Impact of Technical Innovations to Protect Resources: The Case of Plaice in the EU

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Abstract:

The paper analyses effects in the European fish sector which might occur due to technological innovations (pulse trawling in the case plaice) introduced under a regime of output controls to protect fish resources using. A partial equilibrium model (AGMEMOD) which covers among other agri-food products also 8 different fish categories is applied to conduct model simulations for the EU countries and some additional neighbouring countries European countries and the Rest of the world. The paper concentrates on plaice because the categories comprises very few fish species which allows to implement fish quotas and well as technological innovation. Therefore, this technology should contribute with the biomass protection as well as it proclaimed to increase fisher's profits. Hence, model results indicate production increases may occur due to slight bio mass growth or cost decline until quotas are reached. Hence, all production growth will affect future prices negatively as expected growth of use in European countries is lower than production growth. The implementation of the pulse will enhance the currently existing price pressure whereas the impacts will vary significantly across the different European countries, affected by the size of the margin and the share of energy cost in total cost.

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ABSTRACT

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Keywords: Fish model, AGMEMOD, partial –equilibrium model, baseline projections, pulse fishing, plaice, stock recovery

1. INTRODUCTION

During the last decades, fish stocks have faced unsustainable developments beyond their biological limits. According to the FAO (2016), the share of overfished fish stocks increased from 10% in 1974 to 31% in 2013. The same later year, 58% of the fish stocks are considered as fully fished so that stocks are under constant pressure limiting a potential recovery (FAO, 2016). Overfishing may drive the system into resource depletion if it overpasses the maximum sustainable yields levels, hindering the stocks recovery (FAO, 2016, Pope, 2009, Suuronen et al., 2012). Likewise, climate change is threatening marine resources and their ecosystems (FAO, 2016, Msangi et al., 2013). Changes in sea temperature and increasing ocean acidification alter the habitat as well, motivating their migration to other waters and at the same time promote the introduction of invasive alien species (FAO, 2016, Msangi et al., 2013). Remaining fish species will need to rapidly adapt to the new environment. All together with overfishing consequences, it will reduce productivity of fishery industry, as fishers have to sail longer distances to catch usual species or change technologies to catch new migrants species. To overcome the problem, fishers have increased fishing capacity and power of the vessels (Eigaard et al., 2014, Suuronen et al., 2012). However, those technological changes could induce undesirable impacts because uncontrolled fishing efforts led usually to overfishing, as fishers are required to increase their revenues (Eigaard et al., 2014, Emery et al., 2014, Suuronen et al., 2012) . A usual effect is a higher production of the target species but also higher levels of bycatches of non-targeted species and undersized target species alike which will be discarded. Although global discards seems to be reduced (FAO, 2016,), discards in some fisheries are still high and represent almost over 30% of total catches (Rasenberg, 2015, Suuronen et al., 2012). All together jeopardize not only the marine resources, but also the marine ecosystems (van Marlen, 2014). Therefore a major challenge for fisheries is to achieve an economic-sustainable production, without depleting marine resources and damaging aquatic ecosystems (Marchal et al., 2009, Msangi et al., 2013).

In order to overcome overfishing and to restore spawning biomass some management strategies have been developed: input and output controls (Eigaard et al., 2014, Fujii et al., 2017). Input controls are also known as fishing effort management, as it limits the effort[1] use for fishing (Pope, 2009). On the other hand, output controls restrict directly the amount of catches or the landing for specific species in a determined period of time, such as the total allowable catches (TAC). Through that measure, catches are intended to stay under sustainable levels and young and spawning fish are to achieve a protected stock rebuilding (Newell, Sanchirico, & Kerr 2005,). In this manner, the TAC regime fosters the maximum sustainable yield levels. Moreover in cases when stocks of certain species are considered fully-exploited and under risks to be overexploited, TAC levels could be reduce to guarantee the MSY levels (Marchal et al., 2009 Pinkerton, & Edwards, 2009). In addition, discards are threating the biomass as well. On the one hand, some of the gears, mainly used in beam trawls, cannot avoid the catches of non-targeted species, and on the other hand, much of the species returned to the sea are hardly survive (Suuronen et al., 2012). In this case, landing obligation policies intend to minimize pre-harvest mortality and to achieve post-harvesting of non-targeted and small-size targeted species (European Commission, 2013).

Although both, TAC and discard ban policies, should improve the balance between catches and fish stocks (Eigaard et al., 2014) they involve additional cost and income losses of fishers (Marchal et al., 2009, STECF, 2017). As fishers maximize their profits by increasing catches to the optimal limit, they are motivated to adopt technological innovations in order to reduce cost (Emery et al., 2014). Technological development plays an important role in resource conservation and environmental protection (Branch et al. 2006, Fujii et al., 2017). New technologies with respect to effective fishing will improve the balance between harvesting capacity and resource availability, will reduce damages to aquatic ecosystems, will contribute to less gas emissions, and at the same time will save operational cost (Quirijns et al., 2013). Some technologies are focused to reduce discards. As on average only 70% of total catches can be sold, discards represent significant economic losses. Additionally, fished quantities may include bycatches of non-target species under quota regimes. Therefore, fishers are obligated to buy quotas for these species (Suuronen et al., 2012). Some other technologies aim to reduce fuel consumption in order to reduce energy cost which is a major cost of fleets. Therefore fish profits are highly vulnerable to fuel prices volatility (Suuronen et al., 2012).

Since 2007 there is a new technology called electric pulse fishing has been developed to provide an alternative for beam trawls assuring to reduce fuel cost and diminishing damages for marine resources by flatfish catches. Although beam trawls are relatively easier to operate and are more effective regarding to amount of catches, their reputation is to provoke large negative environmental impacts. In beam trawls, the net tows the seabed and catches all marine resources in the area leading to high by catch ratios as well as to negative impact on seabed. Additionally, beam trawls require high levels of fuel. In the end, it results in a loss of sustainability and economically higher expenses (Taal & Hoefnagel, 2010).

On the contrast, pulse trawls use electric pulses to generate an electric field within the sea water inducing flatfish to jump out from the seafloor facilitating its capture and avoiding sweeping the seabed as the traditional beam trawls do (Van Marlen et al. 2014). Therefore electric pulse fishing increases cost effectiveness for the fishers and it is less invasive than the beam trawl fishing by: 1) savings on fuel consumption reaches as much as 50% (Van Marlen et al. 2014), and thus diminishes CO2 emissions (Van Marlen et al. 2014) 2), reduces discards and related indirect cost. Some studies indicate that pulse trawls are an effective alternative for beam trawlers for plaice fishing (Taal & Hoefnagel, 2010). Although the catches of plaice are lower, plaice fishing is more sustainable (Rasenberg et al., 2005), as it decreases discard from younger target species and such reducing the impact on spawning stocks (Taal & Hoefnagel, 2010).

However, this practice is still under regulation, as electric pulse is not allowed in the EU in general due to the fact that mechanical damage on marine species is not totally clear, yet (The Guardian, 2018).

[1] Fishing effort is a measure of the intensity of inputs used for fishing. It could be measured through different variables such as: time for fishing per vessel, size of vessel, number of trips per vessel, number of days at sea per vessel, kw/hour at sea per day per vessel, among others Ref 27.

Therefore, fishers have to apply each year to special permissions (Taal & Hoefnagel, 2010). Nevertheless, this situation might change in the current year, 2018, when the European Parliament will decide whether to approve or reject the technology in general. So to study ex ante likely economic impacts of that technology in combination with policies facilitates the decision making process. Ex ante impact assessment often involve the application of quantitative models to simulate future values of a business-as-usual scenario and compare it future values of policy and technology changes under counterfactual scenarios. Several models such as IMPACT Model (Delgado 2003, Msangi et al, 2013), the Asia Fish Model (Dey, 2008) or the Aglink-Cosimo model (OECD-FAO, 2016) evaluate the development of the fish sector. These models establish long terms baselines covering future changes in biomass, climate and technologies that affect the supply and demand of seafood market. Nevertheless, these models do not integrated effective cost of fishing and therefore they cannot derive impacts on fisheries themselves. There are also some bio-economic models such as Fish Rent (Salz et al., 2011) and EIAA (Frost et al, 2009), which mainly focus on stocks developments and management regimes such as TAC. Although these models integrate information of fishing cost and revenues, they are highly disaggregated by fleet segments and species levels. Besides, both models are optimisation models built on excel. Therefore, it is difficult to assess the interaction across fish categories within and between regions. In contrast, the current fish module of AGMEMOD (AGricultural Member States MODelling details see Chantreuill, Hanharan and Van Leeuwen 2012, Salamon et al 2009, Salamon et al 2018) integrates cost, production and management regiment information for different fish categories at EU Member State levels (Angulo et al. 2017a; Angulo et al. 2017b). The fish module of AGMEMOD is a partial equilibrium model developed under the SUCCESS[2] project and supported by the German Federal Government. The AGMEMOD fish model provides long-term projection for global fish supply, demand and price formation at fish category and country level for European countries and Rest of the world.

This study aims to assess effects of some specific policies to protect plaice population on the fishery sectors within the EU member states. The remainder paper is structured as follows: Section 2 describes the AGMEMOD fish model, details the fish categories comprised in the model, expose the variables, price formation and data sources used. Section 3 summarizes the baseline and outlines the scenarios. Section 4 presents the projection results and discusses the outcomes and section 5 finalize with the conclusions of the study and next steps. By the uses of AGMEMOD fish model, this study carries out two scenarios. Both consider a TAC regime for plaice, and consequently an increase in the stock and a direct technological innovation. Major details of scenarios would be described under section 3.

2. METHODOLOGY

MODEL

The AGMEMOD fish module covers the EU member states, Turkey, Norway and Iceland, places a stylized version for the rest of the world (ROW). In principle, for each of the countries markets are represented by supply, use, trade, and prices for different fish categories (see also Angulo et al. 2017; Angulo et al. 2017). The model version used in this paper follows the group classification for aquatic species defined by FAOSTAT (2016)[3] whereas only seven fish categories of the FAOSTAT group classification are considered which are all called fish in the following description:

- Cephalopods include i.e. octopuses, squids, cuttlefish, and nautiluses.
- Molluscs are excluding cephalopods, but comprise i.e. mussels, oysters and non-penaeid prawn.
- Crustaceans cover i.e. shrimp, prawn, lobster and crab.
- Freshwater and diadromous fish comprises fish that live in freshwater and/or migrate between freshwater and saltwater such as carp, salmonids, tilapia, bream, etc.

[2] Strategic Use of Competitiveness towards Consolidating the Economic Sustainability of the European Seafood Sector, European Research Project under H2020.
[3] For detailed description see: FAO Term Portal under http://www.fao.org/faoterm/collection/fisheries/

- Demersal marine fish refers to species that live and feed on or near the bottom of seas such as plaice, angler, flounder, grouper, soles, etc.
- Pelagic marine fish as a category refers to species that inhabit the pelagic zone of the ocean such as Mackerel, tuna, anchovy, sprat, etc.
- Other marine fish is the category that comprises other marine fish not included in pelagic or demersal marine fish.

Additionally a further category is induced, namely plaice, "*Pleuronectes platessa*", which is split-off from demersal marine fish. It will be considered as a single fish category to depict special developments in a sector relevant for certain EU member states. Then, the AGMEMOD fish module now, comprises in total 8 fish categories. For the readability of the paper, fish is considered as a collective term cover water-based animals species used as food (seafood).

The AGMEMOD fish model details supply, demand and trade relationships of each of the eight fish categories for each of the EU member states and the additional countries Iceland, Norway, and Turkey. All other countries are aggregated in one single group named as Rest of the World (RoW). Separate production and prices are considered for caught and aquaculture fisheries. In contrast, on the use side such a differentiation is not possible due to insufficient data with respect to trade and use although consumers may differentiate between both production systems. Unit values are applied as price proxies for demand, supply, and trade. Additionally, price proxies for production are affected by support and operational cost, in order to reflect on returns on caught and aquaculture fisheries. Trade varies across fish categories and among countries; therefore, it is incorporated as net trade for each fish category. It is implemented as the market clearing conditions, calculated within the model as world net exports equal to zero at the market clearing price for each category. Table 1 presents the list of endogenous variables of the model:

Table 1 Endogenous variables in AGMEMOD fish model

Supply Variables	Description
(1) $SUPPLY_{cc,comm}$	Total supply for category *COMM* in country *CC*
(2) $PROD\_TYPE_{cc,comm,\text{"PRa"}}$	Production of aquaculture fish category *COMM* in country *CC*
(3) $PROD\_TYPE_{cc,comm,\text{"PRc"}}$	Production of caught fish category *COMM* in country *CC*
Demand Variables	
(4) $DDEM_{cc,comm}$	Total domestic demand for total fish category *COMM* in country *CC*
(5) $TUSE_{cc,comm}$	Total domestic use for total of category *COMM* in country *CC*
Price Variables	
(6) $PD_{cc,comm}$	Domestic market prices for category *COMM* in country *CC*
(7) $PC_{cc,comm}$	Domestic consumer prices for category *COMM* in country *CC*
(8) $PI_{cc,comm,fishprods}$	Producer margin of aquaculture and caught fish category *COMM* in country *CC*
(9) $MG\_Q_{cc,comm,fishprods}$	Producer margin under quota conditions for caught fish category *COMM* in country *CC*
(10) $IMG_{cc,comm,fishprods}$	Producer incentive margin of aquaculture and caught fish category COMM in country CC
(11) PW_{comm}	World market price for tradeable category *COMM*
Other Market Variables	
(12) $NETEXP_{cc,comm}$	Net exports (supply minus domestic use) of category COMM in country CC

Source: Own compilation

Domestic demand (use) variable (4) is affected by changes in consumer prices, population growth, consumption trends and income growth, whereas production for both systems, caught (2) and aquaculture (3) fishery, is influenced by variations on technical progress in each production system and the producer incentive margin. Fish stocks respectively fish stock variations are included as exogenous parameter which will affect only caught quantities. Changes will be induced by respective cost categories, price or margins, and stock growth elasticities, which differ among countries and fish categories. Besides, price, income and stock growth elasticities are taken from the literature (Asche, Bjørndal, & Gordon, 2005; Asche & Bjorndal, 1999; Dey et al., 2008; Fousekis & Revell, 2004, Ragnar) and adjusted based on expert knowledge and empirical data.

Producer margins (8) are described as difference between landing or production price and operational cost plus respective fishery support. The variable is calculated for all countries and each fish categories without any quota restriction. Quotas are only applicable for caught species, thus caught production of countries under quota regimes will be affected by a different margin (9) subject to a quota rent. Information on quota rents has been difficult to compile, so that finally a general assumption on quota rents is applied.

Details on the price formation in the model can be found in Table 2. Trade, demand and production data at country level for the eight fish categories come mainly from two sources: FAO FishstatJ (Fishstat, 2016) and FAO Food Balance Sheets (FAO, 2016). In order to compensate for the lack of information with respect to prices, the model uses unit values as price proxies for each fish category and country. Domestic prices are derived from those import values, while production prices are derived from landing and aquaculture production unit values, for caught and aquaculture production respectively. Cost are included in the system so that operational cost comprising labor, capital, energy and feed cost plus a margin and the domestic support form the landing prices respectively the production unit values. Data is provided by the Annual Economic Report of capture fishery (JECF AER, 2016) for cost of fishery and of aquaculture (JECF AER, 2016) for cost on aquaculture while fishery support estimate (FSE[4]) depicts support information. However, from the FSE only budgetary transfers are considered to affect the producer price as this type of support is mainly focused to improve the returns or alleviate the cost of fishers. Development of both exogenous variables, operational cost and support, are over time influenced by shifters which are calculated based on empirical data. Thus, support is expected to slightly increase over time, while at the same time cost shifters would provoke a reduction of cost affected by technological innovations.

Hence, in caught production, reduction of cost is counterbalanced by the discard ban policy, as the measure is only applicable for sea fishing. In the model, this policy is implemented only for plaice category from 2015 onward and produces an increase in capital and labor cost. Similarly, fish stocks and quota restrictions will affect only caught fishery, those measures are only implemented as exogenous variables. The first varies over the years based on historical data from ICES[5] and it is considered within the model only for pelagic and plaice category, while the quota restrictions are obtained from the Common Fisheries Policy and introduce for plaice category only as an example. The background is that quotas are only implemented for a limited number of economically important fish species implying that a certain fish category consists, at the same time, of a mixture fish being subject to a quota and fish not being subject to a quota. To overcome the problem on medium-term

Table 2 Price formation in AGMEMOD fish model

Price equations			
Producer margin	$PI_{indCntr,comm,fishprods}$	=	$f(PD_{indCntr,comm}, Support_{indCntr,comm,fishprods}, Cost_{indCntr,comm,\ fishprods})$
Quota margin	$SHMG\_Q_{indCntr,comm,fishprods}$	=	$f\ (IMG_{indCntr,comm,PRc}, Quota_{indCntr,comm}, BG_{comm}, tp\_gr_{indCntr,comm,\ PRc})$
Producer incentive margin for caught fish with quotas	$IMG_{indCntr,comm,PRc}$	=	$Min(PI_{indCntr,comm,PRc}, SHMG\_Q_{indCntr,comm,PRc})$

4 http://www.oecd.org/tad/fisheries/fse.htm
5 http://ices.dk/Pages/default.aspx

Producer incentive margin for caught fish without quotas	$IMG_{indCntr,comm,PRc}$	=	$PI_{indCntr,comm, PRc}$
Producer incentive margin for aquaculture fish	$IMG_{indCntr,comm,PRa}$	=	$PI_{indCntr,comm, PRa}$
Price transmission	$PD_{indCntr,comm}$	=	PW_{comm}
Consumer Price	$PC_{indCntr,comm}$	=	$f\ (PD_{indCntr,comm}, pctax_{indCntr,comm})$

Source: Own compilation

3. SCENARIOS

Based on the model described above different scenarios are developed which cover (a) a Baseline or business-a-usual scenario and based on that reference (b) two counterfactual scenarios depicting impacts of technology and policy (see Table 3). In both cases the system requires projections (expected future values) for the exogenous variables to cast the system into the future. The projections presented here cover the period from 2011 to 2030. That approach should not be confused with a forecast or prediction but intends (a) to provide a likely or plausible situation of the fish markets in the future and (b) to allow for an ex-ante analysis of different options and their interactions (see also Salamon et al. 2018). All scenarios concentrate in the assumptions on plaice because (a) it is quite straight forward to attribute the TACs and the quota level to the relevant fish species and (b) the pulse technology is already in place in one EU member states (the Netherlands) so information for setting assumptions is relatively easy. With respect to the impacts, all categories and countries are endorsed to be affected by spill-overs.

Table 3 Baseline and scenarios description (countries is misleading, seems to reflect countries in the model, you need to describe what assumptions for which countries)

Variable	Fish category affected	Baseline	Sc.1: Operational cost reduction	Sc.2: Pulse fishing innovation
Stock growth	plaice	10% yearly reduction of stock growth	15% additional yearly increase of stock growth (compared to Baseline) since 2015	15% additional yearly increase of stock growth (compared to Baseline) since 2015
Quota level	plaice	constant level since 2015	same as baseline	3% increase (compared to Baseline) since 2015
Capital cost	plaice	yearly decrease	10% additional yearly decrease (compared to Baseline) since 2018 to 2021	same as baseline
Labor cost	plaice	yearly decrease		
Energy cost	plaice	yearly decrease	10% additional yearly decrease (compared to Baseline) since 2018 to 2021	50% decrease (compared to Baseline) since 2018 to 2021
Discard ban	plaice	additional cost applicable since 2015	same as baseline	15% cost reduction (compared to Baseline) since 2018
Technical growth	plaice	yearly increase	same as baseline	10% additional yearly increase (compared to Baseline) since 2018
Countries	-	EU member states, Norway, Iceland , Turkey	Changes applied only to EU member states, except for Netherlands	Changes applied only to EU member states, except for Netherlands

		and RoW		

Source: Own compilation

The Baseline assumes the following developments: Plaice stocks are not reaching the maximum sustainable yield levels. To remark the effect, the historical stock growth rate is reduced by 10%. This does not mean that the Biomass is getting depleted, but instead the increase in stocks is too small to guarantee the required spawning stock biomass. Therefore, quota levels are kept constant since 2015. Additionally, for the fishing industry we consider a yearly decrease in operational cost for plaice fishing, which differ among cost categories and across countries. Moreover, starting in 2015 the discard ban policy comes into effect which is included as an additional cost for plaice production in the first step. Finally, a technical progress for all fish categories is considers in a different rate among countries.

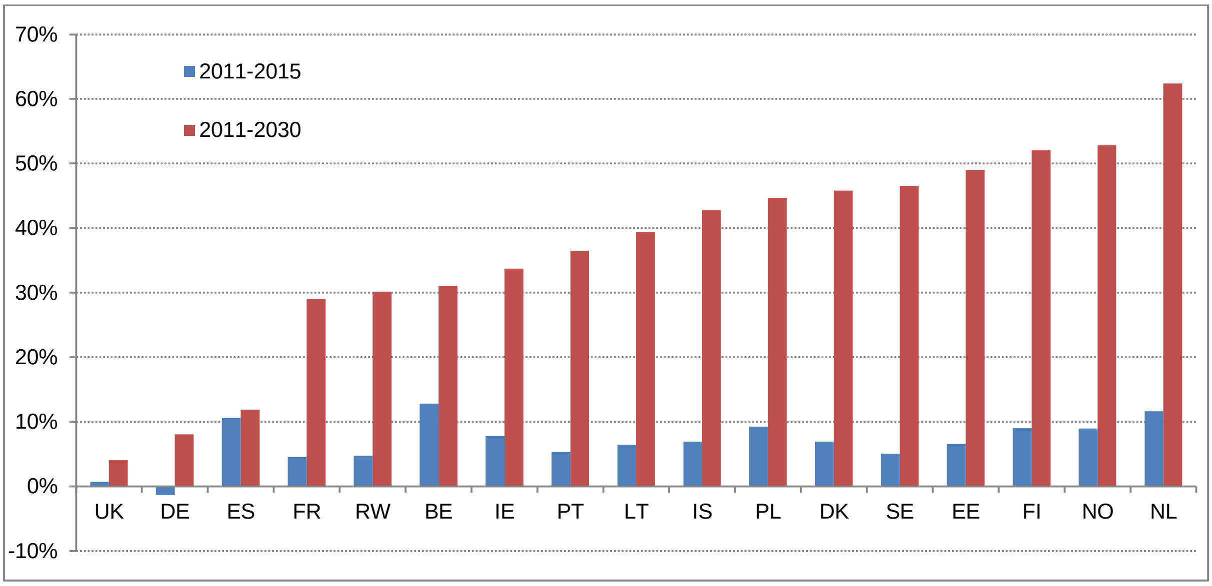
The first scenario: Operational cost reduction (Sc.1) considers a recovery of stocks of plaice translated in 15% adittional increase on the stock growth since 2015 to 2030, promoted by a constant quota level for plaice since 2015. Additionnally, it contemplates that the parliament reject the use of pulse fishing. Therefore, in order to counterbalance the disminishing in returns provoke by the supply restriction, it is expected that fishers reduce 10% the operational cost since 2018 to 2021, for all EU member states with the exception of the Netherlands. As Netherlands are already implementing this technology under special permissions.

The second scenario: Pulse fishing innovation (Sc.2) replicates biomass increase presented in the first scenario but it considers a recovery in fish stocks which will permit an increase in quota levels. Additionally, the effects of elecctric pulse fishing, will be introduced on at EU level built on the premise that the EU Parliament would aprove the use of pulse trawling for the flatfish catches. The Netherlands already applies the technology as they benefit of the special permissions. The scenario include changes in technology and energy cost only for those EU member states which are currently not applying it (all EU member states except the Netherlands). Therefore, all those countries will face an technical increase of 10% between 2018 to 2021, which is reflected in a decrease of 50% in energy cost, and a further reduction on discard ban costs.

4. RESULTS AND DISCUSSION

Baseline results

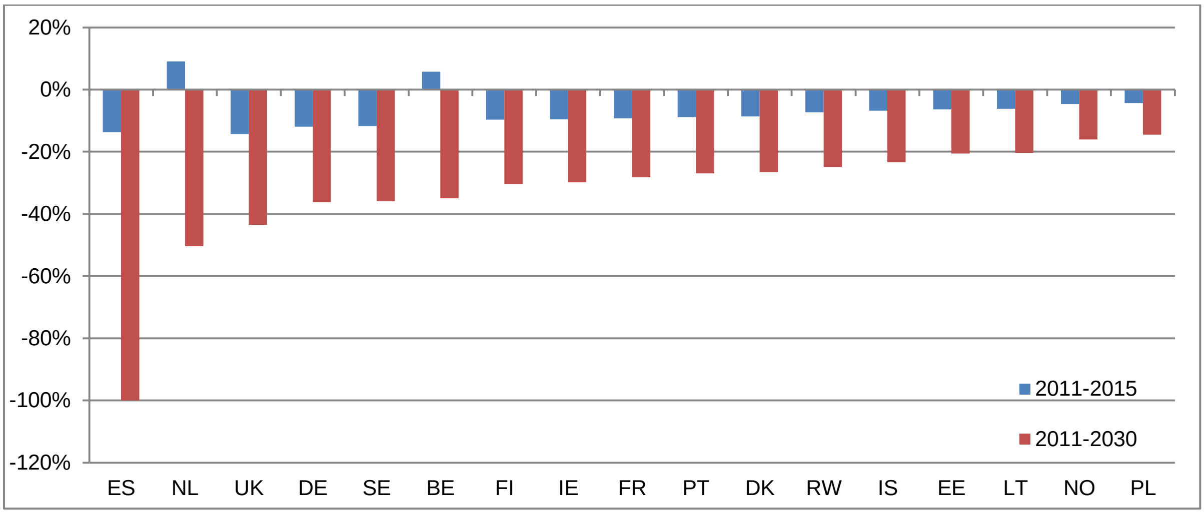
Baseline scenario results show an increase in plaice production over the period for all countries. The Netherlands (NL), Denmark (DK) and United Kingdom (UK) are main plaice producers in 2011, with a share of total production of 29%, 21% and 17%. The Netherlands shows the highest production increase from 2011 to 2030. Although it is limited by a quota, it increases 62%. Production increases until 2026, when the quota level is reached and remains constant hereafter. Denmark produces around 75% of its quota level in 2011 and will remain about 20% below quota despite its production increase. In contrast, United Kingdom depicts the lowest production increase over the period with 4%, thus, it loses market shares. Also Germany (DE) and Spain (ES) have very low growth rates in production, with 8% and 12% respectively. This is motivated by the decreases in producer prices in those countries although cost decline as well. One has also to consider, that Spain reaches its quota level in 2016, thus its quota becomes binding. A number of countries like Spain, Sweden (SE), Ireland (IE), Portugal (PT), Estonia (EE), Poland (PL), Lithuania (LT) and Finland produce less than one thousand of tonnes of plaice, while Belgium (BE), Iceland (IS), Germany, France (FR), and Norway (NO) stay well under the 10 thousand of tonnes (see Figure 1). Turkey (TR), Italy (IT) Romania (Ro), Latvia (LT), Greece (GR), Bulgaria (BL) Croatia (HR) and Hungary (HU) do not produce plaice, therefore they are not included on the Figure 1.



Source: Own results

Figure 1 Production of plaice by countries in period 2011 -2015 and 2011-2030 under the Baseline

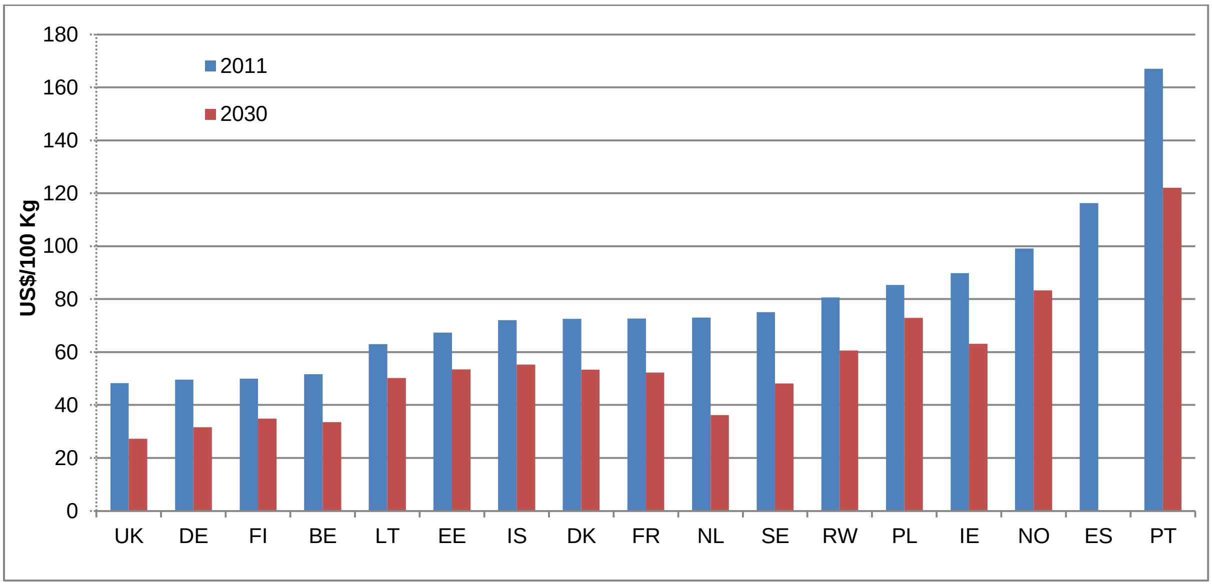
Incentive margin for plaice production declines over the period in all regions. The biggest decreases are observed in Spain (-98%), the Netherlands (-50%), United Kingdom (-44%) and Germany (-36%). Major changes are observed in the second half of the period (see figure 2). During the first period, an increase in profits is observed in the Netherlands and Belgium. One has to keep in mind that the Netherland apply pulse technology also under the Baseline. As both countries reach quota levels after the first period, margin equals quota margins. Spain reaches quota levels in 2016.



Source: Own results

Figure 2 Changes in incentive margin for plaice in period 2011 -2015 and 2011-2030 under the Baseline.

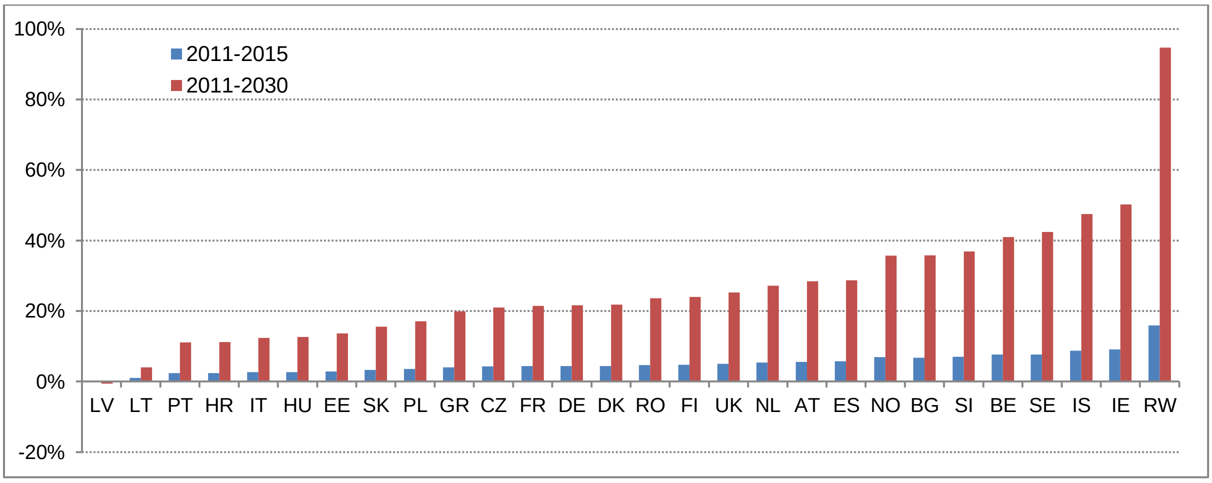
United Kingdom and Germany have the lowest producer margins among the countries (Figure 3). Therefore, those countries face the highest decline in production over the period.



Source: Own results

Figure 3 Incentive margin values for plaice production in 2011 and 2030 in US$/100 kg under the Baseline

The main consumers of plaice are Italy (25%), rest of the world (RW) (22%), the Netherlands (10%), United Kingdom (10%), Denmark (9%) and Germany (6%), together representing 88% of total plaice consumption in 2011. Use increases the most in the RoW (95%), followed by Ireland (50%) and Iceland (48%). Other main consumers increase their use to a much in lesser percentage: Italy by 12%, the Netherlands by 27%, United Kingdom by 25% and Denmark and Germany by 22% each.

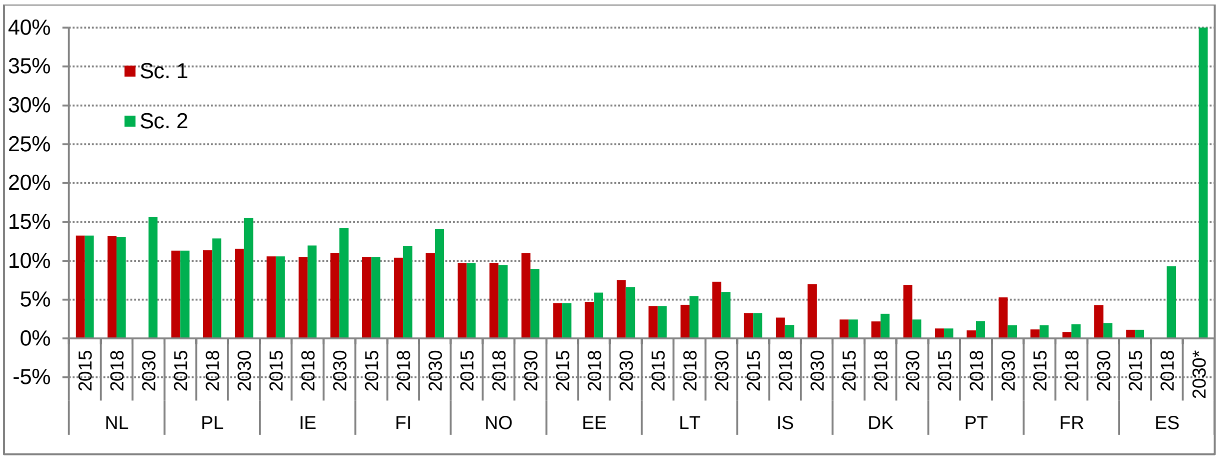


Source: Own results

Figure 4 Changes in plaice demand across the countries in the region in period 2011 -2015 and 2011-2030 under the Baseline

Scenario results

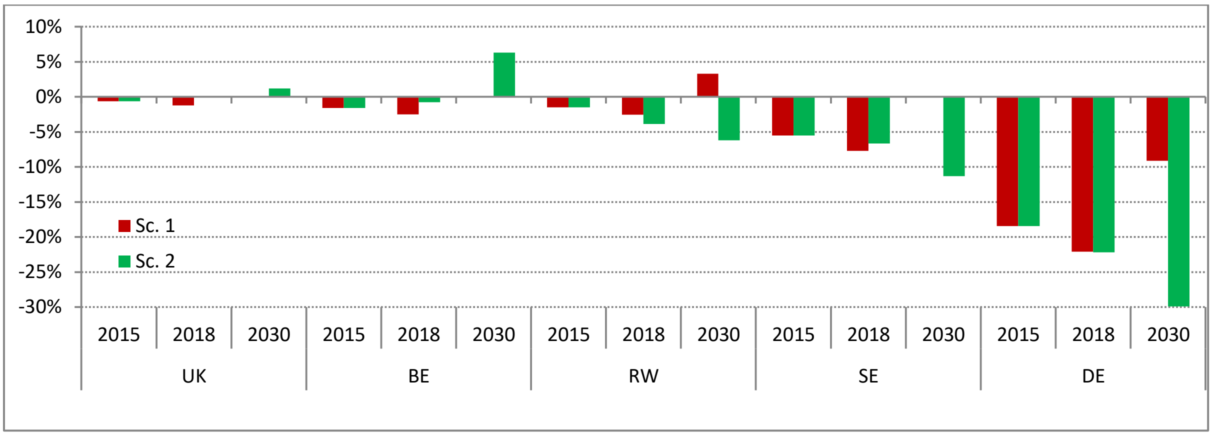
Plaice production increases over the period in all countries under both scenarios, with the exception of Germany; however, growth rates compared to the baseline differ among scenarios. The Netherlands (NL), Poland (PL), Ireland (IE), Finland (FI) and Norway (NO) depict under both scenarios a higher production increase than under the Baseline, while in contrast, a decline is observed for United Kingdom (UK), Belgium (BE), Sweden (SE), Germany (DE), and the RoW (RW) (see figure 5). RoW and Norway do not benefit from any cost reduction therefore has not any cost savings. As prices decreases over the period, their profits diminish more affecting plaice production. The negative effect in Germany, Sweden, RoW, Belgium and United Kingdom (see Figure 6) is mainly explained by its price elasticity of supply. These countries present the highest price elasticity of caught production of plaice among the countries. The group is led by Germany, of which price elasticity almost doubles the average. Therefore, they are more affected to the decline in prices.



Source: Own results

* For better readability the graphs shows only until 40% change, but production in Spain in 2030 under the scenario 2 is 56% higher than under baseline.

Figure 5 Countries with positive changes in production under scenario 1 and 2 compared to the baseline in 2015, 2018 and 2030



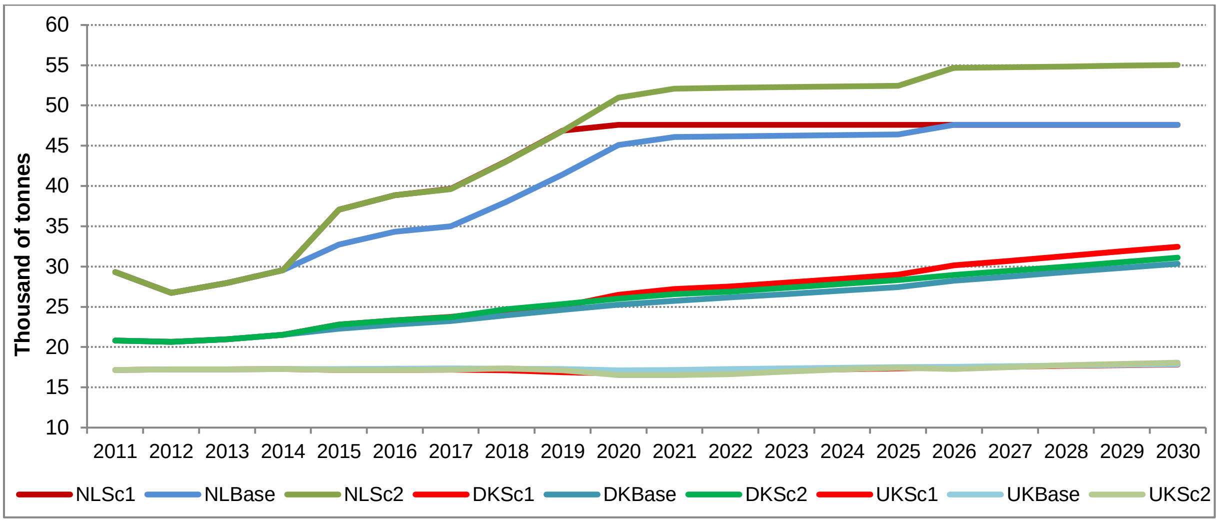
Source: Own results

Figure 6 Countries with negative changes in production under scenario 1 and 2 compared to the baseline in 2015, 2018 and 2030

RoW, Norway, Estonia (EE), Lithuania (LT), Iceland (IS), Denmark, Portugal (PT) and France (FR) shows a higher increase compared to the Baseline under the scenario 1 than under scenario 2, while for the Netherlands, Poland, Ireland, Finland, Spain, United Kingdom, Belgium, and Sweden, it is the other way around. That appears to be counterintuitive at first sight as all countries are subject to higher quotas; however, the impact of the discard ban are apparently higher or cost saving lower under the scenario 2 for those countries.

In the scenario 2, despite the drop in world prices, quota increase promotes higher production in the Netherlands, Poland, Ireland, and Spain. Compared to the baseline results, the application of the pulse fishing technology affects plaice production most markedly in Spain and Germany; but in opposite directions. Germany depicts an interesting result, contrasting the situation in Spain. Plaice production increases by 8% between 2011 and 2030 under the Baseline, while under scenario 1 its production decreases by -2%, and by even -24% under the scenario 2.The deep effect observed in Germany under the second scenario is due to the cost distribution among the cost categories. According to the data, capital and labor represent the higher costs in plaice production in Germany. The reduction in total cost applied on the scenario 1 benefits more than the reduction of 50%on energy cost. The same is observed in other countries such as Norway, Denmark, Iceland, Portugal and France. Plaice production in Spain is quite low, under 0.66 thousands of tonnes at the beginning of the period. Due to the increase of the quota level under the second scenario, Spain will raise its production until 2030, so that it will be 50% higher in compared to the baseline. Spain reaches its quota level already in 2015, under both scenarios. Under scenario 1, as quota level remains the same as under the Baseline, there is no production change in Spain compared to the baseline since 2016.

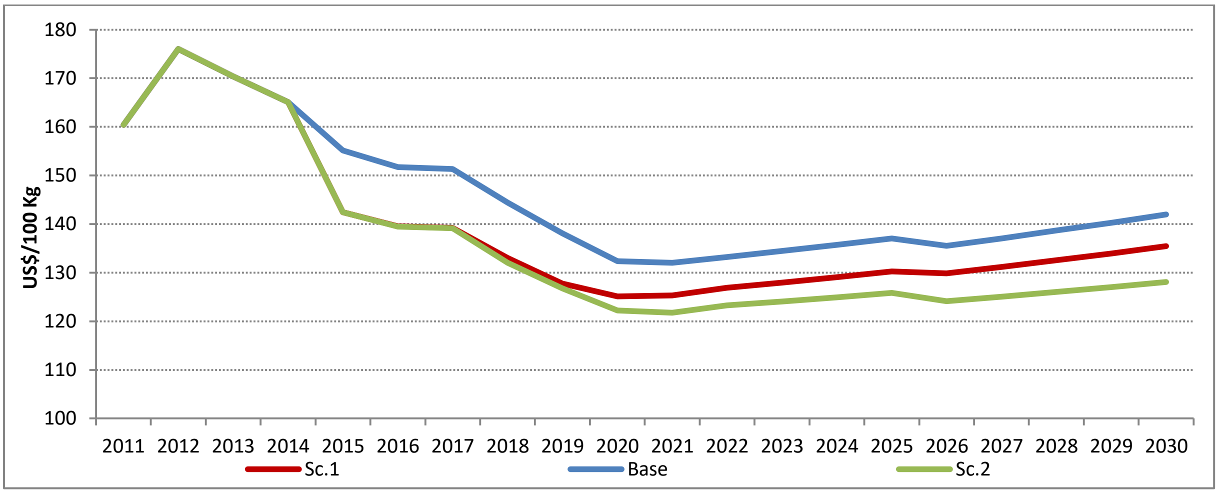
The Netherlands, Denmark and United Kingdom are the main producers of plaice within the EU. Figure 2 depicts the plaice production of those three countries. Under the Baseline, production of the Netherlands and Denmark increases while production in the UK remains quite stable. Relatively strong increases in the case of the Netherlands are driven by the fact that the pulse technology is already in place. Therefore, it already presents the lowest operational costs for plaice production in comparison with the other countries. Under the scenario 1 the relative advantage of the Netherlands diminish to zero so that at the end of the period production levels under scenario 1 are the same as under the Baseline. Moreover, production reaches the quota level in 2020 and stay at the same level until 2030. Under the scenario 2 quota level is projected to increase, in 2030 production results 16% higher than the baseline. Under this scenario, plaice caught production in the Netherlands increase the most, but without reaching the new quota limits. Under both scenarios, production in United Kingdom is slightly smaller than in the baseline. Although quota increases and reduction in energy and discard ban cost (scenario 2) should encourages – at least to some extent - production increase beyond Baseline levels; hence, price declines overshoot cost declines so that production remains stable respectively slightly declines. In contrast to the UK, Danish production increases under both scenarios, over 6% under the first scenario and just 3% under the second. Under the Baseline, production in Denmark did not reached the quota limits, providing more room to extend production after the policies and technology changes.



Source: Own results

Figure 7 Plaice production in the Netherlands, Denmark and the United Kingdom under baseline, scenario 1 and scenario 2 for 2011-2030 in thousands of tonnes

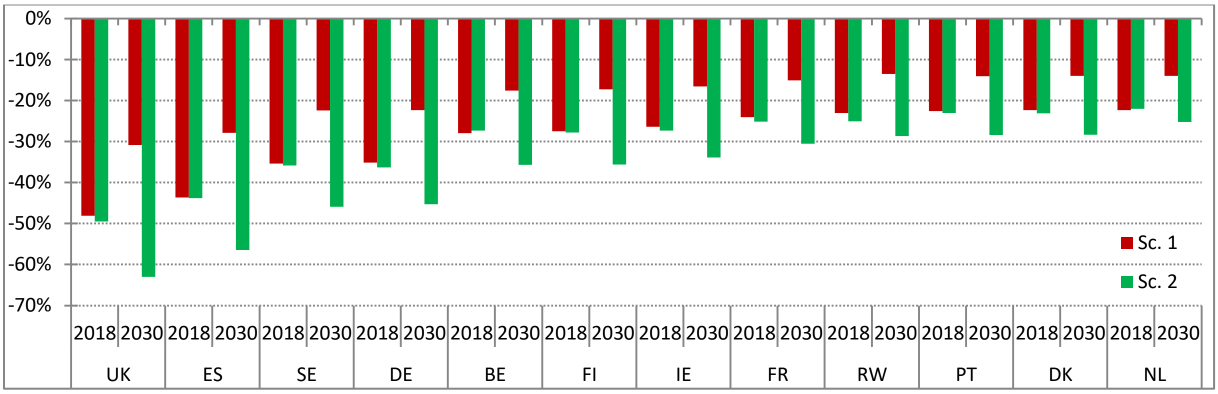
Besides the recovery in plaice stocks, price development influences fish caught of plaice as well. Under both scenarios, prices decrease during the policies implementation and in the following period as plaice supply increases in general. The stock recovery put pressure on the prices starting to increase between 2015 and 2017. In this period, prices under both scenarios are -8% lower than under the Baseline. Under scenario 1, the rate will diminish somewhat to -4.2% until 2026 and in the last 4 years the price will be about -4.5% lower than under the baseline price. Hence, the gap between prices under the scenario 2 and the Baseline increases further, after the implementation of the measures, reaching -10% at the end of the period (See Figure 8).



Source: Own results

Figure 8 Plaice world price development under baseline, scenario 1 and scenario 2 for 2011-2030 in thousands of tonnes

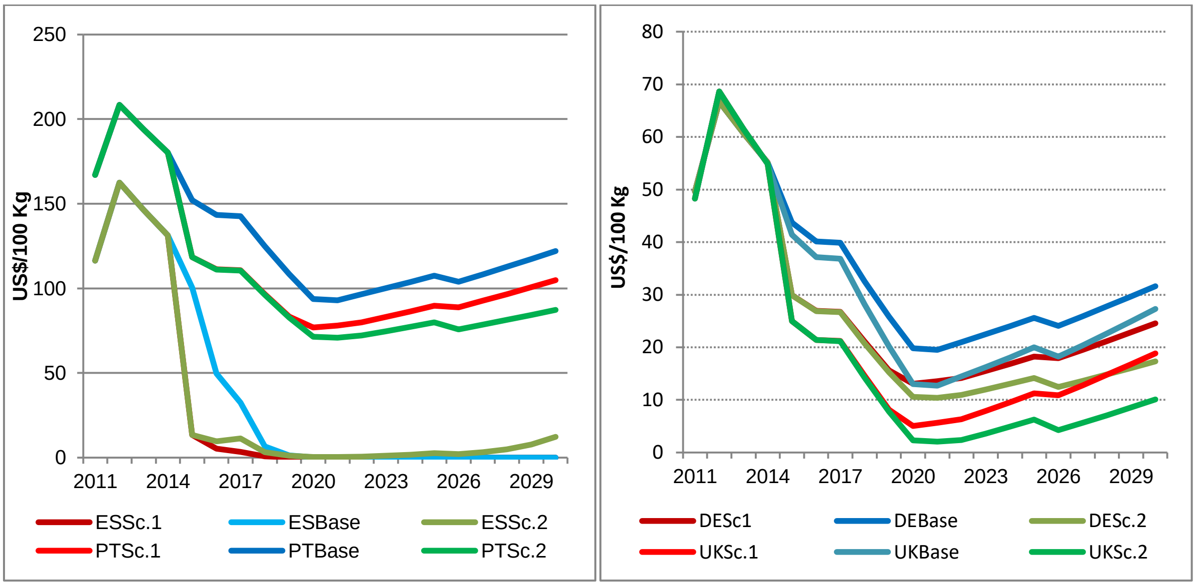
Higher production of plaice will induce significantly lower producer prices whereas it is unclear whether the fishing industry can survive with the related price levels at all. General introduction of the pulse fishing has big producer price effects in most countries, whereas United Kingdom, Spain, Sweden and Germany show the biggest declines (see Figure 4) explaining decline of margins.



Source: Own results

Figure 9 Changes on producer margin under scenario 1 and scenario 2 compared to the baseline for 2018 and 2030

In 2011, Portugal and Spain depict the highest producer incentive margin of plaice, while the lowest are found in in UK and German market. Producer incentive margin under scenario 1 and scenario 2 are similar until 2019. After that, the gap between margin from scenario 1 and scenario 2 in relative terms increases until 2030. In the case of United Kingdom and Germany, that gap is wider. Spain is a special case, as it reaches the quota levels already in 2015 in both scenarios. Therefore, since that year, Spain receives the quota margin, which is much lower to avoid overpassing the quota levels.



Source: Own results

Figure 10 Development of producer incentive margin of plaice in Spain (ES), Portugal (PT), Germany (DE) and United Kingdom (UK) under baseline and scenario 1 and 2.

Consumer prices follow the same development as producer prices, consequently producer incentive margin, although their relative changes are less pronounced as absolute processing, distribution and marketing margins are assumed not to change. Again, prices decrease the most under the scenario 2 and the gap compared to the baseline grows over the years until the end of the period, leading to -10% lower prices than under the Baseline prices in 2030. Although consumer prices under the scenario 1 remain lower than under the Baseline levels, consumer prices will recover over the years, so that in 2030, the difference to the Baseline is only -4%. As a consequence, plaice use increases but only modestly over the period. Under the scenario 1, use stays around 2% higher than the Baseline consumption, with the exception of Germany, where the difference is less than 1% and RoW with a difference of over 5%. Under the scenario 2, those levels are slightly higher with around 3% for most of the countries. Again, Germany depicts lower level with less than 2% increase in use, and in the case of RoW, it is around 10% more.

Although the reduction on costs and the pulse trawl innovation is applied on plaice fishing, it affects other fisheries as well. Producer prices of demersal marine fish stay under the baseline levels. The impacts are more evident for France and Spain, where prices stay -5% under the baseline levels. The effect on production is much smaller, but again deeper for France, Spain, and Croatia as well. On the contrary, the production of pelagic marine fish, other marine fish and other molluscs increase over the baseline levels, although these are minor levels.

5. SUMMARY AND CONCLUSION

The paper analyses effects occurring in the European fish sector when a technological improvement is introduced under a regime of output controls to protect fish resources using the example of plaice. A partial equilibrium model (AGMEMOD) which covers among other agri-food products also 8 different fish categories is applied to conduct model simulations for the European countries and the RoW. As an example in the paper plaice is used because it comprises very few fish species which allows implementing fish quotas as well as technological innovation in a straight forward manner. The pulse fishing is already implemented as experimental use to evaluate reductions on discards and damages on the seabed in the Netherlands. This practice has been discusses in the European Parliament, and in the year 2018 will be decided whether to will be approved or not. According to literature, this practice should reduce the consumption on energy and reduce the discards. Therefore, this technology should contribute with the biomass protection as well as increase fisher's profits. However, results from scenarios differ with the theory.

By the use of AGMEMOD fish model, a baseline is projected for the fishery sector for EU member states, Norway, Iceland, Turkey and the rest of the world until the year 2030. A modest biomass growth under a constant quota regime is outlined. Two counterfactual scenarios are conducted: scenario 1 depicts a rejection of the permission of pulse fishing, considering in contrast to the Baseline a quota regime with slightly growing biomass and cost reductions to some general progress. The second scenario considers the approval of the pulse fishing and applies significant cost reductions in energy expenses.

The Baseline indicates a growth in production as quotas are not biding in a number of European countries, due to the slight increase in biomass and a decline in cost being accompanied by price decline as, in general, use does not increase at the same force. At the beginning of the analysis, Spain shows the higher producer prices among the countries, while United Kingdom has the lowest. Moreover, United Kingdom is one of the main plaice producers while plaice production in Spain is one of the smallest. Results from scenarios 1 depicts similar outcome over the period and across countries. Hence, major diverting effects can be observed under the scenario 2. Comparing results with the baseline projection, producer prices respectively margins in United Kingdom and Spain are most markedly affected. Compared to the Baseline, changes in margins in both scenarios start in 2015 with the implementation of the biomass recovery. Nonetheless, these gaps will decline over the period in scenario 1. A reverse development can be observed in scenario 2, where the gap prices compared to the baseline increases due to the increased cost savings from energy and the additional recovery of the biomass stock and related quotas. Price and margin effects differ across countries with low impacts in Netherland and Denmark and high impacts in United Kingdom, Spain and Germany, reflecting the cost structure in those countries.

At the same time landings increase over the period. The increase in biomass growth induces the production in almost all countries; however, under the scenario 1 growth is more limited by the quota regime. Under this scenario, some countries such as Spain and Netherlands meet the quota levels before 2020. This promotes the production increase in other countries such as Finland and Denmark, from which quota levels give them room to extend production, as quotas are much higher than production levels in scenario 1.

Quota structures play an important role. On one side, the measure limit overexploitation of the resources and as such restrain decline in prices. On the other side, more competitive countries are limited by quota levels, give room to other countries to increase their production levels Leading to inefficiencies. An increase in quotas promotes the production of the more competitive countries, affecting the smaller producing countries by declining prices.

Cost reductions enable an increase in production. However, the effect varies among countries. On the first scenario, the cost reduction is distributed among all fish categories, while under the second scenario the cost reduction is only focus in energy costs. Although energy costs are considered as the biggest share on total operational costs, the shares on costs varies among countries significantly. Therefore in some countries reduced total costs is has a bigger impact than the higher reduction in energy costs Although costs reduction increase the profits of fishers, the increase in production put further pressure on prices affecting negatively profits..

Results indicate that the fishery sector of the Netherlands has most likely generated innovation gains by implementing the pulse technology with a special permission before all other EU member states apply it, that way the Dutch industry could generate competitive advantages compared to other countries. This is captured by Dutch cost level and cost structure although the quotas in the Netherlands are not necessarily binding. Other EU member states like Germany have markedly higher cost limiting their future growth. Production increases may occur due to slight biomass growth or cost decline until quotas are reached. Hence, all production growth will affect future prices negatively as expected growth of use in European countries is lower than production growth. The implementation of the pulse will enhance the currently existing price pressure whereas the impacts will vary significantly across the different European countries, affected by the size of the margin and the share of energy cost in total cost. Negative impacts on production will occur for example in Germany and Sweden, relatively high declines in prices; and therefore marginsd;may face also the UK and Spain. Against this background to enhance the permission of pulse technology to other member states has different dimensions: (a) with respect to the ecological perspective, literature seemed to indicate that pulse fishing has a resource saving effects which perhaps will allow higher yields in the medium-term plus energy use will be lower; (b) with respect to the economic perspective production and use will increase by lower prices; (c) with respect to competitiveness those countries will gain who have high shares of energy cost in total cost and with respect to the competitiveness compared to Non-EU countries the results indicate that their production will increase as well but they will face also lower prices and (d) with respect to food security Non-European use will increase much more pronouncedly due to lower prices. To weighted politically all those effects an EU level will not be a straight process.

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