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# Deliverable 2.5

# Manuscript to a peer-reviewed journal on "boom and bust" cycles in European seafood markets

## February 8th, 2019

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# Executive Summary

As part of WP2 "Economic performance and prices" in PrimeFish, this Deliverable 2.5 consists of a manuscript to a peer-reviewed journal on "boom and bust" cycles in European seafood markets. The audience for the deliverable is the scientific community, analysts and policy makers.

The paper, "Price volatility in the fisheries and aquaculture sector and detection of "boom—and-bust" cycles", has been submitted to Fisheries Research, which has an impact factor of 1.874.

The paper analysis the occurrence of "boom and bust" cycles for the selected species studied in PrimeFish (salmon, cod, trout, herring, seabass, seabream and pangasius) and provides a method to detect boom and bust cycles and to make predictions on price fluctuations, protecting against such future cycles. The paper examines the critical factors, which are responsible for the principal prices' turbulences and drops and spikes in the prices of agricultural commodities in world markets.

The data used comes largely from EUMOFA (The European Market Observatory for Fisheries and Aquaculture) which is the most complete dataset for price series analysis of both fisheries and aquaculture markets. Other data sources were considered but not found to be as suitable. Where necessary, additonal data was gathered directly from processing companies through surveys and interviews. Wherever possible, the analysis was based on data from a single supplier as the uniformity of the collection method is crucial when comparing different time series. The analysis undertaken covered Canada, Denmark, Germany, Greece, Iceland, Norway, Spain, United Kingdom and Italy.

The detection of "boom and bust" cycles, making predictions of price was conducted implementing the Kalman Filters in MATLAB. In addition, the impact of macroeconomic factors on the occurence of boom and bust cycles was analysed using regression techniues. In all, 81 cases of boom were identified and 86 cases of bust.

The application of the Kalman filter to the data from the fisheries and aquaculture sectors made it possible to decompose the time series into elementary parts such as trend, cycle, seasonality and an irregular component. For each of the price series available the fundamental tendency (towards higher, lower or price stability) has been detected, apart from accidental variations (irregularities or outliers), seasonal and cyclical. The irregular component represents unforeseeable and accidental variations related to various types of events. This component in some cases may include extreme values or outliers. The Kalman filter also breaks down the price trend into stochastic or deterministic components, which is of particular relevance since a larger deterministic component in a time series improves the forecasts. The methodology allows for price foreceasts, which of course becomes more reliable the shorter the time horizon. The information could help to predict what will be the selling price in time (seasonal), summer or winter.

According to the DoA, deliverable D2.5 was due in month 40 but was delayed due to the final decision to submit this version of the analysis, using Kalman's Filters, based on WP2 work, and to submit later a new version of the analysis utilising the method developed in WP5 using the MatLab FSDA (Flexible Statistics for Data Analysis) toolbox, simulation and prediction models.

Another paper based on the results of WP2 on "Price co-integration analysis on price transmission and market integration among markets" will be submitted to the journal Food Policy which has an impact Factor of 3.111.

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## Contents

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**TITLE:** PRICE VOLATILITY IN THE FISHERIES AND AQUACULTURE SECTOR AND DETECTION OF "BOOM AND BUST" CYCLES

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# PRICE VOLATILITY IN THE FISHERIES AND AQUACULTURE SECTOR AND DETECTION OF "BOOM AND BUST" CYCLES

**AUTHORS**

Cristina Mora, Marco Riani, Fabrizio Laurini, Gianluca Morelli, Katia Laura Sidali,

**ABSTRACT** This paper is devoted to provide an analysis of the occurrence of "boom and bust" cycles for the selected species studied in PrimeFish (salmon, cod, trout, herring, seabass, seabream and pangasius). The paper has not the intention to go deeply into many different aspects concerning "boom and bust" but rather to provide a method to allow the detection of boom and bust cycles and to make predictions on price fluctuations, protecting against such future cycles. We firstly present the critical factors, which are responsible for the principal prices' turbulences and drops and spikes in the prices of agricultural commodities in world markets. To this end, we have consulted literature obtained from the principal databanks such as Web of Science. Next, we will conduct a similar literature review for price volatility of both fisheries and aquaculture markets. The sequence of price shocks presented in the metaanalysis is further empirically compared with the price series analyses executed using the method of Kalman's filters.

The analysis has been conducted following these steps:

- Introduction on public sources sources on data
- Literature review on price volatility in the global agricultural markets with a specific focus on the fisheries and aquaculture sectors
- Detection of "boom and bust" cycles and price predictions
- Discussion and conclusion

**HIGHLIGHTS**

- A literature review on price volatility in global agriculture markets (with a specific focus on the fisheries and aquaculture sectors) and an analysis of the occurrence and critical factors for "boom and bust" cycles for the selected species studied in PrimeFish
- Provides insights for major component of the behaviour of fisheries and aquaculture products price
- Detection of boom and bust cycles and price fluctuations predictions thus protecting against such future cycles

**KEY WORDS**

Fish price, Boom and Bust, Fisheries and Aquacultures, Price behaviour

**FUNDING SOURCES**

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# 1. INTRODUCTION

## 1.1 PrimeFish Project

European seafood producers are facing increased competition from overseas; prices of seafood products fluctuate and destabilize markets; unsuitable regulations influence the competitiveness of seafood producers; some producers are unable to meet the demands and expectations of consumers and many new fish products fail on markets. These challenges are addressed in PrimeFish, a four-year European funded research project by the H2020 Programme.

The overall objective of PrimeFish is to enhance the economic sustainability and competitiveness of European fisheries and aquaculture sectors. The project will study and analyse the European seafood market in general and five specific seafood supply-chains in particular; cod, herring, trout, seabass, seabream, salmon and pangasius.

## 1.2 Objective

The paper has not the intention to go deeply into many different aspects concerning "boom and bust" but rather to provide a method to allow the detection of boom and bust cycles and to make predictions on price fluctuations, protecting against such future cycles

## 1.3 Introduction on sources publically available for fish prices

The report is largely based on EUMOFA (The European Market Observatory for Fisheries and Aquaculture) tool, which is the most complete dataset for prices series analysis of both fisheries and aquaculture markets, choosen after having analysed the other sources publicly available, namely UNData, The United Nations Commodity Trade Statistic Data Base; FAOSTAT FishStatPlus; FAO FISH PRICE INDEX; UN Comtrade, International Trade Statistics Database; Eurostat; Tradestat.

Because of the higher availability of data, the databank EUMOFA is employed (Sørdahl et al., 2015). However, to compensate data missing in some categories, specific surveys and interview with processing companies are employed to obtain reliable information on the missing categories.

Because of the heterogeneity of the over mentioned databanks, direct comparison of data is difficult to achieve. For this reason, Primefish aims at aggregate data and harmonize them and become, in this way, a benchmark tool that serves effectively to fisheries and aquaculture operators. Specifically, we focus on the economic performance of the following selected species: Atlantic herring, cod, pangasius, salmon, seabass, seabream and trout.

# 2. MATERIALS AND METHODS

The Methods used for the Report vary according to the parts.

The report start with a literature review on price volatility in world agricultural markets with specific focus on the fisheries and aquaculture sectors.

The detection of "boom and bust" cycles, making predictions of price was conducted implementing the Kalman Filters in MATLAB and macroeconomic factors affect B&B occurrence with regression analysis.

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The investigation is conducted through the analysis of aggregate data of primary production units (capture fisheries and aquaculture) obtained from available public sources as well as detailed data from individual companies. The use of a statistical methodology, implemented in MATLAB software, allows the detection of boom and bust cycles in time series and potentially, predictions on price fluctuations, protecting against such future cycles.

The scientific literature has various methods for the analysis of time series and each method is particularly efficient but only on certain data types. In order to choose the best method for data related to the fisheries sector, we had to test different algorithms through many simulations and compare the results. This preliminary analysis showed that the best method for the analysis of time series of prices and the identification of the boom and bust cycles are the Kalman filter, also known as linear quadratic estimation (LQE) (doi:10.1115/1.3662552).

With the support of the economics literature (Gerdesmeier et al., 2012), and through many tests performed on the data it seemed reasonable to argue that we can talk about boom or bust if prices are greater than the 85th percentile or below the 15th percentile. Furthermore, in order to avoid false signals, we classify a set of values beyond thresholds as a group if inside the set we don't have more than three consecutive monthly observations below the thresholds. This method allows avoidance of the formation of two booms or two busts in close periods just because there is a single value in the set that falls inside the percentiles used as a threshold. The classification method used to reduce the false signals produces smoother cycles.

The Kalman filter identifies the cycles in function of the data structure and returns us, if it exists, the amplitude of the cycle. The method of classification of values in periods of boom and bust needs, as a parameter, the amplitude of the cycle as it is not able to generate it as the Kalman filter does. So to calibrate this parameter information from the Kalman filter has been used. Sometimes in the case of stochastic cycle or cycle with negligible variation of prices the amplitude of the cycle in the method of classification of the boom and bust was set a priori at 36 months. The choice was made as a compromise between the length of the economic cycle defined by the literature (60 months) and the length of the time series we have. In fact forcing the cycle length to 60 months in our time series and less than 120 months we risk losing information on the existence of the cycle.

The method of classification of values which determines the periods of boom and bust, sometimes by setting in advance the length of the cycles and generating smoother cycles, can lead to results that, when compared with the plots of the Kalman filter cycles, may seem not exactly accurate, but really they represent the best approximation below the classification constraints and the need to smooth the cycles.

The choice of data sources and their availability has been a significant challenge. The institutional sources (i.e. Eurostat, FISHSTATJ, FAO) almost always turned out to be very poor in information under the point of view of length and continuity of the time series, or due to the presence of outliers or nonhomogeneous values. The long study on the quality of the data led us to choose as data source the data collected by European Market Observatory for Fisheries and Aquaculture Products (Eumofa), by SECRETARÍA DE ESTADO DE TURISMO Y COMERCIO (Spain) and by Institute of Services for the Agricultural and Food Market (ISMEA, Italy). In order to have the highest level of data consistency in most of the analysis we used the Eumofa data and wherever possible we have preferred to use a single

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supplier because we believe that the uniformity of the collection method is crucial to compare different time series.

## 3. THEORY AND DATA ANALYSIS

### 3.1 A literature review on price volatility in world agricultural market, with a aspecific focus on the fisheries and aquaculture sectors

#### 3.1.1 A literature review on price volatility in world agricultural market

In the following chapter we firstly present the critical factors which are responsible for the principal prices'turbulences and drops and spikes in the prices of agricultural commodities in world markets. To this end, we have consulted literature obtained from the principal databanks such as Web of Science. Next, we will conduct a similar literature review for price volatility of both fisheries and aquaculture markets. The sequence of price shocks presented in the metaanalysis is further empirically compared with the price series analyses executed using the method of Kalmann's filters.

The vast literature on price volatility shows that the price trend of the XXth century has stopped and that actual prices since 2000 have increased more than 100%. Thus, a greater proportion of food is being traded internationally between more countries that ever before, and this increases the potential for shocks to local food systems to propagate into global crises.

Generally speaking, there are many causes for this price trend reversal. In primis, supply growth is "per se" limited due to limited resources such as land and water. Furthermore, energy is becoming more expensive, productivity grow is declining, global warming is constraining production and there is a growing resource competition between food and non-food crops (biofuels, copper, rubber, flowers and ornamentals). Additionally von Witzke (2014) explains that from the demand side population and per capita consumption growth are posing a constraint on price stability.

All said, looking at price trends from the 1970s until nowadays; most scholars have reached the following conclusions on price volatility:

- In general terms, price volatility has not increased (von Witzke, 2014; Sartori & Schiavo, 2015) due to the fact that periods of extreme volatility in agricultural markets are seldom. Specifically, Prakash and Gilbert (2011) distinguish the '73-'74 episode as a "crisis" with extreme high price levels and volatility on commodity markets, whereas the recent 2006-2007 is not comparable in size and effects (i.e., taking into account the five million malnutrition related deaths) to the former. To similar results comes also Huchet-Bourdon (2011) who finds that volatility is higher in the last decade than in the 1990s but not higher than that of the 1970s. On the same vein, Gilbert and Morgan (2010) find that recent volatility is higher than in the 1970s, only for cereals. - Regarding speculation in general terms the scientific community agrees on the necessary role for markets to serve as an insurance against price risk. Speculation tends to reduce price volatility. However, in specific categories of commodity, speculation has been shown to favour spikes. For instance, McPhail et al. (2012) show that in the corn market speculation causes spikes in corn price. However, in the long run, other factors, such as energy and increasing global demand are the causes of spikes in corn price. - Finally, keeping our focus in general terms, it is important to distinguish among general price volatility and perceived price volatility. Whereas, as we mentioned before, the diachronic perspective confirms different price spikes but not an upwards trend of price volatility, on the EU level perceived price volatility has changed. In

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fact, due to the more liberal CAP, EU consumers tend to perceive price volatility in world agricultural markets as higher respect to the past.

In order to deep our analysis on price volatility for specific commodities, in the following we deep our analysis on three episodes, namely the grain crisis with price spikes in the wheat, soybean and rice prices (the rice bubble).

I. During the 2008 grain crisis, grain prices spiked due to increased demand for biofuels, higher oil prices, decreasing grain stocks, and the weakened US dollar (Headey, 2011). Rising wheat prices led India, the second largest rice producer, to ban exports of non-Basmati rice which subsequently led other rice exporting countries, including China, Vietnam and Egypt to introduce export bans. Some major importers, including the Philippines, responded by purchasing additional rice at increasing prices. This led to driving up of the global price of rice. By the end of the crisis, the World Bank reported over 130 million people were driven into poverty and the FAO estimated that an additional 75 million people became malnourished (Headey, 2011).
II. Furthermore, the analyses of price trend of wheat prices from January 2007 to July 2008 conducted by von Witzke (2014, available at: www.agriskmanagementforum.org/content/international-seminarfood-price-volatility-looking-viable-policy-approaches) using simply partial equilibrium model, shows that 78% of the price increase of wheat can be attributed to the following factors: freight rates (29.6), oil prices (29.3) , production reduction due to bad weather in southern eastern EU and Australia (hereby with a negative effect of -10.7!), exchange rates (7.6), export restrictions (6.1), population growth (2.3), income growth (2.0) and bioenergy production (0.1).
III. On the other side, the application of the same method to the soybeans price trend in the same time period shows the following factors as the major causes of the 111% price spike of soybeans: freight rates (28.9), oil prices (21.9) , production (11), exchange rates (7.6), export restrictions (4.3), bioenergy production (3.9), population growth (2.3) and, finally, income growth (2.0).

All these examples, explained in table 1, illustrate the potential for multiple stressors (e.g., increasing biofuel demand and oil prices, changes in commodities stock policies and financial crises) to cause shocks which propagate on large spatial scales. Interestingly, recent studies on price volatility show a weakened impact of the oil price on agricultural prices, thereby showing a declining trend of oilintensity in production of agricultural commodities (Alam & Gilbert, 2017). More specifically, SiamiNamini and Hudson (2017) show that volatility of international agricultural commodities prices do not significantly react to the volatility of crude oil price in the short run for the time period 1986-2005. However, they discover that, in the long run, the volatility of crude oil prices does affect the US dollar exchange rate volatility for the time period 2006-2015, which, in turn, affects the volatility of the international agricultural commodities returns through changes in prices. Similar effects have been detected also in the energy sector. For instance, using a dataset from March 2005 to March 2011, Du and McPhail (2012) showed that the shocks in the ethanol market have the largest impact on the corn price. Focusing on the same cereal, Regmi and Featherstone (2017) demonstrated that biofuel production related policies within the U.S. impacts the world price of corn (time period: 1982-2016) and its effect may last for a longer period of time.

As a consequence, particularly in the food systems, price volatility has gathered momentum in the last ten years and a plethora of studies (Canuto, 2014; Cashin et al. 2002; Carter et al., 2011; Kornher &

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Kalkuhl, 2013; Tomek & Kaiser, 2014) analyse the nature and frequency of disruptions, or shocks, to food systems on a regular basis to better understand the factors that contribute to global food security.

Finally, thanks to the great availability of studies, some general conclusions have been reached. For instance, to reduce price volatility in the agricultural commodities markets Semerari (2011) envisages three principal actions at the marketplace: 1) the monitoring and controlling of markets' trends in order to forecast in advance commodities shocks and turbulences 2) decreasing of import and export measures because of their distorting effects on the market and, finally, 3) Policies of market management such as public purchase, constraining stock of commercial retailers, or (which is still controversial) the creation of world-wide stocks to be used in case of market tensions.

### 3.1.1 A literature review on price volatility in fisheries and aquaculture markets

Unfortunately, in the fisheries and aquaculture markets the situation is different. Although these markets are as well exposed to a variety of disruptions, price spikes, overfishing and disease outbreaks, the patterns and trends of these shocks are poorly characterized (Delgado et al., 2003) and underreported due to the fact that temporal analyses have focused more on long-term trends rather than sudden drops and their resulting impacts (Gephart et al. 2017 and 2016). As a consequence, in the following, we present an overview of shocks as reported on the scarce literature in the field, derived essentially by scientific papers and news reports of international institutions such as FAO and IFPRI (see Table 1).

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*Table 1. Literature review of price volatility in the fisheries and aquaculture markets*

| **Title** | **Author** | **Year** | **Study topic** | Methodology | Main results | Data collection |
|---|---|---|---|---|---|---|
| Shock to fish production: identification, trends and consequences | Gephart et al. | 2017 | Analyse patterns and trade of fish shocks | Statistical shock detection approach 1976-2011 + a case study | The largest magnitude shocks focused on Asia, Europe and Africa.<br>In response countries tend to increase imports and experience decreases in supply-<br>Aquaculture systems are more likely to be interested by shocks than capture systems. Shocks have not grown along the time nor in frequency nor in magnitude. | United Nations' Comtrade and Fao Fishstat |
| Economic shocks in the fisheries sector and maritime piracy | Flueckiger and Ludwig | 2015 | Correlation of shocks in the marine sector and piracy | Panel of 109 coastal countries | Negative economic shocks, measured by drops of phytoplankton, in the fisheries sector are associated with an increase in maritime piracy.<br>Ergo: the economic conditions in the fisheries sector have an important impact on modern-day piracy | Decrease of amount of phytoplankton as a proxies for decrease of fish catch |
| Vulnerability to shocks in the global seafood trade network | Gephart et al. | 2016 | Shocks' simulation to assess the food-security outcomes. Comparison of changes in national fish supplies with indices of each country's nutritional fish dependency | Development of a shock-propagation model to quantify how trade flows are redistributed under a range of shock scenarios. | High degree of countries' interconnection the seafood and aquaculture sector. The most vulnerable countries to shocks are those with a high reliance on seafood and that are all large importers relative to their exports. Countries can reduce their overall vulnerability to shocks by reducing reliance on imports and diversifying food sources | United Nations' Comtrade and Fao Fishstat |
| Economic incentives and overfishing: a bioeconomic vulnerability index | Cheung and Sumaila | 2015 | Creation of a vulnerability index | Creation of an index that evaluates the level of vulnerability by comparing discount rates and fihes growth rate | Particular vulnerable countries: Canada, Pacific Coast of Mexico, Peruvian coast, southern and southeastern coast of Africa and the Antarctic | Mix of different sources among which FAO database |
| Disaster response and risk management in the fisheries sector | Westlund et al. (FAO Fisheries technical paper, n. 479) | 2007 | Compilation of both natural and human-induced disaster | Qualitative recollection of cases | Guidelines and recommendations are provided to governments to rapidly solve situations of emergence due to disasters in the fisheries and aquaculture sectors | FAO database and literature |

### 3.1.3 A literature review of the most important shocks in the fisheries and aquaculture markets as reported in the literature (time period: 1990s – 2009)

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Using data of United Nations' Comtrade and Fao Fishstat, Gephart et al. (2016) demonstrate that also the seafood and aquaculture sector is characterized by an increasing degree of countries' interconnection which leads to a rapid propagation of shocks on a spatial scale according to a mechanism of increasing imports and decreasing supply (Gephart et al., 2017). Although shocks have not grown along time nor in frequency nor in magnitude (Gephart et al. 2017), their monitoring is important since seafood is among the most highly traded food commodities. Furthermore, according to Gephart et al. (2016), in the last years, above all those countries that were net importers of seafood, and that depended on seafood for nutrition, tended to be the most vulnerable to shocks to the system. In particular Central and Western Africa stood out as being highly vulnerable. Especially shocks initiated in Northern Europe or Eastern Asia resulted in major supply decreases in West Africa. However, Eastern Asia and Southern and Western Europe were also vulnerable to external shocks, in particular those originating in Southeast Asia. Among the more vulnerable countries, Cheung and Sumaila (2015) count also Canada, Mexico, Peru and the Antarctic. As a consequence, countries can reduce their overall vulnerability to shocks by reducing reliance on imports and diversifying food sources. An interesting perspective on the turbulences that characterized the seafood sector is provided by the work of Flueckiger and Ludwig (2015). These authors illustrate the importance of monitoring the economic conditions in the fisheries' sector, since negative economic shocks are associated with an increase in maritime piracy. Table 2 provides an overview of the most important shocks which are caused by both natural and human-induced disasters (Westlund et al., 2007).

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*Table 2. Overview of the most important shocks in the fisheries and aquaculture markets as reported in the literature (time period: 1990s - 2009)*

| Year of shock | Cause | Consequence | Reported by |
|---|---|---|---|
| 1985-1997 | Rapid growth of aquaculture production | Decline of export unit values for **salmon** | Delgado et al., 2003 |
| 1987-1988 | Overfishing | Dispute between France and Canada | Gephart et al., 2017 |
| 1989 | Oil spills in Southern and Central Alaska | Drop in sell of **salmon, harbour seals, herring, crabs** and **clams** (around 240000 tons of fish) with food security problems for the population | Westlund et al., 2007 |
| 1990 | Farm production fish diseases in 15 Asian Countries | Loss in freshwater **finfish** pond culture and marine cage culture of **finfish** | Westlund et al., 2007 |
| 1991-2002 | War in Sierra Leone | Sharp decline in fish supplies with loss in food security | Westlund et al., 2007 |
| 1992 onwards | Political: dismantling of URSS, | Drop in seafood catch combined with increased export from Estonian governments Not recovered until 2011 | Gephart et al., 2017 |
| 1993 | **Cod** commercial near extinction, collapse and closure of the **cod** fishery | Food security problems for population of islands Saint Pierre and Miquelons (French territories) | Gephart et al., 2017 |
| During the 1980s and mid 1990s, with eventually drop in catch in 2000 | Decline of both **pelagic fish** and **demersal species** in Ghana | Food security problems for Ghana's population | Gephart et al., 2017 |
| 2000 | Floods in Viet Nam | Destruction of fishing vessels and drop in fishing trade infrastructure | Westlund et al., 2007 |
| 2002 | Cyclones in Mozambique | Destruction of fishing vessels and drop in fishing trade infrastructure | Westlund et al., 2007 |
| 2002 | Typhoon in the Philippines | Lost of 3000 metric tons of fish production | Westlund et al., 2007 |
| 2002/2003 | Ice drifts in Canada and USA (Maine) | Killing of large numbers of farm fish | Westlund et al., 2007 |
| 2004 | Long series of hurricanes in the Caribbean | Destruction of fishing vessels and drop in fishing trade infrastructure | Gephart et al., 2016 |
| 2004 | Tsunami | Substantial drop in per capita seafood supply at the shock point and food security for Sri Lanka (and Asian Countries) | Gephart et al., 2017 |
| 2004-2009 | Negative economic shocks, caused by drop of phytoplankton's quantities | Decrease of fish catch and increase of maritime piracy | Flueckiger and Ludwig, 2014 |

Two main conclusions can be drawn on the work so far:

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Firstly we can make a parallel between the seafood sector and the agriculture sector. In the same way as no increase can be found in the number of shocks in agricultural systems in the past 25 years (Sartori & Schiavo, 2015), increases in shocks with time or in frequency or in magnitude in the capture and aquaculture markets cannot be found either (Gephart et al. 2017).

Secondly, in the last 20 years, aquaculture systems were more likely to be affected by shocks than capture systems (Gephart et al., 2017).

### 3.2 Detection of "boom and bust" cycles and making predictions of price

The investigation will focus on the European fisheries/aquaculture sectors and other relevant international players and it is conducted through the analysis of aggregate data of primary production units (capture fisheries and aquaculture) obtained from available public sources as well as detailed data from individual companies. The use of a statistical methodology, implemented in MATLAB software, allows the detection of boom and bust cycles in time series and potentially, predictions on price fluctuations, protecting against such future cycles.

## 4. RESULTS

### 4.1 The decomposition of the price time series

The countries analysed are: Canada, Denmark, Germany, Greece, Iceland, Norway, Spain, United Kingdom and Italy.

The analysis aimed at understanding the trends and cyclical nature of the first sale/landing prices, wholesale, retail and import or export price time series.

The trend analysis and the cycles is based on the factorization of the phenomenon observed in various components (e.g. price level, increasing or decreasing long term trend, seasonality -fluctuations within the year which tend to be repeated, cyclical -deviation from long-term trends-, and irregular component -exceptional events - outliers).

This methodological approach allows us to decompose the trend of prices for components and assigning each part the stochasticity and deterministic features. The classification of a component as stochastic or deterministic is important because it helps understanding in more detail whether the price trend analysis can be considered "fixed" or "probabilistic".

This decomposition should allow us to predict what will be the selling price in the future (seasonal; summer, winter, etc.) according to price forecast.

The Graph reporting Forecast includes Confidence charts. The user can choose the confidence level based on risk aversion. The range of confidence levels helps the user to understand the precision of the prediction.

For every chart and table, showing the decomposition of time series, a short comment has been reported by the authors. However, the chart itself should be quite explanatory for the price trend in the observed period.

The items Slope, Seasonal, Cycle and Irregular yield have values in the interval [0, 1]. The unit of the item Period refers to months.

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# 5. DISCUSSION

## 5.1 Discussion on "boom & bust"

The application of the Kalman filter to the data from the fisheries and aquaculture sectors made decomposition possible for the time series into elementary parts such as trend, cycle, seasonality and an irregular component. For each of the price series available the fundamental tendency (towards the increasing, the reduction or even to price stability) has been detected, apart from accidental variations (irregularities or outliers), seasonal and cyclical. The irregular component represents unforeseeable and accidental variations related to all the most varied types of events. This component in some cases may include extreme values or outliers. The Kalman filter as well, breaks down the price trend in building blocks that may be allocated to each member of the characteristics of stochasticity and determination. The classification of a component as a stochastic or deterministic is of particular importance since it allows us to understand more in detail what inside price trend analysis can be considered as "fixed" or "probabilistic". The Kalman filter also allows us to determine if the individual components are stochastic or deterministic. The classification of a component as a stochastic or deterministic is of particular relevance since a larger deterministic component in a time series improves the forecasts.

So, for each time, series of available prices are presented in the Forecasts, it becomes more reliable within a short-medium horizon, less for long-term scenarios. The information could help to predict what will be selling price in time (seasonal), summer or winter. The question that arises if we can predict it with precision. The production of confidence Graphs can easily help the user to understand the precision of the prediction. User (for each market level) can decide what type of confidence level he wants based on risk aversion.

To complete the task, starting from the results of the first part of the investigation, a methodology has been developed to detect "boom and bust cycles" on the analysed time series. The main challenge was to identify price thresholds beyond classifying the cycle as in a boom period or in a bust period, as reported above.

As concerning Boom has been identified 81 cases, distributed in the 10 countries studied and distributed according species.

According to Species, trout compares with a total of 22 Boom and Seabass with 15 Boom. According to countries, Spain accounts for 23 Boom and Italy for 13.

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*Table 3. Boom for species and countries*

| BOOM | Canada | Denmark | Germany | Greece | Iceland | Italy | Norway | Spain | United Kingdom | Vietnam | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cod | 1 | | | | 2 | | 2 | 1 | 4 | | 10 |
| European seabass | | | | 5 | | 8 | | 2 | | | 15 |
| Gilt-head seabream | | | | 5 | | 5 | | | | | 10 |
| Herring | | 2 | 3 | | 2 | | 2 | | | | 9 |
| Pangasius | | | | | | | | | | 3 | 3 |
| Salmon | | | | | | | 3 | | 2 | | 5 |
| Seabream | | | | | | | | 7 | | | 7 |
| Trout | | 7 | | | | | | 13 | 2 | | 22 |
| **Total** | **1** | **9** | **3** | **10** | **4** | **13** | **7** | **23** | **8** | **3** | **81** |

Considering Bust, it has been identified 86 cases, distributed in the 10 countries studied and distributed according to species.

According to Species, Trout compares with a total of 22 Bust and Seabass with 15 Bust. According to countries, Spain accounts for 20 Bust and Italy, Greece and Denmark for 13 Bust.

Clearly, there is an effect of Species and also a country effect.

*Table 4. Bust for species and countries*

| BUST | Canada | Denmark | Germany | Greece | Iceland | Italy | Norway | Spain | United Kingdom | Vietnam | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cod | 1 | | | | 3 | | 2 | 2 | 5 | | 13 |
| European seabass | | | | 6 | | 8 | | 1 | | | 15 |
| Gilt-head seabream | | | | 6 | | 4 | | | | | 10 |
| Herring | | 2 | 5 | | 2 | | 2 | | | | 11 |
| Pangasius | | | | | | | | | | 3 | 3 |
| Salmon | | | | | | | 2 | | 3 | | 5 |
| Seabream | | | | | | | | 7 | | | 7 |
| Trout | | 10 | | | | | | 10 | 2 | | 22 |
| **Total** | **1** | **12** | **5** | **12** | **5** | **12** | **6** | **20** | **10** | **3** | **86** |

Concerning the level of the market, here below the occurred "boom and bust" are listed.

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*Table 5. Boom for species, countries and level of the market*

| | Canada | Denmark | Germany | Greece | Iceland | Italy | Norway | Spain | United Kingdom | Vietnam | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cod | 1 | | | | 2 | | 2 | 1 | 4 | | 10 |
| Export | | | | | 2 | | | | | | 2 |
| first sale | 1 | | | | | | 2 | | 2 | | 5 |
| Retail | | | | | | | | 1 | 2 | | 3 |
| European seabass | | | | 5 | | 8 | | 2 | | | 15 |
| consumption | | | | | | 2 | | | | | 2 |
| Export | | | | 5 | | | | | | | 5 |
| first sale | | | | | | 3 | | | | | 3 |
| Retail | | | | | | 3 | | 2 | | | 5 |
| Gilt-head seabream | | | | 5 | | 5 | | | | | 10 |
| Export | | | | 5 | | | | | | | 5 |
| first sale | | | | | | 2 | | | | | 2 |
| Retail | | | | | | 3 | | | | | 3 |
| Herring | | 2 | 3 | | 2 | | 2 | | | | 9 |
| Export | | | | | 2 | | | | | | 2 |
| first sale | | 2 | 2 | | | | 2 | | | | 6 |
| Retail | | | 1 | | | | | | | | 1 |
| Pangasius | | | | | | | | | | 3 | 3 |
| first sale | | | | | | | | | | 3 | 3 |
| Salmon | | | | | | | 3 | | 2 | | 5 |
| Export | | | | | | | 3 | | | | 3 |
| Retail | | | | | | | | | 2 | | 2 |
| seabream | | | | | | | | 7 | | | 7 |
| first sale | | | | | | | | 2 | | | 2 |
| Retail | | | | | | | | 2 | | | 2 |
| wholesale | | | | | | | | 3 | | | 3 |
| Trout | | 7 | | | | | | 13 | 2 | | 22 |
| first sale | | 5 | | | | | | 6 | | | 11 |
| Retail | | 2 | | | | | | 3 | 2 | | 7 |
| wholesale | | | | | | | | 4 | | | 4 |
| **Total** | **1** | **9** | **3** | **10** | **4** | **13** | **7** | **23** | **8** | **3** | **81** |

As expected, data show that the number of B&B are considerable higher for First Sale (50% of the total occurrence) and Export than for Wholesale and Retail (only 4 cases).

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*Table 6. Number of B&B for market level*

| | First sale | Wholesale | Consumption/Retail | Export | Total |
|---|---|---|---|---|---|
| **Boom** | 32 | 7 | 25 | 17 | 81 |
| **Bust** | 31 | 6 | 30 | 19 | 86 |
| **Totale complessivo** | 63 | 13 | 55 | 36 | 167 |

In the following table detailed list of the cases.

*Table 7. Bust for species, country and level of the market*

| | Canada | Denmark | Germany | Greece | Iceland | Italy | Norway | Spain | United Kingdom | Vietnam | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cod | 1 | | | | 3 | | 2 | 2 | 5 | | 13 |
| Export | | | | | 3 | | | | | | 3 |
| first sale | 1 | | | | | | 2 | | 2 | | 5 |
| retail | | | | | | | | 2 | 3 | | 5 |
| European seabass | | | | 6 | | 8 | | 1 | | | 15 |
| consumption | | | | | | 2 | | | | | 2 |
| Export | | | | 6 | | | | | | | 6 |
| first sale | | | | | | 3 | | | | | 3 |
| retail | | | | | | 3 | | 1 | | | 4 |
| Gilt-head seabream | | | | 6 | | 4 | | | | | 10 |
| Export | | | | 6 | | | | | | | 6 |
| first sale | | | | | | 1 | | | | | 1 |
| retail | | | | | | 3 | | | | | 3 |
| Herring | | 2 | 5 | | 2 | | 2 | | | | 11 |
| Export | | | | | 2 | | | | | | 2 |
| first sale | | 2 | 3 | | | | 2 | | | | 7 |
| retail | | | 2 | | | | | | | | 2 |
| Pangasius | | | | | | | | | | 3 | 3 |
| first sale | | | | | | | | | | 3 | 3 |
| Salmon | | | | | | | 2 | | 3 | | 5 |
| Export | | | | | | | 2 | | | | 2 |
| retail | | | | | | | | | 3 | | 3 |
| seabream | | | | | | | | 7 | | | 7 |
| first sale | | | | | | | | 3 | | | 3 |
| retail | | | | | | | | 2 | | | 2 |
| wholesale | | | | | | | | 2 | | | 2 |
| Trout | | 10 | | | | | | 10 | 2 | | 22 |
| first sale | | 6 | | | | | | 3 | | | 9 |
| retail | | 4 | | | | | | 3 | 2 | | 9 |
| wholesale | | | | | | | | 4 | | | 4 |
| **Total** | **1** | **12** | **5** | **12** | **5** | **12** | **6** | **20** | **10** | **3** | **86** |

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As concerning the timing of B&B occurrence here reported the numbers of B&B per year.

Figure 1 shown here is only a simplification to connect the results with previous results from the literature review.

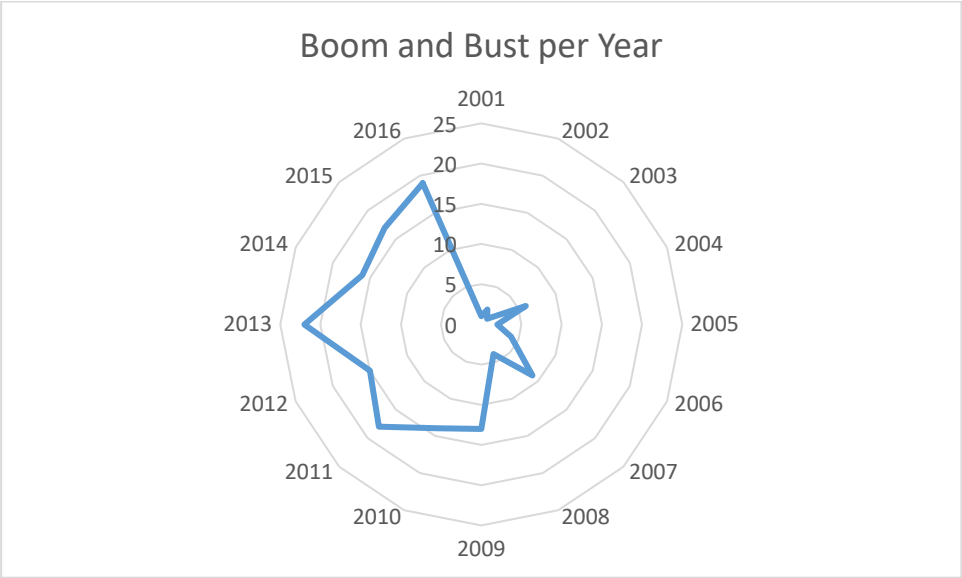


*Figure 1. Boom and Bust per year*

Comparing the B&B identified for our case studies and the literature review, after 2009 the numbers of occurrence of B&B, as identified in the Report, increased meanwhile in the international market volatility also increased, showing an increasing degree of commodities/products interconnection which leads to a fast propagation of shocks. No recent available literature review allows to analyse price volatility and to compare it with the more recent shocks.

## 6. CONCLUSION

The seafood production and trade system is exposed to a variety of disruptions including fishery collapses, natural disasters, policy changes and price spikes. Especially the shocks caused by the latter are particularly negative for fisheries and aquaculture operations because they limit the ability to generalize or predict and, consequently, to adequately response to the market's shocks. The overall objective of PrimeFish is to enhance the economic sustainability of European fisheries and aquaculture sectors to inform operators and help them to identify potential risks and opportunities to build resilience in the global food system. This study is devoted to provide a detection of the component of time series of prices and an analysis of the occurrence for "boom and bust" cycles for the selected species studied in PrimeFish.

In particular, data were first analyzed through analysis of the literature about the main historical shocks on the market of the main agricultural commodities and fish products (in general) to assess the points linked to the Boom and Bust identified (critical factors for "boom and bust" cycles).

This study simply investigated patterns in the price – without trying to explain it beoynd time components i.e. year - trends, seasonality – months and pontentially otter cyclical patterns.

The critical factors which are responsible for the principal prices' turbolences and drops and spikes in the prices of agricultural commodities in world markets have been explored using literature obtained

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from the principal databanks such as Web of Science for the last 10 years. Next, a similar literature review for price volatility of both fisheries and aquaculture markets has been carried out. The sequence of price shocks presented in the metaanalysis is further empirically compared with the price series analyses executed using the method of Kalman's filters.

Comparing the B&B identified for our case studies and the literature review, after year 2009 the numbers of occurency of B&B, as defined in the Report, increased meanwhile in international market volatility also increased, showing an increasing degree of commodities/products interconnection which leads to a rapid propagation of shocks. No recent manuscripts (e.g. peer-review papers, reports, etc.) have shown results about price volatility in the fish sector.

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