Aquaculture Modelling in a General Equilibrium Framework. An Application for the EU

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Abstract. *This paper is the first attempt of analysing the EU aquaculture sector following a disaggregated approach and including public subsidies within a global CGE modelling framework. Using the MAGNET model, it distinguishes five aquaculture sectors, one wild-captured fish and one fish processing sectors. Furthermore, it adds to the system a fishmeal and fish oil processing sector. Both modelling and data adjustments are needed to properly integrate these new features. This paper pays special attention in the incorporation of cost structures for newly added sectors as well as the representation of income subsidies in aquaculture. It set up a baseline at the horizon 2050, looking how the fish related sectors are expected to develop and what could change if extra EU subsidies would be introduced. It also analyses whether the impact of the aquaculture subsidies could differ substantially if the demand for fish products would develop more rapidly than expected.*

1. Introduction

Aquaculture is the fastest growing animal food production sector at global level. Rising demand and supply still offer large potentials for further growth and development. However, overall EU aquaculture production has been stagnant for the last two decades. Despite that over the last two decades, EU support to boost the sector amounted about 3 billion euros and is expected to increase in the next 2021-2027 multiannual financial framework (MFF).

Clearly, the aquaculture sector is a key primary production sector that uses and produces biological resources. Together with wild-capture fisheries, aquaculture is an integral part of the EU *blue* economy, which includes any economic activity associated with the use of renewable aquatic biomass, e.g., food additives, animal feeds, pharmaceuticals, cosmetics, energy, etc. Unlocking the high potential of the *blue* economy is a key element to support local bioeconomy development according the 2018 EU bioeconomy strategy, and more largely to foster a striving *green* growth. Overall, the sector accounts for 14% of the employment, 12% of the value added and 11% of the profits in the total EU blue economy in 2017 (European Commission, 2019). Aquaculture is also a core element of the *Farm to Fork* strategy, at the heart of the *Green Deal*, whose ambition is to make Europe the first climate-neutral continent by 2050.

The EU is the fourth largest producer worldwide, with about 3.1% of global fisheries and aquaculture production (80% of production comes from fisheries, 20% from aquaculture). A highly concentrated sector, in 2015 more than 220,000 people were employed, one third in aquaculture activities. Dependent on the supply of aquatic materials, the fish processing and distribution sector further employ more than 350,000 people. Being a major importer, the EU's self-sufficiency in meeting a growing demand for fisheries and aquaculture products from domestic production is only 45% (European Commission, 2018). Thus, fisheries and in particular aquaculture show a high potential for further growth in an increasingly integrated world market. Besides, although at an early phase, algae biomass is becoming increasingly important in a variety of applications (food, manufacturing, health, energy). Overall, aquaculture can be instrumental in sustainable development, poverty reduction, and food and nutrition security.

Fisheries apart, and despite an emerging literature, there is still a lack of disaggregated data and appropriate modelling techniques of aquaculture sectors able to address above-mentioned challenges. The complexity and interconnections of wild-capture fish and aquaculture sectors to other industries (e.g., soybean production as feed in aquaculture, fishmeal as feed in livestock, etc.) require systems-wide modelling tools, able to capture the input-output linkages between many sectors and their links with the broader macroeconomy. For instance, given limited water and land resources, fishmeal is already well integrated in the food supply system as input for the livestock sector. On the demand side, meat competes with fisheries and aquaculture products in the basket of consumers. Literature on aquaculture modelling show that Input-Output (I-O) models are typically used to apprehend systems-wide effects of economic change (Arita et al., 2013). When multi regional, these models also better account for international trade flow (Guillen, Natale et al., 2019). Grounded on I-O tables, Social Accounting Matrix (SAM) based-analyses also incorporate linkage between the supply and demand sides through a "circular-economy" or "circular-flow" approach. They reflect the full process of production, trade, income generation and its redistribution between institutional sectors. There are many I-O and SAM applications to fisheries, aquaculture and fish processing (Seung and Waters, 2009; Arita et al., 2013; Vega et al., 2014; Cámara and Santero-Sánchez, 2019; Guillen, Natale et al., 2019). I-O and SAM models usually ignore the existence of supply constraints, and are produced for a single specific period. Being static, they hardly integrate technical changes and other socioeconomic fluctuations. Computable General Equilibrium (CGE) approach are able to take into account these long-term considerations together with global resource allocation and income distribution (Pan et al, 2007; Seung and Waters, 2010; Carvalho et al., 2011). However, there is no CGE study separating and disaggregating the EU aquaculture nor fish processing sector.

The aim of this paper is to fill this gap, especially by means of new structural and support data interconnecting the EU with trade partners. It represents the first CGE attempt to disaggregate the EU aquaculture sector and to include public support. A key added value is the construction of a comprehensive baseline at the horizon 2050. Applications focus on the nexus between public support and rising demand for fish and aquaculture products. The rest of the paper is structured as follows. Section 2 describes the EU aquaculture sector and policy within a global context. Section 3 presents the modelling framework, paying special attention in the representation of subsidies. Section 4 presents the baseline at the horizon 2050 with main outcomes for the EU and key trading partners. Under different assumptions of fish product demand, section 5 discusses the results of changes in EU aquaculture subsidies and section 6 faces both increase in subsidies and demand. Section 7 provides some concluding remarks on aquaculture modelling improvement in an increasing open world.

2. Aquaculture – sectoral review and public support

By contrast, to products caught by fishing vessels, aquaculture production gathers products farmed for human consumption, processed or not, and for non-food purposes such as food additives, animal feeds, pharmaceuticals, cosmetics or energy.[1] Aquaculture contributes to about half of global fish and seafood production, reaching 220 billion euros in 2016 (FAO, 2018).[2] In the EU, aquaculture production has increased by one fourth since 1990 (STECF, 2018a), however wild captured fisheries remain the main source of EU human-food production of fish and seafood despite a decreasing trend. Indeed, 80% of production comes from fisheries and 20% from aquaculture. According the European Commission (2017), the EU is the fourth largest producer worldwide, accounting for about 3.1% of global volume

[1] In 2015, plant and aquatic based food contributed to about 11% of biomass uses in the EU (European Commission, 2018).
[2] Exchange rate (2016): 1 USD = 0.904 euro (http://www.fao.org/faostat/en/#data/PE)

fisheries (China, Indonesia and India are ranked first with 37.7%, 10.5% and 4.8% respectively). Despite the absolute increase of aquaculture in the supply of the EU market over the past decades, the EU production is relatively stagnating by contrast to increasing rates of aquaculture production at world level. In 2016, the EU represents 1.2% of the world aquaculture production in volume and 1.9% in value. China is the most important producer of aquaculture products in the world, contributing to 58% of the global production in volume (STECF, 2018a).

Figure 1 shows how concentrated the EU aquaculture sector is. Spain is the largest aquaculture producer in the EU representing 21% of the total volume of production (11% in value), followed by France and the UK with 13% each (15% and 23% in value respectively) and Italy and Greece with 9% of EU volume (9% and 11% in value respectively). In 2018, these five countries account for 70% of the total EU aquaculture production volume (65% in value). These ratios have been decreasing over time as the result of the aquaculture development in other EU countries. In 2014, these ratios of the top-5 producers in volume and value were 75% and 66% respectively. Mediterranean mussels represent around one quarter of the total volume farmed in the EU, while Atlantic salmon and rainbow trout together contribute more than one third of the total value (European Commission, 2019). Within the EU, the aquaculture sector is also specialised at country level such as shown in 2016 Eurostat data with the UK in diadromous fish (90% of EU Atlantic salmon come from the UK), Spain in mollusc (70% of Mediterranean mussels) or Greece in farmed marine fish (60% of EU seabream).

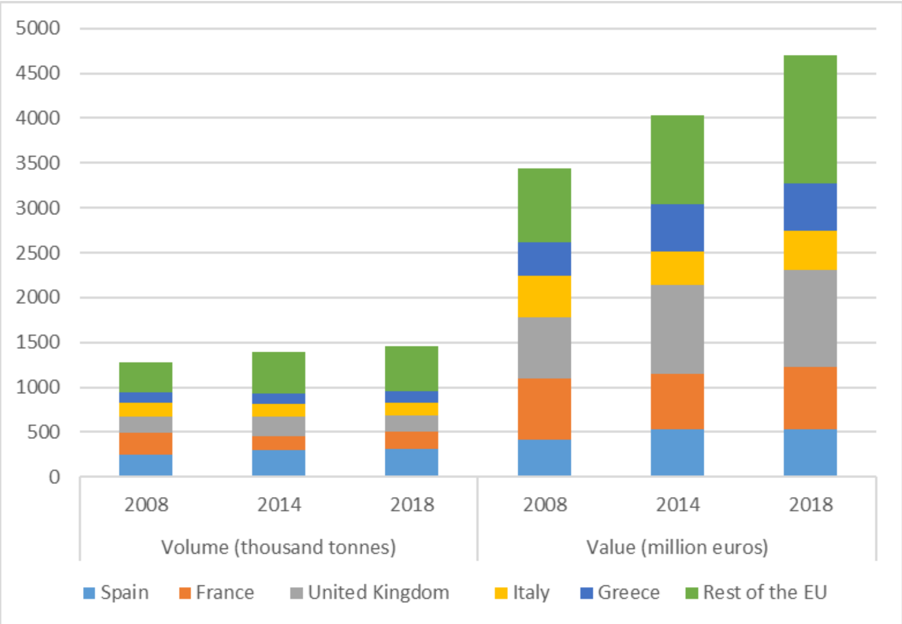

Figure 1. Volume and value of aquaculture production by the major EU producers
Note: 2017 data for Spain and France (2018) and for Greece (2014).
Source: Own elaboration from Eurostat.

Aquaculture is a key component of an EU blue growth strategy. This strategy, adopted by the European Commission in 2012, is a long-term plan to support sustainable growth in the marine and maritime sectors. In this approach, aquaculture is considered as a priority sector based on its potential for creating new jobs and fostering innovation. In order to strengthen aquaculture, the European Commission set up specific plans in 2002, 2009 and 2013.[3] Constraints faced by the sector include a limited access to space and licensing, the fragmentation of the sector and the pressure from imports. This later reflect strict EU rules, particularly on environmental protection that generate competitive constraints vis-à-vis

[3] *A strategy for the sustainable development of European Aquaculture*. COM(2002) 511. Brussels, 19.9.2002; *Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture*. COM(2009) 162 final. Brussels, 8.4.2009; *Strategic Guidelines for the sustainable development of EU aquaculture*. COM(2013) 229 final. Brussels, 29.4.2013.

competitors, especially in Asia and Latin America. Strategic guidelines established identify four priority areas, i.e., simplification of administrative procedures, sustainable development and growth of aquaculture through coordinated spatial planning, enhanced competitiveness of EU aquaculture, and level playing field promotion for EU operators by exploiting their competitive advantages.

Fisheries and aquaculture products are some of the most traded food items in the world. In 2016, about 78% of these products are exposed to international trade and 35% of world production are internationally traded (FAO, 2018c). The EU faces a high trade deficit of 20.9 billion euros in 2018, with imports of 26.4 billion and exports of 5.5 billion euros (WTO, 2019). EU tariffs on fisheries and aquaculture products remain high, with an average Most-Favoured Nation (MFN) rate of 11.8% (range of 0%-26%) as compared to the overall average of 6.3% in 2019. In addition, some fisheries and aquaculture products are subject to seasonal rates or tariff quotas. Interestingly, MFN tariffs for fishmeal and fish oil are 0% and 3.6% respectively (since these inputs to EU productive sectors are insufficiently produced in the EU). That said, WTO (2019) reveals that more than 50% of EU fisheries and aquaculture imports benefit from a Free Trade Agreement (FTA) or unilateral tariff arrangement (14 billion euros in 2018). For instance, duty-free treatment applies for imports from Ecuador (5% of total EU fisheries and aquaculture imports) or Peru (2%). It is a critical chapter of a EU-Vietnam FTA signed in June 2019 (4% of total EU fisheries and aquaculture import).

WTO common rules on subsidies (1994 Agreement on subsidies and countervailing measures) currently regulate public support to aquaculture. Within the world trading system, aquaculture products are not treated differently than industrial products covered by traditional rules. There are exempted from current tough negotiations on fisheries subsidies, which specifically deal with marine wild capture. However, some aquaculture practices may result in potential negative impact on environment or health (for instance linked to the use of antibiotic), which can justify some trade restrictions. Thus, exporting countries can be affected by trade measures that restrict aquaculture imports failing to meet environmental or health standards.

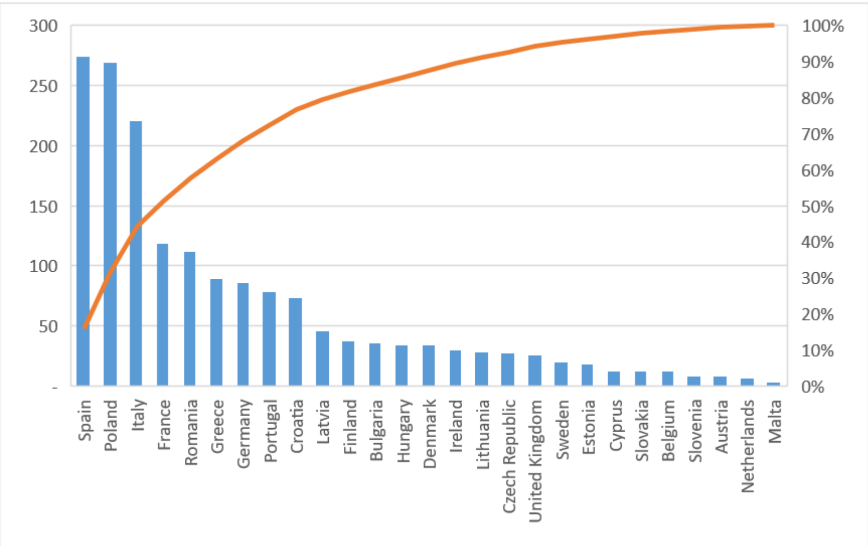

Figure 2. Total planned spending on aquaculture over the 2014-2020 financial period, million euros

Note: European Maritime and Fisheries Fund (EMFF) and national contributions.
Source: STECF (2016).

The Common Fisheries Policy (CFP) is the set of rules for managing sustainably the fisheries and aquaculture sectors, and ensuring food quality, health and safety for EU consumers. First introduced in the 1970s, access to fishing grounds in EU waters (and beyond) and fish stock conservation remain crucial elements of the policy. There are many similitudes with the Common Agricultural Policy (CAP). The goal of the CFP is to foster a dynamic fishing and aquaculture industry and ensure a fair standard of living for producers. The CFP gives EU member states flexibility in implementing (and co-funding) the measures at national and regional level. Guillen et al. (2019) provide a comprehensive overview of aquaculture subsidies in the EU. The Financial Instrument of Fisheries Guidance (FIFG) and European Fisheries Fund (EFF) were the financial instruments supporting the CFP over the financial period 2000-2006 (567 million euros to aquaculture sector, including national contributions) and 2007-2013 (600 million euros).[4] With a reformed CFP in 2013 and greater emphasis on sustainability, the European Maritime and Fisheries Fund (EMFF) has been set up as the new the financial instrument supporting the CFP. Out of a total 8.6 billion euros (including national contributions), 1.7 billion euros are allocated to the aquaculture sector. This corresponds to a sharp increase (22% of total *planned* EMFF) by contrast to the two former financial periods (about 10% and 11% of *spent* FIFG and EFF respectively). However it should be remain that these payments correspond to *planned* spending whose fulfilment can be inferior as in the former periods. Spain is the main recipient while seven member states receive more than two third of the support. With the subsidiarity in support allocation, measures are decided at the national or regional levels. It is interesting to stress the offensive interest of some countries, not being major producers, which planned to invest especially in the aquaculture sector over the 2014-2020 period, i.e., Poland, Romania and Germany (Figure 2).

3. Modelling framework

In order to model the complexity and interconnections of aquaculture sector with wild captured fisheries, food processing sector, and the whole economy, this paper uses the Modular Applied General Equilibrium Tool (MAGNET) (Woltjer et al., 2014). This model is a recursive dynamic variant of the well-known multi-regional neoclassical GTAP model (Hertel, 1997) and database (Aguiar et al., 2019). MAGNET is calibrated to the version 10A of the GTAP database with base year 2014.

3.1. Splitting aquaculture from fisheries

The fisheries module in MAGNET (Bartelings and Smeets Kristkova, 2018) allows new types of analysis in the context of the "blue economy", sustainable management of natural resources and global food security. MAGNET splits the GTAP fish sector (frs) into six sectors. One wild captured fish sector and five aquaculture sectors based on fish families, rather than species, i.e., diadromous fish (salmon and trout), fresh water fish (carp, tilapia, pangasius, other fresh water fish), farmed marine fish (sea bass and other marine fish), molluscs (clam, mussel, oyster) and crustaceans (shrimp, other shellfish). According Eurostat, in 2014, these sectors contribute to 93.6% of the added value generated by the aquaculture sector, i.e., diadromous fish (37.8%), fresh water fish (4.5%), farmed marine fish (28.1%), molluscs and crustaceans (23.2%). Remaining 6.4% of total added value mostly come from the production of algae and aquatic plants.

Furthermore, the fisheries module includes one fish processing sector which processes fisheries and aquaculture products according to the consumer demands. This sector also produces fishmeal and fish oil. Fishmeal and fish oil processing sector has been also added to the system. For instance, fisheries providing fishmeal to livestock are taken into account. Feed is explicitly modelled and attention is given to the competition between aquaculture and cattle sectors for available feed. Interactions between these sectors are schematically presented in the Figure 3. Finally, on the endowment side, wild fish stocks are introduced by removing the use of natural resources and adding the use of 4 types of fish stocks: crustaceans, demersal fish, pelagic fish and other marine fish.

[4] Table A1 in the appendix face the public support to EU aquaculture by member state over the 2000-2020 period.

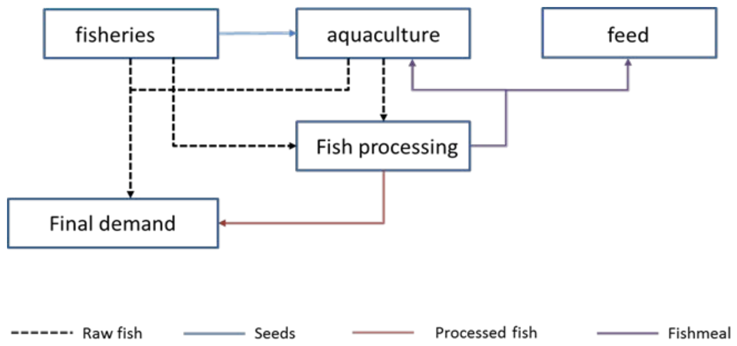

Figure 3. Schematic representation of interactions between fisheries, aquaculture and fish processing sectors in MAGNET
Source: Bartelings and Smeets Kristkova (2018).

Having five aquaculture sectors allows to better reflect different cost and feeding structures as presented in Table 1. Cost structures are adapted from various studies, formulated as percentages of total cost, and for feed also in content of the feed (from fish and from crops, distinguished by crop). Because of the lack of data, trade in aquaculture sectors is assumed to follow similar patterns as the fisheries sector in the GTAP database (frs). Next to the aquaculture split, frs represents the wild-captured fish sector.

Table 1. Cost structure of aquaculture sectors

	labour	capital	feed	animal	chemicals	energy
diadromous fish	13.20%	11.30%	43.00%	31.20%	1.20%	0.00%
fresh fish	6.10%	9.30%	63.30%	13.80%	3.10%	4.30%
crustaceans	3.70%	14.80%	40.50%	17.70%	10.30%	13.10%
marine fish	25.80%	21.20%	42.70%	10.30%	0.00%	0.00%
molluscs	3.00%	12.00%	50.00%	14.00%	7.00%	14%

Source: Own elaboration from University of Sterling (2004), Kongkeo (2005), Ahmed et al. (2010), Scheerboom (2010), Towers (2010).

3.2. *Splitting fish processing sector from other food*

Other food in the GTAP database (ofd) includes among other activities the fish processing sector. A new sector is therefore created after treatment (split) based on data from the Scientific, Technical and Economic Committee for Fisheries (STECF). A cost structure for each European country is created following the 2013 Economic Report on the EU fish processing (STECF, 2013). As there is a lack of data for countries outside the EU, it is assumed the rest of the world adheres to an average cost structure based on the EU data (Table 2). It is assumed that all fish used in the GTAP ofd sector is actually fish used by the fish processing sector. Based on the total intermediate use of fish and the cost structure of the fish processing sector, it is possible to determine the size of the sector in the base year. It is assumed that fish processing sector produces both proceed fish (e.g., filleted, slices, frozen, fish fingers, smoked, ready meals, etc.) and fishmeal. Finally, international trade of fish processing sector follow the trade patterns of ofd sector.

Table 2. Cost structure of fish processing sector by EU member state and the rest of the world

	labour	capital	energy	raw materials	other
Belgium	8.1	0.7	1.0	82.8	7.3
Bulgaria	17.3	2.1	2.5	58.3	11.1
Cyprus	17.3	2.1	2.5	58.3	11.1
Denmark	15.3	3.4	1.8	58.3	21.2
Estonia	21.8	4.3	3.1	55.3	15.6
Finland	21.2	3.0	1.4	64.7	9.7
France	20.4	1.9	4.6	36.4	36.8
Germany	17.6	2.8	1.7	57.8	20.1

Greece	19.3	1.0	2.7	62.3	14.7
Ireland	33.3	4.1	2.7	57.9	2.0
Italy	11.4	1.3	4.4	69.4	13.5
Latvia	23.3	4.0	5.5	50.4	16.8
Lithuania	19.7	6.1	2.3	57.9	13.9
Malta	5.5	4.7	0.7	75.4	13.7
Netherlands	18.6	2.9	1.4	66.0	11.1
Poland	14.1	3.2	1.2	64.8	16.8
Portugal	9.5	1.3	1.3	50.9	36.9
Romania	17.3	2.1	2.5	58.3	11.1
Slovenia	27.1	8.6	2.4	59.7	2.2
Spain	18.9	1.0	1.9	64.4	13.8
Sweden	20.8	2.9	1.1	54.2	21.0
UK	20.0	2.1	1.1	65.6	11.1
Average (ROW)	17.3	2.1	2.5	58.3	11.1

Source: Own elaboration from STECF (2013).

4. Fisheries and aquaculture subsidies

This paper is the first attempt of including within a CGE context aquaculture subsidies, and for consistency fisheries subsidies. To do so it is crucial to adjust subsidy rates in fisheries and aquaculture in MAGNET. The subsidy data for fisheries and aquaculture are provided by EU Member States under the 2018 Data Collection Framework (DCF) fishing fleet economic data call.[5] In both cases, the subsidies refer to direct income subsidies. Investment subsidies are omitted because of limited coverage and the absence of investment subsidy modelling in MAGNET. Income subsidies as implemented as output subsidies. This means that subsidies will potentially have an impact on both the price and output of a sector.

Under the DCF regime, member states report subsidies, which are defined as "*operating subsidies received from public authorities or the institutions of the European Union which are excluded from turnover*". These subsidies include direct payments (e.g., compensation of stopping trading, refunds of fuel duty or similar lump sum compensation payments) and exclude social benefit payment and indirect subsidies (e.g., reduces duty on inputs such as fuel or investment subsidies). For non-EU member states, European Commission (2016) provides economic overview of fisheries and aquaculture for key world producers, i.e., China, Russia, Japan, South Korea, USA and Taiwan. To maintain consistency, selected data only account for direct income subsidies, i.e., exclude indirect subsidies on fuel, special insurance, infrastructure investments and research.

Keeping in mind, fisheries and aquaculture production are very concentrated in the EU, major EU producers exhibit low income subsidies as a proportion of total income. For aquaculture, less for fisheries, this is comparable with non-EU member states. At the level of different aquaculture species, there are some exceptions that show a higher support rate.

4.1. EU fisheries subsidies

Subsidy rates for fisheries by EU member states are obtained from the 2018 Annual Economic Report on the EU Fishing Fleet (STECF, 2018b). Figure 4 shows main recipients of EU income subsidies over the period 2010-2016. Subsidy rates are calculated by dividing the total amount of income subsidy by the value of production at market prices. In the GTAP database version 10 (and previous releases), no fish sector related subsidies are taken into account.

In terms of proportion of subsidies in the total value of production, countries like Spain, France and Italy with the largest subsidy payments, report relatively moderate subsidy rates, mostly about 1% of total income. The largest subsidy rates are recorded in Slovenia (14%), Poland (12%) and Croatia (7%). Because of a low share of these countries in total fish production value, the EU average subsidy rate is

[5] https://datacollection.jrc.ec.europa.eu/

only 1%. Interestingly, whereas total fisheries value of production has an increasing trend, subsidies in fisheries are falling. The lower reliance of the fishing sector on income subsidies can be interpreted as positive but it can also show there is some room for higher support, especially in view with the support level in the third countries (see below). Furthermore it should be remained that most subsidies are not income subsidies but indirect such as fuel support.

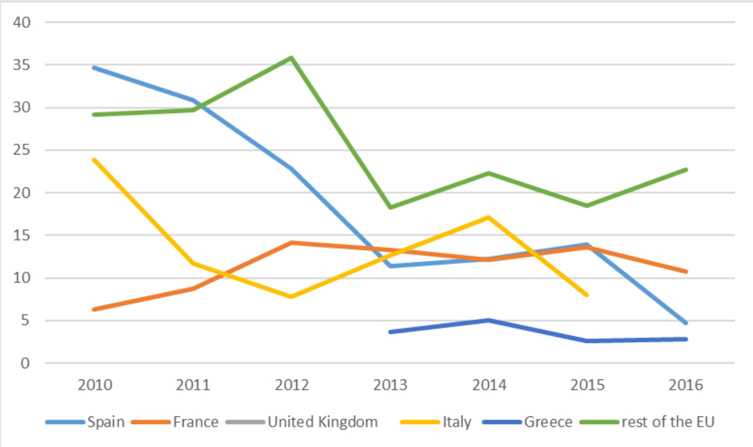

Figure 4. Direct income subsidies in fisheries by EU member states, million euros, 2010-2016
Source: Own elaboration from STECF (2018b).

Table 3 shows the subsidy rates in fisheries which are rather stable over time, except for Poland and Greece. This means that for the MAGNET base year (2014), we can take an average over the full period. For Greece, we use the subsidy rate from the last two years. For Poland, we include the reduction in subsidy rate from 0.27 to 0.12 in 2015. As no direct subsidy data is included in the GTAP database, we shock the variable output tax/subsidy (to_b) in the first-time period (2014-2020) to include the direct subsidy on fisheries production.

Table 3. Subsidy rates in fisheries in MAGNET aggregation

Regions/years	2011	2012	2013	2014	2015	2016
Western Europe	0.02	0.01	0.01	0.02	0.01	0.01
Eastern Europe	0.01	0.01	0.01	0.01	0.00	0.00
Southern Europe	0.01	0.03	0.01	0.03	0.02	0.04
Northern Europe	0.01	0.00	0.00	0.00	0.00	0.00
France	0.01	0.01	0.01	0.01	0.01	0.01
Italy	0.01	0.01	0.01	0.02	0.01	0.00
Netherlands	0.00	0.00	0.00	0.01	0.00	0.01
Poland	0.27	0.22	0.17	0.12	0.12	0.01
Spain	0.01	0.01	0.01	0.01	0.01	0.00
UK	0.00	0.00	0.00	0.00	0.00	0.00
Greece			0.05	0.02	0.02	0.01
Ireland	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.01	0.01	0.01	0.01	0.01	0.01

Note: Blank refers to no data available.
Source: Own elaboration from STECF (2018b).

4.2. EU aquaculture subsidies

Subsidies rates for aquaculture are obtained from the 2018 Economic Report of the EU Aquaculture sector (STECF, 2018a). As for fisheries, subsidy rates by member states are calculated by dividing the total amount of income subsidy by the value of production at market prices.

In 2014, the larger recipients of income subsidies are France (16.5 million euros) and Spain (13.6 million euros). The amount of subsidy distributed in the UK is rather low in relation with the production volume (0.4 million euros). As for fisheries, the largest subsidy rates are provided in relative small producing countries like Slovenia (30%) and Bulgaria (15%), while largest producers exhibit subsidy rates between 1% and 2%. In the global context, income subsidies rates are comparable, except for Russia (see Table 6).

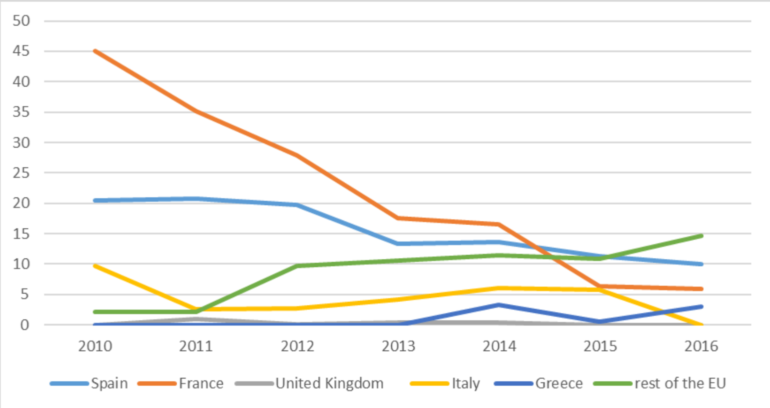

Figure 5. Direct income subsidies in aquaculture by EU member states, million euros, 2010-2016
Source: Own elaboration from STECF (2018a).

There is a significant decline of the total value of subsidies between 2010 and 2016, from 77 to 34 million euros (Figure 5). This is driven largely by a decline of subsidies in France, negatively affected by high mortality of oysters, and some data scarcity issue (STECF, 2018a). Table 4 shows the evolution of subsidy rates in aquaculture over the period 2011-2016.

Table 4. Subsidy rates in total aquaculture in MAGNET aggregation

Regions/years	2011	2012	2013	2014	2015	2016
Western Europe	0.00	0.00	0.00	0.00		
Eastern Europe	0.12	0.03	0.06	0.05		
Southern Europe	0.00	0.02	0.02	0.02	0.02	0.03
Northern Europe	0.00	0.00	0.00	0.00	0.01	0.00
France	0.04	0.03	0.02	0.02	0.01	0.01
Italy	0.01	0.01	0.01	0.01	0.01	
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00
Spain	0.04	0.04	0.03	0.02	0.02	0.02
UK	0.00	0.00	0.00	0.00		
Greece			0.00	0.00	0.00	0.01
Ireland	0.00	0.00	0.01	0.01	0.01	0.02

Note: Blank refers to no data available.
Source: Own elaboration from STECF (2018a).

The subsidy rates vary by aquaculture sector and member state (Table 5). For instance, in Spain, subsidy rate in crustaceans is rather high (0.36), whereas in an aggregated Eastern Europe molluscs benefit from a high support rate (mainly driven by Bulgaria). Crustaceans present also high support rate in Ireland. As no direct subsidy data is included in the GTAP database, we shock the variable output tax/subsidy (*to*) in the first-time period (2014-2020) to include the direct subsidy on aquaculture sector productions.

Table 5. Subsidy rates in aquaculture per group in MAGNET, 2014

Regions/sectors	crustaceans	diadromous	fresh	marine	Molluscs	total
Western Europe					0.00	0.00
Eastern Europe	0.00	0.03	0.04	0.00	0.53	0.05
Southern Europe	0.00	0.01	0.05	0.01	0.03	0.02
Northern Europe		0.00	0.00		0.00	0.00
France	0.02	0.00			0.02	0.02
Italy	0.00	0.02	0.00	0.01	0.01	0.01
Netherlands					0.00	0.00
Poland		0.02				
Spain	0.36	0.00	0.03	0.02	0.02	0.02
UK		0.00			0.01	0.00
Greece	0.00	0.00	0.00	0.00	0.00	0.00
Ireland	0.10	0.01	0.04	0.00	0.01	0.01

Note: Blank refers to no data available.
Source: Own elaboration from STECF (2018a).

4.3. Non-EU fisheries and aquaculture subsidies

Table 6 reports the data for the non-EU countries. With respect to the production value, China stands out with fisheries and aquaculture production values of 33 billion and 64 billion euros respectively. In terms of subsidy rates in fisheries, largest ratios are shown in South Korea and USA (0.26 and 0.31 respectively). Subsidy rates in aquaculture are rather moderate, except in Russia (0.26).

Table 6. Production value, subsidies and subsidy rates in the major non-EU countries

Regions	Production value (million euros)		Direct subsidies (million euros)		Subsidy rates per unit value	
	wild fish	aquaculture	wild fish	aquaculture	wild fish	aquaculture
Japan	7,436	2,520	239	0	0.03	0.00
South Korea	4,246	1,130	1,096	19	0.26	0.02
China	32,800	64,460	555	86	0.02	0.00
Russia	5,800	340	115	39	0.02	0.11
Taiwan	1,740	1,140	17	2	0.01	0.00
USA	4,970	1,220	1,527	0	0.31	0.00
EU	7,489	3,134	59	33	0.01	0.01

Source: Own elaboration from European Commission (2016).

5. Baseline at the horizon 2050

The database is aggregated into 36 countries or regions and 44 commodities presented in Table 7. The regional disaggregation takes into account the most important fish producing countries. The baseline (and scenarios) are run for 5 periods ranging from 2014 to 2050.

The baseline assumes that the availability of fish stocks remains constant over the period 2017-2050. The years 2014-2017 have been shocked to values reported by FAO (2018a). Based on aquaculture growth projections of the FAO we assume a moderate technological development in aquaculture production worldwide in the period 2014-2030 (World Bank, 2013). The assumed GDP and population growth are based on the Shared Socioeconomic Pathway 2 (SSP2) scenario of the IPCC (O'Neill et al., 2017). The SSP2, with moderate GDP and population growth, is referred as the *middle of the road* and therefore considered as a suitable baseline (Arnell and Kram, 2011). Overall, baseline results are consistent with latest prospects and trends from OECD-FAO agricultural outlook at the horizon 2028 (OECD/FAO, 2019).

Table 7. MAGNET data aggregation

Periods (4):
2014-2020; 2020-2030;2030-2040; 2040-2050

Regional Aggregation (36 countries/regions):
Eastern Europe: Poland, Rest Eastern Europe, Rest Europe
Northern Europe: Ireland, Norway, United Kingdom, Rest Northern Europe, rest of EFTA,
Southern Europe: Greece, Italy, Spain, Rest Southern Europe
Western Europe: France, Netherlands, Rest Western Europe
Asia, Russia, and Oceania: China, Hong Kong, Mongolia and Taiwan, India, Indonesia, Japan, Korea, Malaysia, Philippines, Rest of Asia, Thailand, Turkey, Viet Nam, Russia, Oceania
Africa: Egypt, Morocco, rest of Africa
America: USA and Canada, Brazil, Chile, Mexico, rest South and Central America

Sectoral disaggregation (44 commodities):
Aquaculture and wild fish (6 commodities): Crustaceans (Crust); Diadromous fish (Diad); Freshwater fish (Fresh); Marine fish (Marin); Molluscs (Molus); Wild fish (fsh)
Primary agriculture (5 commodities): Paddy rice (pdr); Wheat (wht); Other grains (grain); Oilseeds (oils); Vegetables, fruits and nuts (hort); Other crops (crops)
Livestock (6 commodities): Cattle and sheep (cattle); Pigs and poultry (pigpoul); Raw milk (milk); Meat (cmt); Meat product (omt); Dairy (dairy)
Processed food (4 commodities): Sugar processing (sugar); Vegetable oils and fats (vol); Other food and beverages (ofd); Processed fish (fishp)
Feed (4 commodities): Animal feed (feed); Crude vegetable oil (cvol); Fishmeal (fishm); Oil cake (oilcake)
Industry and services (18 commodities): Biodiesel (biod); Biogasoline (biog); DDGS (ddgs); Chemicals (chem); Coal (coa); Crude oil (c_oil); Electricity (ely); Electricty from hydro (ely_h); Electricty from wind and solar (ely_w); Ely fossil (ely_fossil); Fertilizer K (fert_k); Fertilizer N (fert_n); Fertilizer P (fert_p); Forestry (frs); Fossil gas (gas); Other industry (othind); Petroleum (petro); Services (serv)

Baseline results are driven by the macroeconomic development assumptions, fish stocks, subsidies and technological growth. The biggest nominal GDP growth is expected in Asia and Africa. Population growth is expected to be highest in Africa and Oceania. In Europe, the population growth is expected to be slight or even negative in the case of Eastern Europe. GDP growth will be moderate for most EU countries.

At the horizon 2050, aquaculture production is still growing fast in most countries especially in Asia. Overall Asia is and will remain by far the highest producer of fish related products. Asia produces 70% of all fish products in 2050. Within Asia, China is the biggest producer with more than half of fish production. The production of wild fish is fairly constant in most regions, apart from Africa where production is still increasing due to an increased demand for wild fish by a fast increasing population.[6] The growth of aquaculture production is expected to continue to outpace the growth of fisheries due to limited capacity of fish stocks to produce more and expected technical change in the aquaculture sector. While overall aquaculture production is the largest in Asia, the growth rate of aquaculture products is higher in other regions as show in Figure 6. Processed fish production is also increasing in most regions.

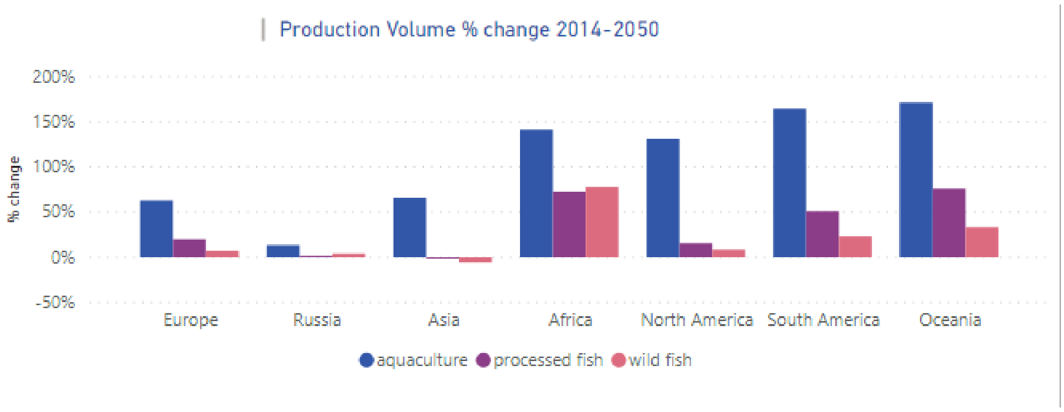

Figure 6. Production volume of fish products, % change
Source: MAGNET results.

[6] Results of every sector, at both regional and country level, are available upon request to the authors.

The expected development of nominal fish prices is shown in Figure 7. For most regions, consumer prices for fish products decline. This is mostly due to a decline in aquaculture prices. Aquaculture is expected to become more feed efficient and will therefore experience a reduction of cost per unit of output. To stay competitive with aquaculture fish, wild fish prices will also slightly decline. The price of processed fish is behaving differently in the various regions in the world. In most regions the price is fairly stable or declining because aquaculture and wild fish products (inputs) that the sector processes are becoming cheaper. However, in Africa the price is increasing. As a country or region is becoming richer, it is expected that consumers will switch from primary food products to processed food products. In Africa, GDP is expected to increase sharply, with consumers demanding more fish, in particular processed fish, pushing up the price of processed fish products.

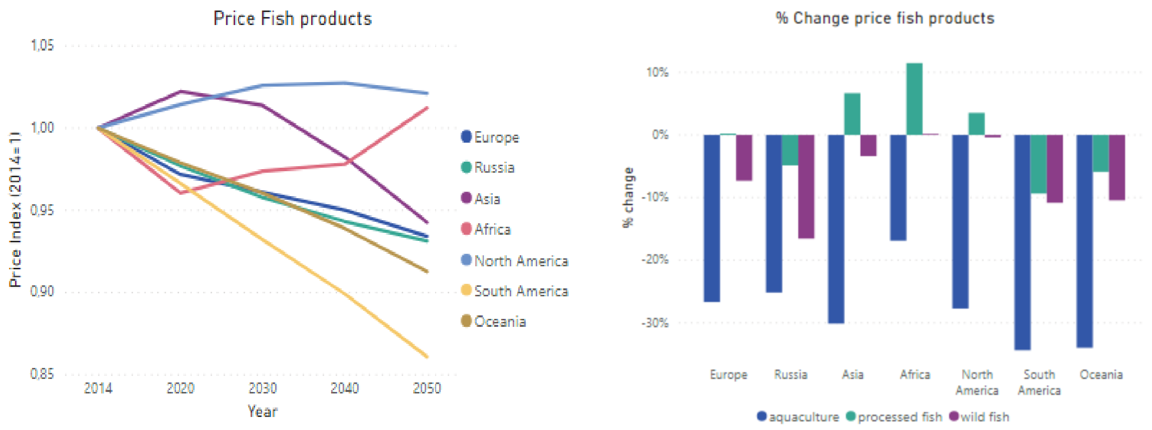

Figure 7. Consumer price of fish products, price index (left), % change (right)
Source: MAGNET results

Total consumption of fish products remains by far the highest in Asia in 2050, but consumption increases the most in Oceania and Africa. The increase is moderate in Europe, with aquaculture showing the highest growth rate in all the regions (Figure 8). Over the period 2014-2050, overall fish consumption per capita increases the most in Europe (17%) and Oceania (20%), the largest increase being the consumption of aquaculture products. In Asia and Africa the overall consumption of fish per capita slightly declines (-3% and -1%respectively) mainly because of strong demographic pressure (the rise of population is higher than the increase in fish consumption). It should be highlight that in all region consumption per capita of aquaculture increases.

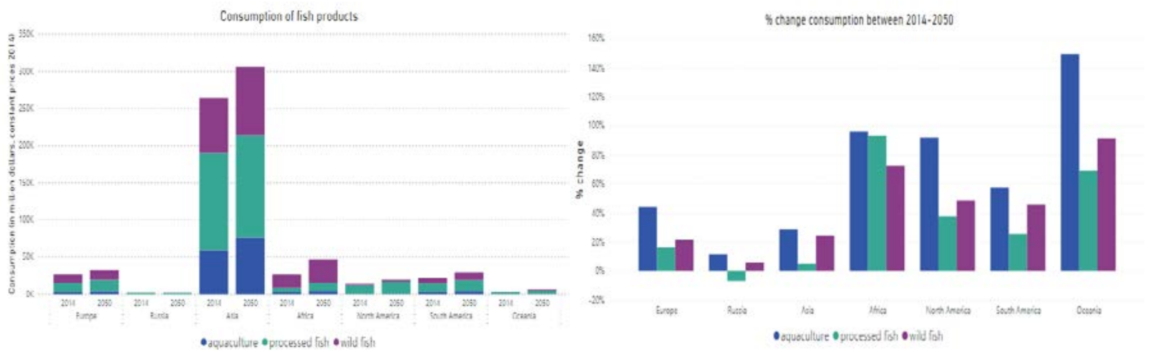

Figure 8. Consumption of fish products, million dollars (left), % change (right)
Source: MAGNET results

Taking advantage of fish and aquaculture sector disaggregation, Figure 9 shows different consumption per capita by European region. In the Northern European countries, most of the fish consumed is processed fish whereas in Southern countries most fish consumed is wild unprocessed fish. These consumption patterns stay relatively stable over the period 2015-2050.

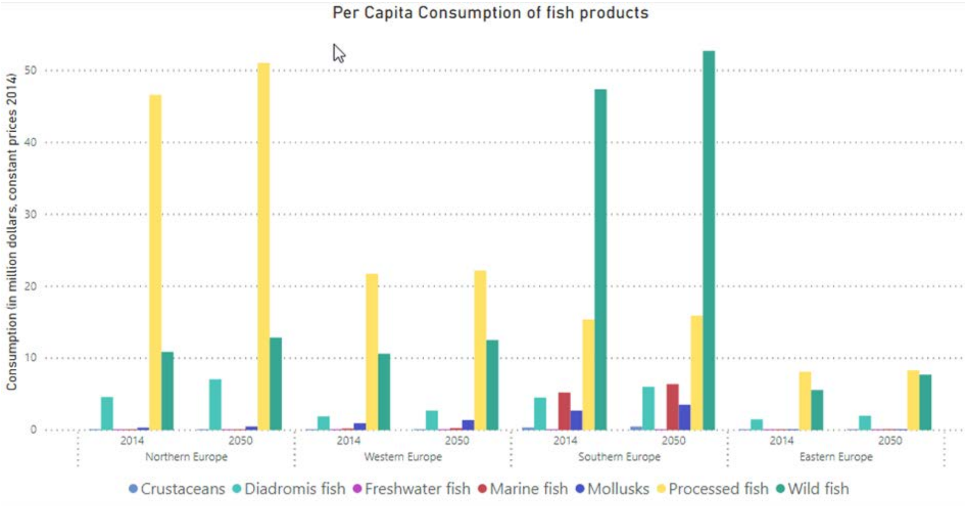

Figure 9. Per capita consumption of fish products by European regions, disaggregated aquaculture sector, million dollars
Source: MAGNET results.

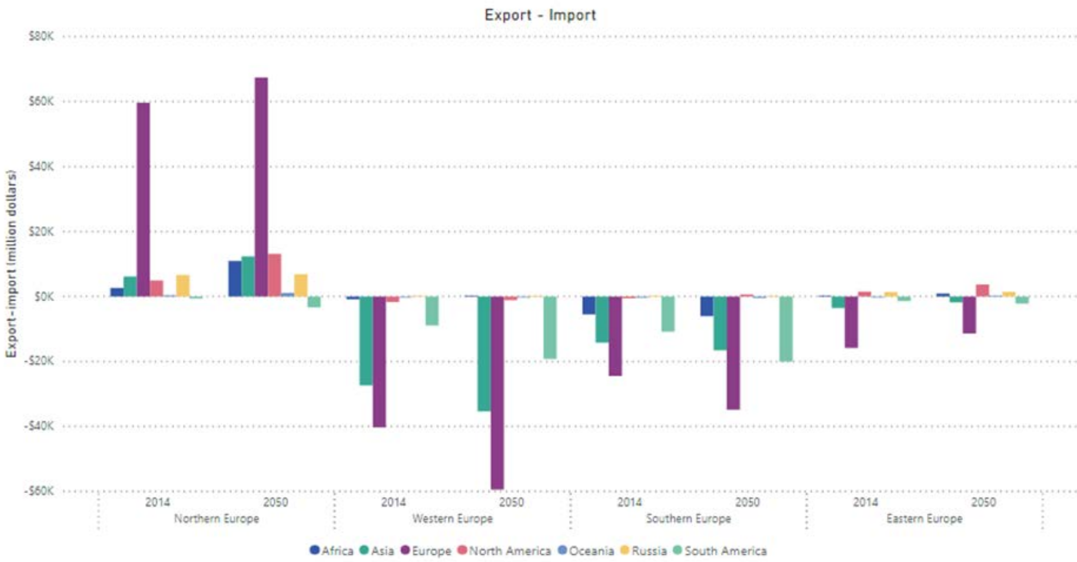

Figure 10. Trade balance in fish products by European regions, million dollars
Source: MAGNET results.

Figure 10 shows the trade balance for fish products in Europe. Most trade is intra-European trade. Overall, the Northern European countries are net fish exporters and the rest of Europe is net fish importers. Trade patterns hardly changes between 2014 and 2050. Northern Europe exports massively to the rest of Europe. Trade between Northern Europe and the rest of Europe is expected to increase in 2050. Northern Europe is also expected to start exporting more to the rest of the world, especially Africa, Asia and North America. The increase of exports are mostly aquaculture products and processed fish. Imports from Asia are expected to increase in Western and Southern Europe. Eastern Europe increases its exports of fish products faster than its imports. Negative trade balance get smaller.

6. **Scenarios**

Three simulation scenarios propose to scrutinise the nexus between (low/high) aquaculture subsidies under (low/high) demand for fish products.

An important consideration in this modelling exercise is the expected channel between income subsidies and production volume. The low subsidy rates provide room for simulating increase in public support. We propose to increase EU27 aquaculture subsidy at the horizon 2050 by 20% and 60%. Support in the UK, rather low, remains unchanged. The impact of subsidies can also influenced by the demand for fish products. The World Bank (2013) shows a moderate expected increase in the demand for fish products, FAO (2018b) a very slight global decrease but increase in low-and middle-income countries. Change in demand is driven mainly by population growth, rising incomes and urbanization. Historically the boom in aquaculture products has been also facilitated by the strong expansion of food fish production together with more efficient processing, storage and distribution channels (FAO, 2018a). Still, demand shifts are difficult to predict. Rabobank (2018) looks specifically at Chinese demand for fish products. This report shows that consumer preferences for fish are shifting possibly faster than World Bank and FAO expect. It remains to be seen how different paths in fish and aquaculture demand have on worldwide production given possible change in aquaculture subsidies. We propose to simulate a world demand growth of 2% and 4% extra per year compared to the baseline.

The three scenarios adopt an incremental approach. First, we discuss how aquaculture subsidies influence production, prices, and trade of fish products given the expected demand for fish products as projected by World Bank (2013). Then we explore the effect if the demand for fish products increases faster and further. Finally, we explore the cumulative effects of both increase in aquaculture subsidies and worldwide fish demand. Results are presented in absolute or relative change compared to the baseline in 2050.

6.1. Impact of extra subsidies for aquaculture production

Additional subsidies on aquaculture products have a positive impact on the production of aquaculture in Europe as shown in Figure 11. Both aquaculture production and processed fish increase in European aggregates. The increase is the smallest in Northern Europe as this region also includes Norway and the UK (it is assumed that these two non-EU27 countries do not increase their aquaculture subsidies). The increased production of aquaculture has a small negative impact on the wild fish production. Intermediate demand for fish by the fish processing sector switches partly from wild fish to cheaper aquaculture fish, driving down the production of wild fish sector. It should be mentioned here there is no clear/complete substitution between wild captured fish and aquaculture products, especially at species level (e.g., wild vs. farmed salmon). The EU aquaculture subsidies also have a small negative impact on the production of fish product in the rest of the world. Europe imports slightly less from the rest of the world thus driving down the production of fish product in Asia and South and Central America.

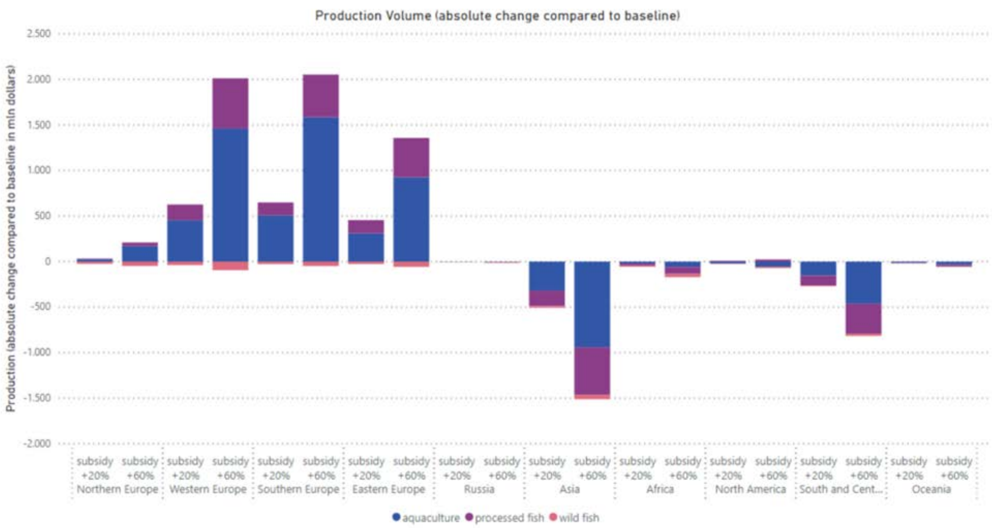

Figure 11 Production volume of fish products, 20% vs. 60% aquaculture subsidy increase, million dollar change
Source: MAGNET results.

A large part of the subsidy on aquaculture products is transferred to the consumer through a decrease in consumer price. Aquaculture products become much cheaper in Europe, up to 25% in Southern Europe with a 60% increase in subsidies by 2050 (Figure 12). Aquaculture fish also becomes cheaper in Russia. Due to the aquaculture subsidies, Eastern Europe extends production of aquaculture products and increases export of aquaculture products to Russia. This leads to a price decrease of aquaculture fish in Russia. In the rest of the world, the increase trade with Europe is not large enough to have a significant impact on the price of fish products. Therefore total demand for fish products increases, with the highest increase in Southern Europe. As the price of processed fish also decreases due to the aquaculture subsidies, the demand for processed fish increases in Europe. Furthermore, Europe starts exporting more processed fish to Asia. This leads to a small price decrease of processed fish in Asia, which in turn leads to a small increase in the demand. Some aquaculture fish is substituted with cheaper processed fish in Asia.

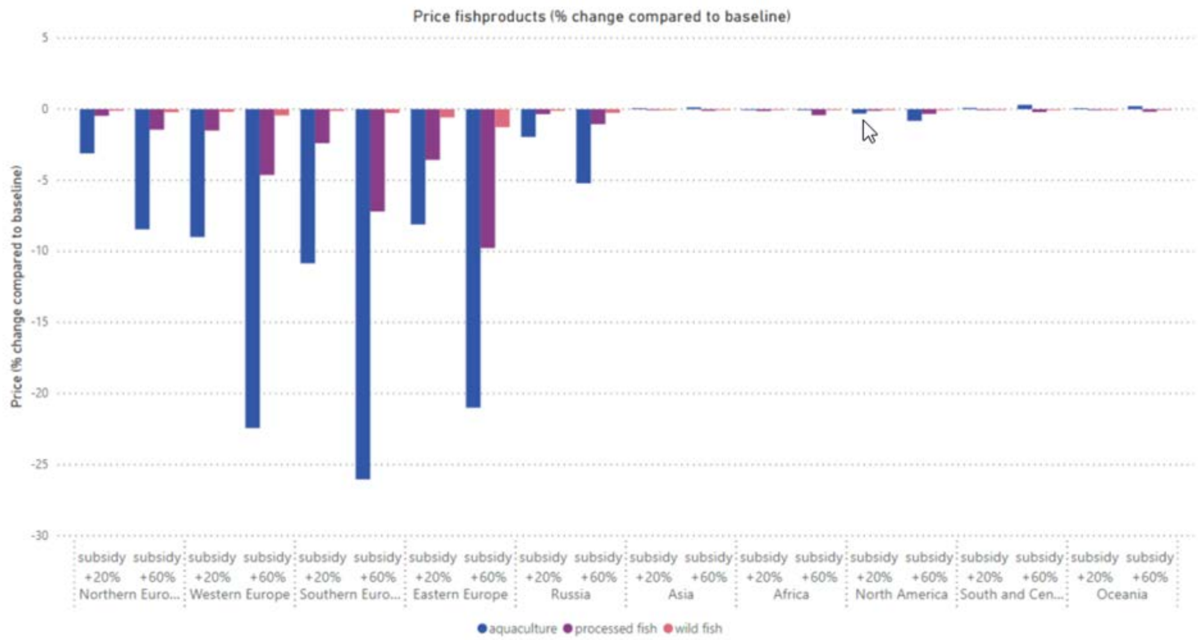

Figure 12. Consumer price of fish products, 20% vs. 60% aquaculture subsidy increase, % change
Source: MAGNET results.

The trade balance for fish products improves for the European countries. While most European countries remain net importers of fish products, the difference between export and imports decreases. While more aquaculture products are traded, the biggest increase in trade is seen in processed fish that becomes cheaper because of cheaper aquaculture fish that is used in the processed fish sector. Figure 13 shows the change in export of fish products due to the extra subsidies in aquaculture. It is noticeable that further subsidy on European aquaculture increases intra-European trade of fish products the most. Northern Europe trades less because of the absence of extra support in Norway and the UK. Isolating these two countries would be useful since it is expected that the EU will still import Atlantic salmon from Norway. Trade with other regions in the world also increases but far less than trade within Europe. The increased intra-European trade does have an impact on the fish products traded by other regions in the world as shown in Figure 13. With the subsidies, Europe imports less from all other regions in the world since it can produce more at lower prices.

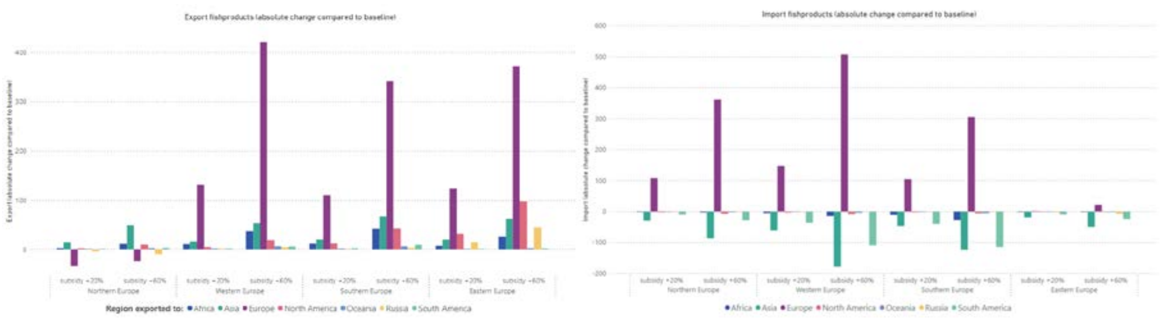

Figure 13. Exports (left) and imports (right) of fish products by European regions, 20% vs. 60% aquaculture subsidy increase, million dollar change
Source: MAGNET results

6.2. Impact of increased demand for fish products

A higher fish demand impacts worldwide production of fish products, especially in Asia (Figure 14). The production of aquaculture and processed fish grow the most due to limited stocks of wild fish. The higher demand has a significant impact on the price of fish products. The price of fish products increases between 3% and 9% for aquaculture products, between 13% and 39% for wild fish products. The difference in price increase is caused by the difference in production. Aquaculture production can grow enough to meet the higher demand, therefore the price increase is relatively modest. Wild fisheries production cannot increase enough to meet the extra demand due to limited fish stocks.

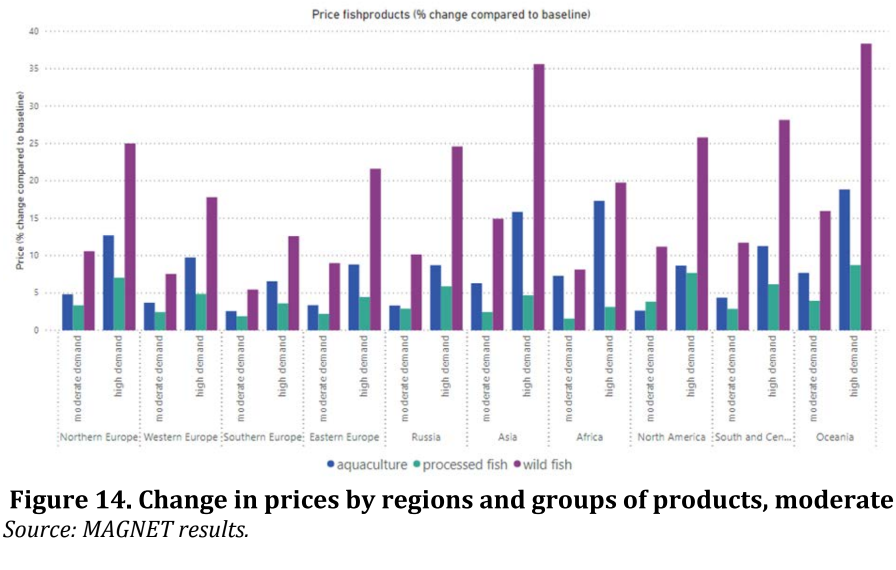

Figure 14. Change in prices by regions and groups of products, moderate vs. high demand, %
Source: MAGNET results.

The increased demand for fish products stimulates trade. Norway, especially, exports more fish products to Europe. Other European countries also trade more but on a moderate scale (Figure 15). While imports from other European countries increase the most, the increased demand for fish products in Europe is also met by supply from Asia and South America. For most regions in Europe, the imports increase more than the exports, therefore deteriorate trade balance for fish products.

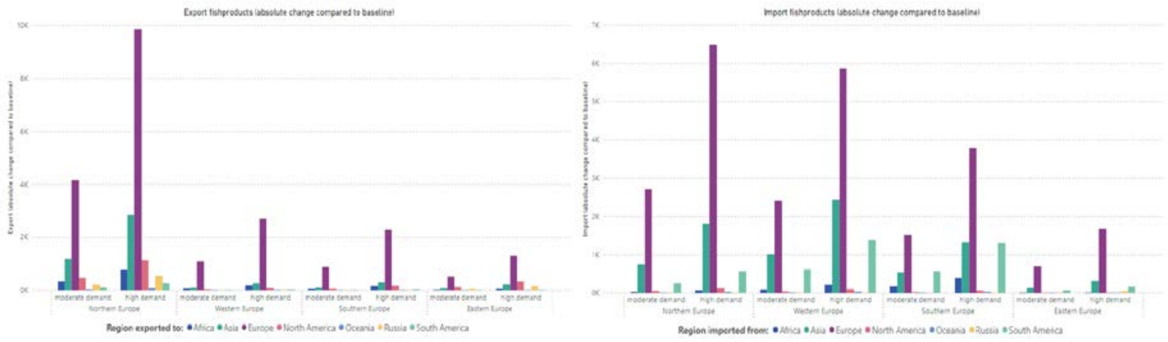

Figure 15. Exports (left) and imports (right) of fish products by European regions, moderate vs. high demand, million dollar change
Source: MAGNET results.

6.3. Impact of both extra subsidies for aquaculture production and increased demand for fish products

To analyse the impact subsidies have, given different assumptions about the development of demand for fish products, we calculate the change due to an increased subsidy (60%) compared to the baseline with higher demand. In the lower demand scenario, the fish demand corresponds to the one of the baseline; in the moderate and high scenarios, the fish demand increases by an additional 2% and 4% a year over the period. Results show larger aquaculture subsidies have a higher impact depending on the world fish demand. Aquaculture and fish processing will grow substantially more in Europe. Production of wild fish will slightly decline. Still aquaculture subsidies in Europe have a decreasing impact on fish production, especially in Asia and South and Central America. Surprisingly. The change in price of fish products due to the aquaculture subsides is hardly affected by the assumptions about the development in demand for fish products. This means the decrease in fish price is rather similar with the several assumptions of increase in demand.

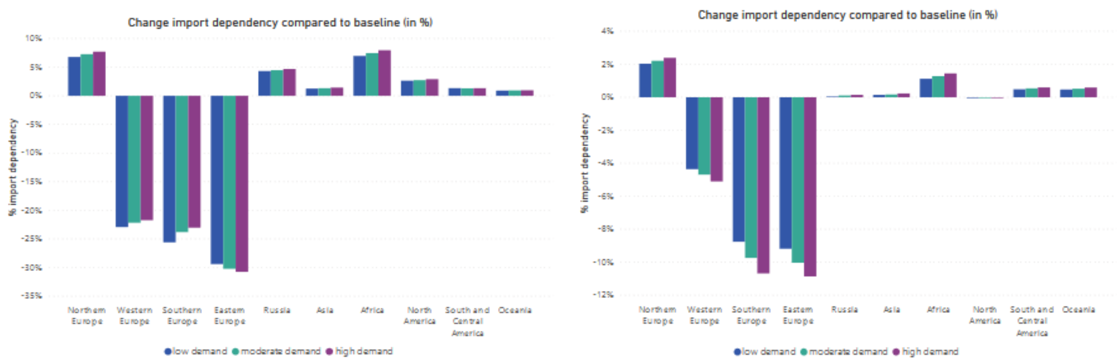

Figure 16. Import dependency for aquaculture (left) and fish processing (right) with a 60% aquaculture subsidy increase, baseline vs. moderate vs. high demand, % change
Source: MAGNET results.

The impact on trade patterns is similar to previous scenarios. Larger subsidy on aquaculture increases the intra-European trade. Especially with a high demand for fish products, the European aquaculture sectors produce more for the European market making Europe less dependable on foreign imports (Figure 16). Europe also starts exporting more to the rest of the world due to the aquaculture subsidies especially when the demand for fish products is high. Overall, the EU remains net importer of aquaculture products but improves its self-sufficiency. Interestingly, all regions in the world increase imports from Europe, especially Asia, Africa and North America.

7. Concluding remarks

This paper is the first attempt of analysing the EU aquaculture sector following a disaggregated approach and including public subsidies within a global CGE modelling framework. Using the MAGNET model, it distinguishes five aquaculture sectors, one wild-capture fisheries and one fish processing sectors. Furthermore, it adds to the system fishmeal and fish oil processing sectors. Both modelling and data adjustments are needed to properly integrate these new features. This paper considers individual cost structures for these newly added sectors as well as the representation of subsidies in aquaculture. It sets up a baseline at the horizon 2050, looking how the fish related sectors are expected to develop and what could change if EU public support would be increased. It also analyses whether the impact of the aquaculture subsidies could differ substantially if the demand for fish products would develop more rapidly than expected.

The baseline results show that aquaculture is expected to grow. The sector becomes more feed efficient. In absolute terms, Asia and in particular China are the largest producers of fish and aquaculture products. This is not expected to change by 2050. However, since the growth of aquaculture products is higher in other regions, the rest of the world is slowly catching up with Asia. The expected growth in aquaculture products is modest in European countries, less than half the growth of regions like Africa, North America, South America and Oceania.

Adding subsidies to aquaculture products has a significant impact on the price of aquaculture products. The impact on the production is more modest but significant. The junction of increased production and decreased price stimulates trade in aquaculture products. Most of the increased trade is intra-European trade but also between Europe and mainly China and South and Central America.

Increasing the aquaculture subsidies does not benefit the aquaculture sector only. It also benefits the fish processing sector. Due to decreased price of intermediate products, the processed fish sector can expand production and reduce price. This in turn stimulates the trade in processed fish products. Wild fisheries are slightly worse due to the absence of extra-subsidies and production constraints. To remain competitive the sector needs to reduce its price and production declines in some European regions. As the demand for fish switches partly from wild to farmed fish, the price of wild-captured fish declines. Interestingly, fish is often modelled using inverse demand systems (i.e., quantity is not a function of price, but price is a function of quantity). Modelling assumptions assume incomplete substitution between wild-captured and farmed fish. Indeed, limited potential increases in catches from fish stock constraints dramatically the development of wild fisheries. The fall in wild fish prices leads to a reduction of production in some European countries as fishing becomes less profitable. The overall impact of aquaculture subsidies in the EU is expected to be very modest for the rest of the world.

Some strong assumptions expose robustness of the results. First, the paper assumes that fish stocks remain stable over the time. This assumption is made because of a lack of available data; however, it would be preferably to include a trend or dynamics in the status of fish stocks. Also performing sensitivity analysis for key elasticities would allow to better capture some substitutions (i.e., between fish stocks and the rest of inputs in the wild fish sector, between wild fish and aquaculture products). In addition, robust data on technical change in the sectors are missing.

Second, aquaculture subsidies are modelled as output subsidies whereas they may be more akin to transfer payments. More research is needed to analyse how the subsidies should be implemented and if implemented as transfer payment, to which factor. Data used (available) are direct income subsidies to aquaculture, whereas investment subsidies in the EU aquaculture sector by member state and main species would be needed. This calls for further work on how public support affect productivity in fisheries and aquaculture sectors.

Importantly, there are tough negotiation at the WTO to regulate harmful fisheries subsidies, going well beyond aquaculture subsidies. Sustainable Development Goals (SDGs) target 14.6 sets a deadline of 2020 for prohibiting certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminating subsidies that contribute to illegal, unreported and unregulated fishing (United Nations, 2015). Modelling accurately these subsidies within a CGE framework is still missing, with scarce data on activity, natural resources and support. The Fisheries Support Estimate (FSE) database from OECD (2017), which provides budgetary support to fisheries in 33 countries and economies that amounts 13 billion USD, could be considered as valuable source. Integrating (part of) these support estimates within the GTAP database, as already done for agricultural domestic support, would allow to improve CGE analysis of fisheries and aquaculture.

Third, trade policy in fisheries and aquaculture products is absent of the analysis. Beyond existing tariffs, countervailing and anti-dumping measures, international trade faces a high range of standards regarding the origin, labelling, and the sanitarian or environmental dimensions of the production processes (e.g., use of antibiotic, pesticide, and other chemicals products). FAO (2018c) highlights that on average the number of technical measures applicable to fish products is about 2.5 times higher than those applicable to manufactured products, with critical consequences to developing countries since they are major suppliers of fish and fish products in international trade. There is still a lack of literature assessing the trade restiveness of NTMs in fisheries and aquaculture sectors. Dey et al. (2005) show that the implementation of the standards on fish and seafood exports in Asia significantly increases the cost of processing (with a cost per unit of processed fish higher for smaller plants). Nimenya et al. (2012) estimates ad valorem tariff equivalents ranging from 63% to 270% for imports of frozen fish fillets in EU countries from Kenya, Tanzania, Uganda, and Zambia. Recent bilateral estimates by group of species are dramatically missing.

Fourth, *Brexit* and new trade relations between the EU and the UK, and the UK vis-à-vis third countries such as Norway, Iceland, Asian countries, etc. are not considered. Given the importance of the UK for the EU fisheries and aquaculture sectors, more as a producer than consumer, *Brexit* will cause strong implications. For instance, in the diadromous fish sector, 90% of EU Atlantic salmon production come from the UK (Scotland) in 2016. Bartelings and Smeets Kristkova (2018) propose an impact analysis of a hard Brexit using the MAGNET model. They conclude that a hard Brexit would imply a lose-lose situation with notable welfare losses due to increased protectionism and misallocation of resources. Having a better idea of the coming relation between the UK and the EU27 is critical to provide more robust assessments.

Fifth, aquaculture production cannot be considered completely benign and various environmental impacts have been identified. These impacts (i.e., externalities) are diverse and not included in the present modelling framework. They include aspects such as adding physical structures to the environment that may entrap wildlife and affect currents, sedimentation and light; removing wild individuals and affecting habitat and ecology, etc. (Science for Environment Policy, 2015). For example, Roheim (2004) estimates that more than 60% of Asia's mangroves have been converted into aquaculture farms leading to habitat loss and land degradation.

Finally, the recent outbreak of the COronaVIrus Disease (COVID-19) is having an important impact on the economy and lives of millions of people (Shereen et al., 2020). Fisheries and aquaculture sectors have also been affected by the outbreak. In particular, fisheries effort and landings have in general terms decreased due to decreases in demand and constraints in the distribution. This decrease in demand is due to the shutdown of the HORECA channel (hotels, restaurants and catering) and lower home consumption of fresh fish and seafood, which led to price decreases. However, the impact is not homogeneous, and frozen and canned fish sales have not been reduced, even increased during this crisis compared to previous years. The impact for the aquaculture sector has been lower than for wild-capture fisheries, but still significant. The reduction in fresh fish demand has led to some decreases in the sales of aquaculture products. Currently, it seems that the outbreak is being controlled in most countries. This should lead to similar consumption patterns to the ones before the crisis; however, it is still pending to see if consumption will fully recover and will not be affected by an overall decrease in income due to the economic impacts of the COVID-19.

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Table A1. Public spending on aquaculture by multiannual financial framework (MFF) and EU member states, euros

	FIGF (2000-2006)			EFF (2007-2013)			EMFF (2014-2020)		
	National	EU	**Total**	National	EU	**Total**	National	EU	**Total**
Austria	3,462,350	2,575,974	**6,038,324**	2,831,494	2,931,120	**5,762,615**	4,353,925	3,604,000	**7,957,925**
Belgium	753,627	724,268	**1,477,895**	348,575	193,522	**542,097**	5,790,000	6,725,000	**12,515,000**
Bulgaria				4,131,128	12,393,383	**16,524,511**	9,053,750	27,161,250	**36,215,000**
Croatia							18,420,397	55,261,186	**73,681,583**
Cyprus	1,035,485	621,291	**1,656,776**	933,125	933,125	**1,866,249**	3,150,000	9,450,000	**12,600,000**
Czech Republic	1,181,139	2,755,989	**3,937,128**	3,332,110	9,996,314	**13,328,424**	6,924,050	20,772,150	**27,696,200**
Denmark	1,407,105	4,207,519	**5,614,624**	11,742,743	8,755,682	**20,498,424**	8,583,500	25,750,497	**34,333,997**
Estonia	926,660	1,935,828	**2,862,488**	1,872,579	5,617,731	**7,490,310**	4,467,471	13,402,413	**17,869,884**
Finland	3,995,776	3,363,553	**7,359,329**	5,739,738	4,408,481	**10,148,218**	22,100,000	15,600,000	**37,700,000**
France	21,708,903	21,206,278	**42,915,181**	19,369,872	13,058,423	**32,428,295**	29,596,569	88,789,702	**118,386,271**
Germany	5,533,934	9,186,502	**14,720,436**	5,944,830	12,523,925	**18,468,755**	21,410,667	64,232,000	**85,642,667**
Greece	10,127,748	35,046,138	**45,173,886**	8,947,902	6,623,129	**15,571,031**	22,439,696	67,319,086	**89,758,782**
Hungary	962,402	3,062,394	**4,024,796**	8,122,605	24,025,515	**32,148,120**	8,589,375	25,768,125	**34,357,500**
Ireland	5,450,960	27,867,457	**33,318,417**	3,706,033	1,833,451	**5,539,484**	14,900,000	14,900,000	**29,800,000**
Italy	40,624,542	32,945,099	**73,569,641**	9,782,029	18,552,023	**28,334,052**	110,567,415	110,567,415	**221,134,830**
Latvia	686,087	1,114,914	**1,801,001**	6,394,859	19,184,574	**25,579,433**	11,566,667	34,700,000	**46,266,667**
Lithuania	1,182,097	1,247,218	**2,429,315**	3,017,534	9,052,602	**12,070,136**	7,073,008	21,219,022	**28,292,030**
Malta	14,135	98,942	**113,077**	101,253	303,758	**405,011**	826,706	2,480,116	**3,306,822**
Netherlands	698,024	418,813	**1,116,837**	3,060,718	1,513,684	**4,574,402**	1,640,000	4,920,000	**6,560,000**
Poland	3,603,519	14,302,468	**17,905,987**	31,545,226	94,605,496	**126,150,722**	67,246,817	201,740,451	**268,987,268**
Portugal	35,469,873	27,509,372	**62,979,245**	3,766,454	11,299,365	**15,065,819**	19,666,667	59,000,000	**78,666,667**
Romania				16,448,179	49,344,538	**65,792,717**	28,085,982	84,257,945	**112,343,927**
Slovakia	453,102	1,057,238	**1,510,340**	6,843,875	5,132,906	**11,976,781**	3,135,510	9,406,530	**12,542,040**
Slovenia	94,598	283,270	**377,868**	1,245,432	3,736,295	**4,981,726**	2,000,000	6,000,000	**8,000,000**
Spain	67,841,690	141,376,484	**209,218,174**	57,367,018	41,434,134	**98,801,152**	68,635,448	205,905,843	**274,541,291**
Sweden	400,794	1,787,110	**2,187,904**	8,088,051	5,380,020	**13,468,072**	7,914,184	11,871,275	**19,785,459**
United Kingdom	7,500,466	17,416,421	**24,916,887**	4,288,218	7,111,962	**11,400,180**	6,442,778	19,327,305	**25,770,083**
Total	215,115,016	352,110,540	**567,225,556**	228,971,580	369,945,156	**598,916,736**	514,580,582	1,210,131,311	**1,724,711,893**

Note: FIGF (2000-2006) and EFF (2007-2013) correspond to real spending; EMFF (2014-2020) corresponds to planned spending.

Source: STECF (2016).