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Efficiency vs resilience: The rise and fall of the German brown shrimp fishery in times of COVID 19

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ABSTRACT

In times of world crisis such as climate change and the COVID pandemic much has been said about the need for resilience. However, in scenarios of less concern about crisis the leading paradigm is often that of efficiency. The current study shows how efficiency might have got on the way of achieving the necessary resilience to face the COVID 19. With the example of the German brown shrimp fishery in the North Sea the interaction between those two paradigms – efficiency and resilience – is shown in the context of the COVID 19 pandemic. For instance, the quest of efficiency for rationalisation may reduce the resources available to set aside buffers to resist shocks, and the standardisation key to efficiency may also hinder more diversity and hence open innovation for solutions to the crisis, all characteristics of resilient organisations. By making use of a literature review including peer reviewed, grey literature and web media as well as of interviews with experts and quantitative data the value chain of the German brown shrimp fishery is analysed under the conceptual framework of organisational resilience.

Results: show that, despite being more oriented towards efficiency, the German fleets does not show particularly good results in selected efficiency indicators. Additionally, key stages of the value chain as processing and commercialisation together with the investment strategy fail to present some commonly accepted components of resilient organisations, such as redundancy, flexibility, adaptability, diversity, prudence and embeddedness. Despite developments in the direction of sustainability with the MSC certification, the German fleet should pay attention to its capacity to face disturbances, which should be supported by a more long-term, targeted, resilience-oriented policy support.

1. Introduction: resilience vs efficiency in crisis times

After stock collapses, fuel crisis, and the economic crisis, and with the current and future effects of climate change, the COVID 19 crisis brings about a new scenario for which small-scale fisheries (SSF) do not seem to show the necessary preparedness [1,2]. Researchers are used to consider the effects of fishing activity or climate change on stocks or the ecosystem, but even though the COVID crisis may unusually be positive for some stocks [3], this time it is the economic effects on the fishing sector that are more relevant. COVID has caused economic effects on both the demand and the supply side of the fishing sector. Problems lay mostly on the demand side, as the practical disappearance of demand from the Hotel, Restaurants and Catering sector (HORECA) [4,5], which is sometimes key especially for small-scale fisheries. The situation with the COVID crisis has caused a shift in demand towards preserved foods. Problems in the supply side include the difficulties in the movement of the crews or the hiring of manpower for the processing industry. In the case studied here, the crisis has generated a bottleneck in intermediate production. These and other locally important issues have caused severe decreases in profitability, unequally distributed among different fishing fleets and processing industries [6]. To address these issues there have been economics measures as direct support from the EMFF [7] and other national measures, according to the reactive management style often employed in fisheries management (e.g. impact assessment and management plans). In a circular way, how fishing firms are capable of reacting to this crisis will determine their effect on fish stocks in the future.

Besides the stronger focus of the fisheries scientific literature on biological issues rather than on economic ones [11] when research considers economic impacts on fisheries it has often highlighted issues such as efficiency [1], or costs [12]. As a main focus of fisheries economics, and possible solution against crisis, efficiency has been...
approached in a variety of ways, from technical efficiency to allocation of fishing opportunities. Technical efficiency has highlighted for instance the substitution of fishing gears for other less fuel intensive (e.g. pulse fishing, [13]) the use of other sources of fuel, from liquid gas to wind energy or hybrid engines [14,15]) or, as a direct, important factor of fuel costs reduction, the introduction of subsidies and fuel tax exemptions [16,17]. In the North Sea brown shrimp fishery efficiency gains occurred mostly in the processing part of production and that resulted in problems during the COVID restrictions for the fishing companies. Another technical factor of cost reduction is a higher catchability, be it through an increase in the size of the stock or through technical improvements [18,19]. A further typical argument for efficiency in fishing is economics, and relates to the reduction of over-capacity through the allocation of fishing rights, mostly focused on individual transferable quotas (ITQ) regimes. The primary reasoning behind the efficiency in ITQ is to reduce (over)capacity by allowing the most efficient vessels buy quota from the less efficient ones [20]. Finally, some attention has also been paid to economic efficiency along the value chain [21–23]. The technical and economic efficiency arguments shown therefore focus on operational aspects of the fishery and on fisheries management (ITQ).

The efficiency approaches tend to miss other economic and social aspects [24,25] among them organizational aspects from inside fishing firms. We argue that the COVID shock is too big to manage it the traditional way and it requires other type of behaviour, more proactive, based on resilience. This is especially true in cases where cumulative effects in fishers and fishing firms occur [26,27]. As a result of many kinds of crisis (from biological to social) different concepts of resilience have been developed. In fisheries literature, resilience is mostly considered a biological concept, as introduced by Holling in 1973 [28] (further developed by Folke [29–31]). Biological resilience in fisheries applies at different levels (fish stock, ecosystem [10]). Though resilience was initially considered a biological concept implying the “persistence of relationships within a system and […] the ability of these systems to absorb changes […] and still persist” [28] there is also a growing interest in other applications of the concept, as coastal communities [32] or regional governance [33]. Narrowing a bit the focus (without reaching the lowest level of psychological resilience) there is a level of resilience that is relevant to fisheries and has not been so much explored: organisational resilience [34–36]. In this context, a definition of resilience would be “the capacity to absorb stress, recover critical functionality and thrive in altered circumstances” [37]. Organisational resilience brings a different perspective to the more common emphasis on economic efficiency used in fisheries, and has more complex components than the usual definitions of results per resources used.

The relationship between efficiency and resilience is not a clear one, but mainly efficiency might imply a certain degree of specialisation even within a short value chain that contradicts the need for a certain redundancy in resilience, as we will see with this study. This occurs when, due to the high competition in international markets that companies suffer, efforts are made through rationalisation to optimise individual processes to the maximum. In turn, this causes a certain myopia, which prevents the firm to allocate resources to more contextual issues and create buffers that would be needed to improve resilience [38]. Other aspects of the relationship between efficiency and resilience are that a certain degree of efficiency for instance in limiting costs is good for resilience [39]. But the concepts of resilience and efficiency may face set in a form that makes them incompatible. An efficiency mindset can on the contrary preclude a certain type of learning [40], which is necessary for resilience. In this article we will look more in detail at the aspects of organisational resilience that can be useful in a crisis such as the COVID 19, but also other as climate change, analysing to a lesser extent the study of efficiency which has been more extensively studied in the literature.

The authors will show how efficiency may have stood in the way of a better reaction to the COVID crisis by using the example of the German Brown shrimp fishery in the North Sea, as well as certain policy/sectoral suggestions for an increase in resilience. As the brown shrimp fishery presents characteristics of SSF (short trips, owner-operated) and of large-scale fisheries (LSF active gear, vessels over twelve metres) the current study could be of interest for other fisheries both LSF and SSF. Additionally, the concept of organisational resilience would be useful for other crises different than COVID 19, be they ecological or economic. The topic of organisational resilience has received considerable attention in the literature, with many reviews being published recently [36, 41–43]. Some recent papers consider resilience applied to natural phenomena (e.g. flooding [44]) or even in relation to the COVID 19 pandemic [45]. However, the use of organisational resilience framework has, to our knowledge, still not been used in an applied manner to the fisheries sector for this pandemic. The article presents the methodology, including a brief description of the case study, and then analyses three aspects of the fishery with respect to efficiency and three related to resilience, ending with a discussion and conclusions.

2. Methods

2.1. Quantitative efficiency indicators and qualitative data on efficiency

First of all, quantitative efficiency indicators have been calculated for the German and similar brown shrimp fleets from other countries. Quantitative data has been obtained from the database of the data collection programme of the EU (EU MAP), as well as from the European Fleet register and the German Federal Office for Agriculture and Food (BLE). BLE data included brown shrimp catch weights, values and prices as well as data on the vessel age of the German brown shrimp fleet. Brown shrimp prices were calculated by dividing landing value (in €) by landing weight (in kg) and averaged per month. Catch efficiency and fuel efficiency indicators as well as a cost efficiency indicator already developed for the Annual Economic Report (AER) of the Scientific, Technical and Economic Committee for Fisheries in the EU [46] have been chosen for the availability of data and contrasted methodology. The catch efficiency indicator shows how many kilograms of fish are landed per unit of effort, measured in days at sea (Landings Per Unit Effort, or LPUE). This indicator was calculated by dividing the total catch (in kg) by the total days at sea per year for each of the respective fleet segments. The fuel efficiency indicator, named “fuel intensity” in the AER shows how many litres of fuel a fleet employs for each kilogram of catch landed. It was calculated by dividing the total amount of used fuel (in l) by the total catch (in kg) for each of the respective fleet segments. Finally, as cost efficiency indicator the proportion of fuel costs over income has been calculated (named “fuel efficiency” in the AER). This indicator was calculated by dividing the total fuel costs by the total annual income from landings for each of the respective fleet segments with the result given in percent.

Advantages and disadvantages of EU MAP economic data for the analysis of economic behaviour of the shrimp fleets have already been highlighted [47]. The advantages of these data are a relatively long time series (2008–2018 for economic data) and coverage for all EU fishing countries. The disaggregation per geographic area, fishing gear and size of vessel allows an identification and comparison of the Brown shrimp fishing fleets of different countries. We selected beam trawler (TBB) fleets segments between 12 and 24 m length to represent the brown shrimp fishery of the three major brown shrimp fishing nations Germany, the Netherlands and Denmark. Although these segments do not comprise all brown shrimp fisheries per definition, they account for 90–98% of annual brown shrimp landings. Data on capital costs, necessary for determining the investment strategy, is highly dependent on certain assumptions for the estimation of the capital value according to the Perpetual Inventory Method (PIM, OECD 2009 [48]) (i.e. price per gross ton, useful lifetime and depreciation scheme, which is the recommended method for the estimation of capital value in the context of the Data Collection Framework [49]) Dutch and German data on capital
value are based upon PIM, but not the Danish. This hampers a quantitative analysis. Moreover, part of the PIM result is linked to the year of construction. Thus, it is partly a proxy for the vessel age. The useful lifetime, which indicates the time of replacement of vessel components, is usually not adjusted frequently enough to reflect particular investment activities within certain fleets. Thus, the age structure of the fleets appears as a meaningful indicator for investment activities – at least in relative terms. Therefore, time series of age data are considered to address this aspect. For German vessels, time series for all vessels are available, for Danish and Dutch vessels only the average age as provided in the AER [50] was available. In the current analysis the LPUE data has the disadvantage that days at sea might have variations in their measurement across countries (see results Section 3.1) [51,52]. The cost efficiency indicator depends not only on the technical efficiency of the vessels, but also on fuel and shrimp prices. However, fuel prices are fundamentally similar for all countries involved, and the evolution of shrimp prices for the German fleet has been shown in Fig. 2 for contrast. Fuel cost efficiency is used as an indicator of the ability of firms to obtain income from their inputs, and is considered in the context of the German fleet strategy to increase efficiency.

Qualitative information on the German Brown Shrimp fishing fleet was obtained from the literature and focused interviews with experts. The sources were mostly grey literature and media, as little economic analysis of the fishery is available (see case study Section 2.2 below). Focus was set on the different value chain stages, from which the second step of processing (shelling), the commercialisation and the investment processes were identified as relevant for the economic efficiency strategy of fishing firms, and selected for further analysis. For additional sources, our study bases on a mixed-source approach: four semi-structured phone interviews with brown-shrimp skippers and value chain experts, open comments from two more representatives of the German brown shrimp fleet out of an international study on the effects of COVID 19 towards EU fisheries sector and personal email contact. The interviews took place between April and December 2020, the survey was closed at December 2020 and the email contact happened between September and December in 2020. All data collected was framed by the leading theme Covid-19 impact towards German brown shrimp fisheries including the guiding open question “how is the situation of the fleet/industry with respect to the COVID 19 pandemic?”. The semi-structured interviews took between 30 and 60 min and were transcribed directly using a simple semantic transcript system according to Kurckartz et al. (2008 [53]). The focus of transcription was on the content and here on Covid-19 impact towards fisheries in particular. Syntax, non-verbal messages and stressing had been negligible. Extractions from semi-structured interviews, statements from survey or email contact were allocated towards categories, which originates from the framework of value chain resilience. The content analyses thereby followed the principles of a structural content analysis according to Mayring (2012 [54]).

2.2. Conceptual framework of organisational resilience

The framework of analysis employed in the study is that of organisational resilience, also referred to as strategic resilience and related to supply chain resilience and social resilience [55]. The focus on the organisation rather than on the value chain is preferred because the value chain in the case study is too short and lacks the complexity of global value chains, which are often the object of value chain resilience studies (e.g. [56]). A focus on the organisation also allows to compare between different degrees of vertical integration, key issue in our

Fig. 1. German brown shrimp fishing area and ports. Haul positions and most important homeports of the German brown shrimp fishing fleet, based on logbook and landings data of 2018. Only ports from which more than 300 fishing trips were undertaken are displayed.
Finally, as seen below, many of the indicators of resilience are common to both the organisational and the value chain approaches, which makes the distinction less relevant to an applied approach such as the one presented here. The organisational resilience framework is more often employed in the management literature [36], and considered a field in development in the scientific literature) [34] which is underlined by the high amount of reviews in recent times (for instance [34,36,43,57]). Several of these studies present frameworks for organisational resilience [58,43].

The resilience components that appear most often in the reviews mentioned above and which have been found to present a higher degree of concretion for their application to the brown shrimp fishery were redundancy [36,37,43,56,57], diversity [37,58] (also related to dispersion [58] and diversification [36]), modularity (or flexibility [35–37,56–58]), adaptability [35–37,56,58], prudence [35,37,43,56] (also related to proactiveness in Ref. [43]) and embeddedness [35,37,56], (also called collectiveness in Ref. [43] and collaboration in Refs. [36,58]). Redundancy is often defined by duplication of resources, or resources with a variety of functions, which can act as a buffer, contrasting with short run efficiency which would aim at minimising resource use. Diversity refers to a variety of people involved in the organisation and an open environment, with related concepts such as dispersion, diversification or decentralisation of resources and contrasting with the standardisation often required by efficiency. Flexibility or modularity refer to an organisation divided in smaller segments with well-defined interfaces that can be quickly recombined, as opposed to tightly integrated organisations. Adaptability is related to flexibility but also to learning and having the organisational capacity for experimenting, as opposed to the stability and minimum variance related to standardisation and efficiency. Prudence, related to proactiveness, implies an organisational strategy of monitoring possible risks, performing contingency planning, and analysis. Finally, as seen below, many of the indicators of resilience are common to both the organisational and the value chain approaches, which makes the distinction less relevant to an applied approach such as the one presented here. The organisational resilience framework is more often employed in the management literature [36], and considered a field in development in the scientific literature) [34] which is underlined by the high amount of reviews in recent times (for instance [34,36,43,57]). Several of these studies present frameworks for organisational resilience [58,43].

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requiring a use of organisation resources that may not be considered efficient, at least in the short term. Finally, embeddedness entails an integration with other actors of the wider social and economic environment, implying common goals with wider collectives, and collaborating, which can contribute to overcome resistances to face shocks. Hillmann and Günther [35] also advance some measurement criteria, which include time of recovery, stability (severity of loss) and survival, however it is still too early to measure the impact of the COVID 19 crisis on the fleet quantitatively and this is in any case beyond the scope of this study.

According to [35] the unit of analysis will be the organisation. In our case study the whole German brown shrimp fleet will be taken as an organisation, considering that they share to a great extent the same practices and organisational criteria, including the same purpose, technology, activity and value chain [59]. Despite fishers belonging to different producer organisations (see case study description in Section 2.3 below) the German Brown shrimp fleet has also shown its capability of acting as a unit in an organised way, for instance in the MSC certification process.

The case study will thus be mainly examined with regards to the elements of the value chain, and then analysed with respect to the efficiency and resilience principles extracted from the literature. To complete the analysis a literature research has been undertaken, with special attention to grey literature, professional and general publications and internet websites (both in English and German), as well as expert interviews with PO representatives, a management representative and an NGO.

2.3. Case study: The German brown shrimp fishery

Though the brown shrimp (Crangon crangon) is present form the Artic to the Black Sea, it is only economically exploited in the EU coast of the North Sea, the Adriatic and the Black Sea, with The Netherlands, Germany and Denmark covering 95% of the European production [60]. In the North Sea, brown shrimp is exploited since the 18th century [61]. At the beginning coastal inhabitants walked into the Wadden Sea during low tide and emptied crangon traps or used an active shrimp gear. Only later in the 19th century fishers begun to use vessels with beam trawls, a fishing method developed in The Netherlands. That allowed a substantial increase in catches, demand increased especially in the large cities and women peeled the shrimps at home in their kitchens earning extra income in an area with few economic opportunities before later on the coast became a popular tourist area. The number of vessels increased during the 20th century and today it is the most important coastal fishery in Germany [62].

The EU catches of North Sea brown shrimp are mostly harvested by two countries, the Netherlands followed by Germany, with together 79% of EU brown shrimp production on nearly 50 ports along the North Sea coast. A representation of the fishing intensity and main fishing ports can be seen in Fig. 1. Each point on the map resembles a haul position as they were given in the logbooks of vessels targeting brown shrimp in 2018. The number of fishing trips started from each port was used to identify the most important home ports of the Brown shrimp fleet. Approximately three quarters (75.7%) of all fishing trips of the German Brown shrimp fleet in 2018 started at one of the 11 ports displayed in the figure.

Source: Landings and logbook data were provided by the German Federal Office for Agriculture and Food (BLE).

In 2020, the German brown shrimp fishery constituted a total of 195 vessels, all have two beam trawls as gear, but they differ in their vessel size, from 5 to 25 m (9.7% 0–12 m; 51% 12–18 m, 36% 18–24 m) and crew size (1–3 persons). Ownership of the vessels is German or Dutch, with most vessels probably being owner-operated, as there are only eleven owners of 2 or 3 vessels. The organisation of the fishers has evolved in the last two decades, with five producer organisations (PO) now grouping the majority of the fishers under German flag: the “PO for German shrimpfishers” (EzDK) with 82 vessels, the smaller “PO for coastal fishers of the North Sea” with 30 vessels, the “PO for coastal fishers of Toenning, Eider, Elbe and Weser”, with 20 vessels and the “Elsflet PO” with 14 vessels. In addition to these German POs 30 vessels with German flag are members of a Dutch PO: Rousant.

The management of the fishery has been conditioned by the short life of the species which makes it difficult to assess [63], and a management plan has first been designed in the process of MSC certification [64], which groups 421 vessels from the Netherlands, Germany, Denmark, and Belgium. The management plan specifies the gear (Beam trawl with bobbin/roller groundrope), mesh size (minimum 20 mm) and the maximum beam length (10 m). The plan also considers reductions of fishing effort when the landings per unit effort (LPUE) decrease, in accordance to ICES criteria [63]. It is mandatory to follow these technical restrictions in order to sell the product as MSC certified. Therefore, most of the vessels are now following the same set of rules and have basically no room for individual strategies. The producer organisations represented by the MSC label do not follow a quota plan or谭 management but they occasionally agree on maximum weekly catches for all vessels to distribute catch opportunities fairly between all members. These maximum weekly catches are coordinated with the wholesalers and normally applied when their maximum processing capacity is reached, and therefore the amount of brown shrimp they can buy is exhausted.

There are few studies of the brown shrimp fishery based on the economic aspects [26,65], and they are mostly bioeconomic [66,67]. The brown shrimp fishery is nevertheless the most important fishery for Germany in economic terms: given both its large volume and high price it yields the highest revenues of all coastal fleets [46]. A measure of its profitability compared to other national fleets can be found in Fig. 2b. However, price and catches evolutions may have strong variation across time (see Fig. 2a below), leading to important economic crises as that of 2011, when the fishers went on strike [68] Considering the demand, the main market is Belgium, where the shrimps attain their highest price [69].

Source: 2a) German Federal Office for Agriculture and Food (BLE), 2b) Annual Economic Report 2018.

The current situation of the brown shrimp fishery was already problematic before the outbreak of the pandemic, as they came from a year of low revenues in 2019 and they were getting prepared to resume the season in March, after the seasonal stop from December to February. Therefore the current economic situation of the fishery is considered as “at risk” [70].

3. Results

Based on the literature on resilience and efficiency, supported by economic data and interviews with different stakeholders, the analysis focuses on elements of the value chain of the German North Sea brown shrimp fishery that are relevant in terms of efficiency and/or resilience.

3.1. Efficiency factors in the BS fishery

The German shrimp fishing fleet shows at least three aspects of (short-term) efficiency: externalisation of shelling, externalisation of marketing tasks and capital cost reduction. In a way, these externalisation of processing and marketing processes can be seen as a specialisation in the harvest and primary processing activities (shrimps are boiled in the vessel before they are landed). As background to the relative efficiency of the German fleet Fig. 3 shows some efficiency indicators of the German brown shrimp fleet compared to similar fleets from the Netherlands and Denmark, Belgian, French and British vessels have been left out because of their very low overall significance. We have used catch efficiency and fuel efficiency indicators as well as cost efficiency indicator (AER 2020, see methods Section 2.1). The Dutch and Danish fleets show a higher catch efficiency throughout the data series. The
Fig. 3. Efficiency measures of the German (DEU) Brown shrimp fleet in comparison with similar Dutch (NLD) and Danish (DNK) fleets: a) Landings per unit of effort (LPUE), measure of catch efficiency; b) Litres of fuel per kg landed, measure of fuel efficiency (“fuel intensity” in the AER); c) proportion of fuel costs over income, measure of cost efficiency (“fuel efficiency” in the AER).
The strategy with shelling implies extending a logistic chain to Morocco, where labour costs are lower, and corresponds to a certain use of preservatives, partly to withstand the extra time taken by the 3000 km journey. The Moroccan factories, property of the commercialising firms, shell currently 90% of the German catches [71], in a strategy that until now has brought aspects of efficiency such as standardisation and minimal variance, but has also reduced diversity in knowing how (Table 1). Formerly, part of the production was also sold in other countries such as Poland, but this alternative has lost importance. This has brought a reduction of redundancy in the shelling capacity (see Table 1). Opposite to certain kinds of shrimps, the consumption of unshelled brown shrimps is negligible, the manual shelling in Germany has also been given up, among others, due to early EU regulations on hygienic infrastructures in the nineties [72]. The cultural practice of manual shelling has provoked a reduction of the embeddedness of shrimp processing in the German coastal communities (see Table 1).

With the COVID crises the Moroccan firms have taken restrictive measures as to for instance the minimum distance between workers in the chain, therefore reducing the overall capacity. There have also been problems recruiting workers for processing (mostly women) because of fear of being contagious. To the contrary of what has happened with some other food products and consumer goods, there has been apparently no problem with the transportation of the shrimps in both directions (to and from Morocco), the transportation part of the value chain was not a problem but there were apparently no other alternative processing plants to take the shrimp to, and no risk assessments or contingency plans (see prudence in Table 1). The explained restrictions at the Moroccan factories have been decisive and reduced the shelling capacity to a 40% level (local management representative, personal communication).

3.1.2. Monopsony

The sales tasks externalization strategy refers to a concentration on the intermediate demand side in two large companies (monopsony), the Dutch Heiploeg and Klaas Puul. Some years ago the market was shared by at least four companies, the two mentioned plus Stühkr and Kok International Seafood [73]. This has increased efficiency through a reduction of transaction costs, but it has also reduced the redundancy of actors in this step of the value chain, their diversity and also their possibilities for experimentation with more sale channel and therefore new ways of adaptation when facing shocks (see Table 1). Due to an EU cartel lawsuit [74] and millions of euro as fines for some of the companies, only Heiploeg, (the largest) and Klaas Puul (the one that presented the complaint and thus escaped the fine) remained in the market. These two remaining companies, both Dutch, take care of the sales of the majority of the catches and have a combined market share between 80% and 90%,[75,76]. The largest firm, Heiploeg, has undergone further vertical concentration as it has been bought by the Dutch fisheries conglomerate Parlevliet and van der Plas [77], while Klaus Puul has been sold to an equity group [78]. Heiploeg and Klaas Puul also take care of the processing of the shrimp, and own factories in Morocco for this purpose. The German fishers have contracts with the processing companies given them security regarding the selling of their catch but leaves them also no real room for alternatives (see modularity in Table 1). Therefore, the value chain is short with the catching sector and then the vertical integration from collecting the shrimps at landing facilities to marketing in one company. So most of efficiency gains are basically within one company, with German firms of the catching sector being less embedded in the economic and social tissue (see Table 1). There is also an asymmetry of information between the German and Dutch vessels as both processing companies are from The Netherlands and have a certain degree of vertical integration with some Dutch vessels.

The reduction in the shelling capacity of the factories in Morocco together with other factors caused a bottleneck further down the value chain. As there was no (or very little) shelling and therefore very limited exit of production to the market, the storehouses of the intermediate firms reached their maximum capacity at storing unshelled shrimps. Therefore the intermediary firms could not keep more unshelled shrimp and stopped buying more shrimps from the vessels. The catching sector do not have storing capacities of their own, in part because this is seen as a task of the intermediate sellers. Though POs have recently taken up some tasks formerly performed by the sellers, as sieving, the crisis caught the fleet without storehouses to handle the changed situation of sellers. The very low presence of other outlets for the shrimp as direct sales of unshelled shrimps to end consumers, restaurants or other intermediate firms with shelling facilities contributed to worsen the effect of the bottleneck in the two big intermediate sellers. In this way the catch sector did not have any other alternative but to reduce their catches, by reducing the number of days the vessels went out at sea (PO representative, personal communication) and with them their income. A few fishers sold their catch on auctions in The Netherlands and later in 2020 the situation improved compared to 2019 regarding catches and prices but 2019 was already a relatively bad year for the German vessels and, therefore, the situation of the fishers did not improve in 2020.

3.1.3. Reduction of capital costs

The brown shrimp fishery operates with a declining, relatively old fleet, but the replacement of vessels is not taking place at the moment (see Fig. 4 below). Only 8 vessels have been newly built in the last two decades and there has not been any new vessel entering the fleet in the last ten years, which also has a very high average age (41 years) with most vessels spread between 30 and 54 years and some reaching as many as 74 years. A comparison among the capital costs of the different national fleets has been discarded, as explained in the Methods Section 2.1. Instead, a time series of average vessel age is used for comparison between the Dutch, Danish and German fleet (see Fig. 5). The steadiness of the Dutch vessels’ age corresponded with a relatively stable fleet size

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1 The Brown shrimp stock is quite dynamic in its natural range and it is highly possible, that the LPUEs in Germany and Denmark are low, but are normal or high in the Netherlands (or the other way around).
Investments in new or at least younger and more modern pre-used vessels remained constant (28\% in the same time period, the number of vessels in the fleet practically unchanged. Furthermore, the average vessel age declined between 2008 and 2012, which has not been documented for the other brown shrimp fleets. The decreasing age curve is almost horizontal since 2015. However, if this development is due to new construction or due to preferential decommissioning of the oldest vessels cannot be derived from the available data. The analysis in this study shows how necessary it is to dig deeper into the detail of this economic data to enable meaningful inter-country comparison, in this case needed to assess the different strategies of the countries with respect to investment in physical capital.

The lack of investment in physical capital of the German brown shrimp fleet could be seen as a reduction of fixed costs, but it is so only in the short term. On the contrary, investment in physical capital could be seen as a way of saving costs in the future, with for instance savings in fuel through investment in a more efficient engine. It could also mean that spare parts and equipment could be exchanged separately/handed over to a new hull. The increasing concentration of the demand has not led to designing alternative scenarios or fostering other forms of demand. The lack of diversity in the processing and marketing has not led to designing alternative scenarios or fostering other forms of demand.

Fig. 4. Time series of vessel ages in the brown shrimp fishery. Blue dots represent single vessel’s ages of German brown shrimp vessels, squares and line represent the mean age of the fleet of the respective fishing nations. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
higher income in the future, if investment would be employed in conditioning the vessels for further uses, such as welcoming tourists [79]. Finally, investment in more modern, safer vessels and/ or vessel equipment could be seen as a risk reduction strategy, to prevent accidents and major losses due to natural phenomena or mechanical breakdown [80,81].

Source: German Federal Office for Agriculture and Food and STECF AER 2020.

Other investments in physical capital, such as new gear technology, have also had only a marginal effect in the efficiency of the brown shrimp fleet. These kind of partial investments could however have impacted the modularity of fleet: how renewed parts of the vessel (as e.g. on board processing equipment or electronic equipment) could have improved its capacity to adapt to shocks in processing or in the availability of crew (see Table 1). Periodical improvements in the vessel also contribute to build better relationships with other actors, as the ancillary industry, embedding the fleet in its social and economic environment (see Table 1). The introduction of the pulse technology, used by many vessels in the Dutch fleet, has had more restrictions in Germany. The different regulation has awarded licensed for only a short time in Germany, which together with the high costs (8000€ per gear [59]) and the low saving in costs as compared to the flat fish fishery (only 10% in fuel costs [59]) has made the shift to the new technology less attractive. As a result pulse trawling has only been used by two vessels of the German fleet [13].

There is also a problem with the succession of skippers, which, considering the requirement to undertake an apprenticeship in order to become skipper, could be interpreted as a lack of investment in human capital. Brown shrimp cutters are operated by 1–3 people (the larger ones) and have an average age of workers (around 40 or over, PO representatives, personal communication) similar to that of the overall German fleet (approximately 40, Knappßacht Bahn See). However, if the brown shrimp crews also follow the age trend of other national fleets, the younger cohorts of fishers, those who would succeed the current fishers, are smaller (data from Knappßacht Bahn See), and succession could be jeopardised. High cost of fishing vessels prevent the incorporation of younger skippers, as there are no particular facilities to access to credit (no newcomer schemes as in other countries [82]).

The following table is a summary table of current aspects of efficiency in the brown shrimp fishery in light of organisational resilience components which are e.g. redundancy or diversity.

3.2. Resilience factors

Compared to the efficiency strategy within the short value chain described above, one could imagine an alternative strategy, that of resilience. The last shocks that the fleet has suffered, from price drops to stock problems and now the COVID 19 pandemic show that it would be necessary to build a certain rebound capacity as part of a resilience strategy. Similar strategies and capacities have already been undertaken by neighbouring countries such as the Netherlands, where they have introduced fuel saving technologies or vertical integration of their fleet with the processing industry. In the case of the German brown shrimp fishery, such a strategy of building up could mean that capacities that have been externalised so far could be internalised again, as seen in the examples below.

3.2.2. Portfolio of buyers

Another capacity that could internalize the German shrimp fleet would be the marketing and sale of the shrimps. The sale of North Sea shrimps presents the difficulty of dealing with large daily volumes of a perishable commodity. This characteristic of the catches has led to the fact that, until now, only large companies have been able to deal with it. It has also contributed to the fact that, after the lawsuit on collusion [74], there has been paradoxically an even greater concentration of buying companies. The process of re-integrating the shrimp marketing process would therefore be a difficult one, and would require a great deal of marketing effort to introduce some flexibility and redundancy in the sales of the product (see Table 2). This effort could be supported by producer organisations, local government and EMFF resources, and would be a medium to long term process, that would bring a better embeddedness of the producers in their community, thus bringing for instance opportunities for open innovation and better monitoring of demand. One way to expand the buyers' portfolio would be through vertical integration. Some successful examples have taken place in Germany already (Kutterfisch, [91]) and in the Netherlands (Parlevliet & Van der Plas within the shrimp fishery itself [91]).

Some smaller initiatives have already taken place, such as a pilot project to produce and market higher quality brown shrimps for the HORECA channel [72]. Other steps have been taken in the sustainability of the fishery through the MSC certification process [64]. However, the sustainability of the fishery is still in conflict with some ecologist groups involved in the protection of the Wadden Sea, and this might influence the process.
Table 2

| Redundancy | Diversity | Modularity | Adaptability | Prudence | Embeddedness |
|------------|-----------|------------|--------------|----------|--------------|
| Mechanical shelling | Re giãn the mechanical-shelling takes place in different, near firms, the fishers are also in contact with their nearest economic cause. | Having a diversified portfolio of buyers allows to avoid losses when a buyer may compensate the loss of another. | Adapting new technology to move the added value chain (vertical integration from landing to marketing plus catch) contribute to create and/or incorporate innovations that may make the fishing fleet more resilient. | Having a successor is by itself a measure to increase demand for local production (as synergistic but take modularity into account). | Taking care of apprentices is a way of increasing the number of fishers, which is missing when the renewal of the vessel is delayed. |
| The sequential manoeuvring of the same vessel can be substituted by another vessel. | Being in contact with customers that buy unpeeled shrimps and premium shrimps. | A diversity of products and production (as synergistic but varying in time and space). | Having a successor is by itself a measure to increase demand for local production (as synergistic but take modularity into account). | Taking care of apprentices is a way of increasing the number of fishers, which is missing when the renewal of the vessel is delayed. |
| If operations are well adjusted in mechanical shelling, machines fail and work on a non-stop basis, they can perform more work. | Taking care of apprentices is a way of increasing the number of fishers, which is missing when the renewal of the vessel is delayed. | A diversity of products and production (as synergistic but varying in time and space). | Adapting new technology to move the added value chain (vertical integration from landing to marketing plus catch) contribute to create and/or incorporate innovations that may make the fishing fleet more resilient. | Taking care of apprentices is a way of increasing the number of fishers, which is missing when the renewal of the vessel is delayed. |
| If the mechanical-shelling takes place in different, near fishers, the fishers are also in contact with their nearest economic cause. | Being in contact with customers that buy unpeeled shrimps and premium shrimps. | A diversity of products and production (as synergistic but varying in time and space). | Having a successor is by itself a measure to increase demand for local production (as synergistic but take modularity into account). | Taking care of apprentices is a way of increasing the number of fishers, which is missing when the renewal of the vessel is delayed. |

3.2.3. Broader capital measures (including human capital)

The reduction of the capital costs of the vessels needs to be further analysed in order to consider the adequacy of investing in new vessels. Some of the vessels may have an old cash, but their engines and other equipment can be updated. The causes for not renewing the vessels need to be discussed with the fishers, especially in relation to risks situations (e.g. accidents, see Table 2 under prudence) but also the benefits of redundancy (keeping a state of the art vessel and leaving an older one as replacement) and embeddedness (holding a long term relationship with the ancillary industry through partial renovations of the vessel). Causes for the reduced investment situation, a part of the negative economic developments of the most recent years could be regulatory measures or rigidities in the credit or public funding system.

The evolution of the physical capital of the fleet cannot be analysed without taking into consideration the human capital that goes with it. As mentioned in Results Section 3.1.3, the younger cohorts of fishers are much more reduced than some years before (Knappschaft Bahn See data). The enrolment in the fisheries schools has decreased in the last years (Tobias Lasner, personal communication), and reasons for this decrease and possible incentives to keep the succession of the shrimp fleet for the coming years need to be explored. Including more diversity in the fleet and administrative teams (e.g. producer organisation) can contribute to create and/or incorporate innovations that may make the fishing fleet more resilient.

In summary, the concentration process led to a very efficient short value chain (vertical integration from landing to marketing plus catch sector) but as the pandemic shows with little resilience to shocks like the capacity reduction for shelling in Morocco. Shelling is not the only factor for improved efficiency, also e.g. the concentration process with larger processing companies. To improve the resilience of the sector mechanical shelling seems to be the only possibility also to move the added value to coastal communities at the North Sea coast. It will take time and more testing until a mechanical alternative with more or less the same costs will exist to replace the outsourcing to Morocco at least to a certain extent.

4. Discussion

Regarding the results on quantitative efficiency indicators, it could be argued that the German strategy of specialisation on harvest and primary processing has not dealt the expected results in terms of efficiency. Differences in catch efficiency are difficult to explain, even though Dutch fleets include only larger vessels, while the German fleets have vessels under 12 m, the differences remain when comparing similar vessel sizes. In some cases as in 2015–2016 a better availability of the resource in the southern Wadden Sea may have favoured the Dutch fleets (see Results Section 3.1.1, data from AER). The analysis in this study also serves to highlight some deficiencies already pointed out in the EU MAP data (e.g. STECF 2013). This should serve as an incentive to further develop cooperation in the collection of data at EU level.

The efficiency gains come nevertheless from particular circumstances in the fishery, to which fishing firms have adapted. For example, the monopoly allows to market large amounts of shrimp in short lapses of time, due to the existing contracts. This is particularly convenient for
the shrimp fishery because it is a species that is caught in relatively large volumes and has comparatively a very short shelf life (around one day without preservatives, lower than common fish). The outsourcing of the shelling of the shrimps is an adaptation to a cultural reality, where shrimps are not accepted by the market if they are not shelled, to the contrary of other crustaceans and also to the loss of the custom to shell at home. It would need further initiatives to make people aware of the advantages of unshelled shrimps and teaching those people to shell shrimps themselves (for instance as undertaken by the NGO Sustain Seafood, see https://sustainseafood.de/).

We have decided to concentrate our analysis on organisational resilience and have not used the conceptual framework of value chain resilience because it the value chain is very short and even redirecting of shellong to Germany could be also within one organisation. In our case study classical tensions from other value chains such as asymmetry of information and lack of reliability [93] would be reduced through the short value chain, while aspects more related to the organisational context as innovation (see new shelling possibilities) and capacity building (as training sales people for new sale channels) would be more relevant. The latter two aspects (innovation and capacity building) could in the long run improve efficiency in the brown shrimp fishery, highlighting the fact that efficiency and resilience may be compatible in a longer time horizon as discussed by Gölgeci et al. [38] and not so conflicting as presented here, with a shorter term focus. The errors of the German brown shrimp fishery with respect to attaining organisational resilience can be compared to other errors analysed in the literature [39]. Though there has been an initiative to improve the marketing of the brown shrimp (MSC certification) this is more a reaction to the requirements of the market than a proactive strategy to changing the commercialization of the product [94]. Attempts to introduce redundancy in the marketing of shrimps encountered disinterest from both some regional administrations and fishers (NGO representative, personal communication).

The resilience initiatives have their limitations, as the capacity of mechanical shelling or the costs of ultrasound shelling, both in energy and in the social cost of reducing the jobs in the shelling factories to a fraction of what they are now. As stated by Coulthard (2012) [95]. “Enhanced resilience does not automatically result in improved well-being of people”. State aid will remain necessary to maintain the livelihoods during the adaptation process. But state aid should maybe be conditional on the adoption of measures conducting to a better resilience. The total repatriation of some steps of the value chain (e.g. to perform machine shelling exclusively in Germany) is subject to debate [96,97], as such a repatriation or “reshoring” Bayer could cause the same kind of lack of redundancy that would stop the value chain in case e.g. of a lock down in Germany due to COVID 19.

Alternative scenarios to the exploitation of the brown shrimp by the German fleets have been a departure from the activity, which would either lead to further direct exploitation (i.e. catches harvested from Dutch or Danish fleets), or indirect exploitation of the area through further German wind farms, [98,99]. Another scenario would be a closure of the area for fishing due to nature conservation objectives (which could not guarantee that the ecosystem would return to its “original state” [100]).

Especially the loss of fishing grounds will have an increasing negative impact on the shrimp fishing fleet. The areas where shrimps can be harvested will decrease and without any changes fewer vessels will be able to catch a sufficient number of shrimps to earn a living [98,99]. The sector needs, therefore, strategies to adapt to the new situation which could include exploring new gears which could still be used in some of the marine protected areas (less harmful for bottom habitats [13]) and sell their catch for higher prices (these shrimps are fished with less impacting gear in the national park, etc.) and participate in new marketing initiatives of unshelled shrimps which also could be improving the prices for their catches (for instance https://wattenmeerkrabbe.de). There could be also the possibility to diversify to a certain extent and, if allowed, catch edible crabs which increase in stock size due to the increasing number of wind parks (which introduce a different habitat in the North Sea [101]).

The policy impact of the direct support (rent substitution) measures seems limited, as they do not precisely target the issues portrayed above and in general have no long-term orientation. A better use of the aid given (direct aid) would be conditional to longer-term oriented actions. This would require, for example guidelines for EMFF aid in the direction of incentives to long term strategies as compared to substitution for loss of short-term profits. Examples of these could be targeted funding of (further) projects on marketing alternatives, second parts of existing pilot projects (as e.g. Wattenmeer Krabbe) or promoting seed capital for innovation (e.g. for mechanical and ultrasound shelling), as well as building up social capital through further networking initiatives.

5. Conclusion

The study presents an economic analysis of the German brown shrimp value chain as it has been managed in terms of efficiency, and the consequences that have occurred with the COVID 19 crisis. As a way forward, the same value chain steps are analysed in terms of current and potential organisational resilience, and how an enhancement of this type of resilience could represent a success strategy to fight the negative effects of the pandemic. The article collates many disperse sources on the evolution and present of the fishery, showing a new perspective on the dichotomy efficiency-resilience in times of the COVID crisis. Given the large sums of funding that are used for direct support to the different economic sectors in this crisis, and their opportunity costs in terms of public debt, the study helps to focus on the most acute problem areas as well as the most promising ways of solution, presenting alternatives for future policy. The article also analysis parts of the marketing stages of the value chain, which could be of interest to other fisheries, and have been paid less attention up to now. An appraisal of a whole value chain of a fishery is seldom present in the literature, but it is needed to make sense of a resilience approach, where resilience refers to systems and not only to individual firms [27]. In this sense, the article contributes to open a path to more holistic approaches to fisheries economics in the assessment of impacts of crises, such as climate change. As it has been shown, more cooperation between the fleet, the industry and the management of the fishery [8,9] would be needed to make the most of the support measures. The long-term orientation of many of the proposed measures should not conceal the fact that action in this and other fisheries affected by the COVID 19 can be urgent, given the sometimes critical situation and the cumulative effects involved.

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CRedit authorship contribution statement

Leyre Goti-Aralucea: Conceptualisation, Investigation, Visualisation, Writing-original draft, Writing - review & editing. Jörg Berkenhagen: Investigation, Data Curation, Visualisation, Writing - review & editing. Erik Sulanke: Investigation, Data Curation, Visualisation, Writing - review & editing. Ralf Döring: Writing - review & editing.

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[11] The brown shrimp fleet has an average of 890 kg per fishing trip (overall average of landings data from 2002 to 2020), compared to 160–340 kg for other typical SSF species in the German fleet as Baltic flounder or cod.
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Declarations of interest

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