au chapitre IIII - section 7. Selon les résultats, les écolabels devraient inclure non seulement les questions environnementales, mais aussi d'autres types d'informations, les questions sociales et éthiques étant les plus importantes, suivies des questions de bien-être animal, des questions de santé et de sécurité, et enfin des questions de qualité alimentaire. Les résultats montrent également que les consommateurs, les producteurs et les parties prenantes qui sont plus interventionnistes et pensent que les organismes publics et le gouvernement devraient être impliqués dans le contrôle de l'étiquetage écologique sont plus disposés à inclure des informations en plus des questions environnementales.

En outre, un certain nombre d'implications de gestion ont été proposées sur la base des résultats. En ce qui concerne les implications visant à améliorer le marché des produits de la pêche et de l'aquaculture en fonction des préférences des consommateurs, il a été constaté que certains aspects susceptibles d'augmenter la consommation des produits de la pêche et de l'aquaculture à domicile consistent à rendre les informations d'accompagnement plus claires et à mettre l'accent sur leur salubrité, leur coût équitable, leur goût et leur digestibilité. En outre, les produits de la pêche et de l'aquaculture, rapides et faciles à préparer, peuvent

constituer une alternative appropriée pour augmenter la consommation à domicile, ainsi que pour améliorer l'apparence du produit. Enfin, il a été constaté que l'industrie des produits de la pêche et de l'aquaculture doit proposer des produits qui plaisent aux jeunes générations afin d'augmenter leur consommation à domicile.

En ce qui concerne les implications des résultats pour la consommation hors foyer de produits de la pêche et de l'aquaculture en Europe, les preuves empiriques ont montré que pour l'augmenter, les parties prenantes devraient chercher des stratégies pour attirer les clients plus âgés et proposer des recettes et des plats plus sains.

En ce qui concerne les politiques visant à améliorer le marché et le secteur de l'aquaculture en Europe, il a été constaté que les autorités et les parties prenantes devraient investir dans des campagnes de marketing pour aider à changer l'image négative actuelle des produits aquacoles. De même, pour améliorer la gestion des risques, le gouvernement et les institutions aquacoles devraient accroître leurs efforts dans le développement de stratégies visant à réduire le risque de maladies, qui sont particulièrement pertinentes pour l'industrie aquacole. En outre, les entreprises aquacoles devraient être en mesure d'anticiper la manière de réagir aux grandes fluctuations de prix en utilisant diverses méthodologies basées sur la simulation et des modèles de choix discrets grâce à la collecte de données. Les résultats permettront aux entreprises d'élaborer des stratégies face à l'évolution des conditions du marché. En outre, l'approche des leviers de contrôle de Simons (1994) peut être utilisée pour aider à la gestion des risques des entreprises.

Dans le cas spécifique des produits à base de daurade et de bar de Gran Canaria, les industries concernées devraient chercher des moyens d'améliorer l'hygiène et la sécurité alimentaire des produits afin d'accroître la satisfaction des consommateurs et, par conséquent, leur volonté de payer et leur fréquence de consommation. De même, les producteurs sont encouragés à investir dans le développement de produits enrichis en nutriments. En outre, les parties prenantes et les autorités devraient investir dans des campagnes de marketing qui soulignent les avantages pour la santé de la consommation de daurade et de bar, dans de nouvelles recettes de cuisine des fruits de mer qui rehaussent le goût des produits et dans la manière d'évaluer la fraîcheur des produits.

Quant aux résultats des préférences d'étiquetage pour les informations obligatoires accompagnant les produits de la pêche et de l'aquaculture, il a été constaté que le "nom du produit et de l'espèce" et la "date limite de consommation" devraient être mis en évidence avant tout ; tandis que les autorités devraient faire plus d'efforts pour éduquer les consommateurs sur l'importance de l'équipement des produits de la pêche. Plus important encore, il pourrait être nécessaire d'évaluer l'ampleur future des informations ex ante obligatoires afin de déterminer si certains pays présentent des différences significatives, de sorte que la réglementation puisse être adaptée spécifiquement à ces cas, en vertu du principe de subsidiarité.

En conclusion, il a été constaté que, outre les informations environnementales, le label écologique de l'UE pour les produits de la pêche et de l'aquaculture devrait inclure, dans l'ordre

d'importance suivant : les questions sociales et éthiques, les questions de bien-être animal, les questions de santé et de sécurité et les questions de qualité des aliments. En outre, les promoteurs du label écologique communautaire pour les produits de la pêche et de l'aquaculture devraient s'efforcer de persuader les titulaires du label écologique, en particulier, des avantages que présente l'inclusion des questions sociales et éthiques dans le label écologique. En outre, les promoteurs du label écologique devraient chercher à savoir pourquoi les producteurs ont évalué les questions différemment de l'échantillon général, afin de proposer des actions et des stratégies qui ne feront pas perdre aux producteurs leur intérêt pour le label écologique.

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Appendix

Other contributions in the doctoral learning process

Some other papers that were written during the PhD are presented in this appendix.

For each paper, the title, abstract and link to access to are presented.

These papers are not submitted for discussion.

Paper: Discrete choice experiments in the analysis of consumers' preferences for finfish products: A systematic literature review

J. Cantillo, J.C. Martín, C. Román.

This work has been published in Cantillo *et al.* (2020a). Food Quality & Preference 84, 103952.

https://doi.org/10.1016/j.foodqual.2020.103952

Abstract

Discrete choice experiments (DCEs) have become an important tool for assessing the preferences of consumers for finfish seafood products. This investigation presents a systematic literature review of studies performed in the last 20 years (2000–2019) that use DCEs to analyse consumers' preferences for finfish products, with the purpose to identify the main insights of consumer behaviour towards these products, the most used attributes for this type of experiments and to discuss and compare some willingness to pay estimations. We found that origin was the most used attribute for this kind of experiments, while other important factors were the harvest method, a specific certification label and the species or products considered. The WTP estimates evidenced that consumers are willing to pay premiums for domestic products, while similarly, wild products were preferred over farmed products. Also, there were higher WTP estimates for certified products, in which specific certification labels were better options rather than just claiming that the product was certified or not. All claims and labels related to sustainability, nutritional, health and safety information provided premiums that consumers were willing to pay, however, the importance differed depending on the type of label or claim, the country and species. Future research should consider the influence of being or not the main purchaser in the household, as it might affect the WTP values. Also, given the importance, future research extensions using DCEs are needed on the Chinese and Asian finfish market.

Keywords: Finfish; Consumers' preferences; Discrete choice experiments; DCE; Systematic literature review.

Paper: A hybrid-fuzzy TOPSIS method to analyze the consumption and buying behavior of fishery and aquaculture products (FAPs) in the EU28

J. Cantillo, J.C. Martín, C. Román.

This work has been published in Cantillo *et al.* (2020b). British Food Journal Vol. 122 No. 11, pp. 3403-3417.

https://doi.org/10.1108/BFJ-12-2019-0884

Abstract

Purpose: The purpose of this investigation is to develop a hybrid fuzzy TOPSIS methodology in order to understand in a practical and integrated way, the consuming and buying behavior of EU residents towards Fishery and Aquaculture Products (FAPs), with an emphasis in the consumption and buying frequency.

Design/methodology/approach: Data were obtained from the Special Eurobarometer Survey (European Union, 2018b), which is a survey of 27,732 EU residents with different socio-demographic characteristics that represent the 28 EU countries. A hybrid fuzzy TOPSIS methodology that synthesizes the consuming and buying behavior of the EU residents toward FAPs was developed.

Findings: The results show that among the countries, Spain has the highest consumption and buying patterns of FAPs, while among the generations it corresponds to the residents born between 1928 and 1945. In addition, there are important differences that depend on the country of residence as well as the generation of the residents. The elasticity analysis evidenced that marketing strategies would have the biggest impact in the countries located in the Central-Eastern zone of the EU and on the generation formed by the people born after 1980.

Originality/value: Although in the literature there are many studies that aimed to understand the behavior of consumers for FAPs, few investigations have focused on analysing and integrating both the consumption and buying behavior, and to our best knowledge, there are no studies providing a methodology that allow making comparisons between different countries regarding the consumption and buying behavior of FAPs.

Keywords: Fuzzy logic, Triangular fuzzy numbers, TOPSIS, Fishery and aquaculture products, FAPs, Residents' consuming and buying behaviour, EU28.

Paper: Visualization analysis of seabream and seabass aquaculture research using CiteSpace

J. Cantillo, J.C. Martín, C. Román.

This work has been published in (Cantillo et al., 2021f). Aquaculture research

https://doi.org/10.1111/are.15560

Abstract

In terms of production, seabream and seabass are the two most important species of marine Mediterranean aquaculture, which is why they have been extensively studied in the literature. This study uses visualization analysis with the CiteSpace software to determine the research status quo and the most important trends of seabream and seabass aquaculture research. The Web of Science (WoS) database was used to select the papers associated with seabream and seabass literature from the period between 1986 and 2020. The results were separated using two indices (Science Citation Index Expand and Social Science Citation Index). The visualization analysis identified the networks for (1) author, institution, country and category co-authorship, in order to find the most prolific authors, institutions, countries and categories respectively; and (2) journal, document and author co-citation, which identifies the most relevant journals, the most important studies and the most cited and influential authors. Finally, a keywords co-occurrence network was built to identify the most important topics and the research frontiers—body of knowledge—of the seabream and seabass aquaculture research—SSAR.

Keywords: Seabream and seabass aquaculture research; Visualization; Co-authorship analysis; Co-citation analysis; Keywords co-occurrence analysis

Paper: Understanding the public image of aquaculture and its products: does the influence of positive or negative wording matter? do the opinions vary amongst different segments? – An application to the island of Gran Canaria

J. Cantillo, J.C. Martín, C. Román.

Abstract

Many investigations have looked to understand consumers' perceptions of aquaculture and its products, with Likert scales being the most popular instrument employed. In some of them, negatively and positively worded survey items are mixed looking to reduce potential acquiescence bias. Nevertheless, several studies found that this solution could be problematic because reverse recoded negatively worded statements might not exactly measure the same as their positively worded counterparts. This study aims to examine the impact of positive and negative wording on surveys that analyze the public image of aquaculture and its products. Results revealed that the inclusion of negative statements on Likert scale instruments is not a good idea because it increases aquaculture{s refusal and the information seems to be less reliable and with more variability in comparison to positively worded data. In addition, the study determines how the public image of aquaculture differs amongst segments in Gran Canaria (Spain).

Keywords: positive and negative worded survey items; aquaculture perception; Gran Canaria, TOPSIS.

Paper: The perception of risks and risk management practices in the aquaculture industry: a systematic literature review

J. Cantillo, D. Van Caillie.

Abstract

Over the last 40 years, the aquaculture industry has become the fastest-growing food production sector (FAO, 2018). Compared to other industrial activities, this industry is considered to be a relatively risky business because it depends heavily on the environment, weather conditions and regulations (Tveterås, 1999). Given that the literature assessing risk management for the aquaculture industry relies more on individual farmer perceptions than on actual observations of practices, mainly due to the reluctance of farmers to disclose information that might damage their reputation, understanding these perceptions is an essential step towards the development of more safety practices in the aquaculture sector. The current investigation presents a systematic literature review of the rare and specific studies addressing the perceptions of aquaculture farmers for risk sources and/or risk management practices. The aim of the paper is twofold: (1) understand the main findings of the reviewed papers such as the main characteristics of the eligible studies, the main perceptions of farmers for risk sources and risk management strategies, and key findings for some critical types of risk such as the risks of diseases and escapes, as well as a risk related to sustainable development goals (SDGs) such as climate change, and (2) based on the results found in the literature review, propose an analytical framework for testing the main risk sources and risk management practices in a managerial the TOH model, the value chain analysis and the 5M model. Our findings indicate that most of the studies have taken place in countries located in Asia, with mainly shrimp and tilapia farmers. Moreover, the most important recurrent risk sources were related to diseases and market risks such as the future price of the product, market uncertainty, price and availability of fingerlings and operating inputs. The most recurrent risk management practices were to use quality fingerlings/inputs, prevent diseases and escapes, produce at the lowest possible cost, choose quality feed and maintain a well-managed water environment. The managerial approach emerging from these studies suggests that there is an inconsistency in the way that farmers focus their risk management practices, as risk sources focus more on operations while the practices focus more on firm infrastructure. This may be due to a lack of knowledge, an excessive focus on risk management control or insufficient consideration for a holistic vision of risks.

Keywords: risk perceptions; aquaculture farmers; risk sources; risk management practices; systematic literature review.