

A first-sale price index of seafood products: Evidence from France 1994-2020[#]

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Abstract: Studies on price trends of seafood products in the medium run remain scarce. In this paper, we investigate changes in first-sale prices of fish sold in France over the last 25 years. Drawing on the index number literature, we construct monthly chained fish price indices which are free from seasonal fluctuations. Our empirical analysis relies on a dataset including 126 million transactions completed in all French fish markets from 1994 to 2020. We show that first-sale prices of seafood products have substantially increased in the medium run, more than the inflation rate, except during the economic crisis from 2007 to 2009 and recently in 2020 due to the Covid pandemic. However, those higher prices have not always led to an increase in sales revenue of fishermen because of the continuous decrease in fish catches. In particular, the economic situation of fisheries has substantially worsen since 2017.

Keywords: seafood products, first-sale prices, price indices, seasonality, Covid crisis

JEL Classification: Q11, Q22

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1. Introduction

The fishery sector faces several challenges both in the short and the long run. In the short run, fishery activities have to deal with risks like weather conditions and uncertainties of quantities caught due to natural variability of species (Petermann, 2004). Also, external shocks may affect both quantities and prices on fish markets as illustrated by the Brexit decision and the COVID pandemic. In the long run, fisheries are under threats like overfishing, climate change, ocean acidification, and preservation of the marine ecosystem (FAO, 2018). In such context, fish catches have strongly decreased over the last three decades in European Union countries and especially in France (Eurostat, 2021). Many countries have implemented fishing quotas and Total Allowable Catches (TACs) among others tools aimed at preserving fish stocks.

While expected changes in quantities of seafood products are rather well predictable, this is clearly not the case of the price variations induced (OECD, 2020a). Consider for instance the case of the COVID pandemic. The lockdown with restaurant and catering closure as well as cancellation of many private and public events has resulted in difficulties in seafood products trade (OECD, 2020b). The decline in production was estimated at around 50% for French fisheries in April 2020 compared to the previous year, with up to 80% fewer vessels operating in the Mediterranean Sea (OECD, 2020b). When turning to prices, the negative demand shock should have induced lower prices for fixed supply and the negative supply shock should have induced higher fish prices for fixed demand. However, as the pandemic has induced both demand and supply contractions, the variation in fish prices cannot be signed on a priori grounds which creates an additional source of uncertainty for fishermen revenue.

While the evolution of fish landings is well documented (FAO, 2020), studies on price trends of seafood products remain scarce. Previous works have mainly focused on seafood market integration and the law of one price (see Gordon and Hannesson, 1996; Asche et al., 2012; Norman-López et al., 2014; Gobillon and Wolff, 2016; Gobillon et al., 2017). In an historical dimension, Vickers (1996) produced a price index for cod between 1505-1892 for Spain and the United States and Bezanson et al. (1936) documented prices of many commodities including mackerel, cod and herring between 1785 and 1860 for a set of American cities. Sumaila et al. (2007) investigated the prices that fishermen received when selling their catch for all commercially exploited marine fish stocks by country of fishing fleet.

Using data from France, Steinmetz et al. (2008) constructed Fisher price and quantity indices for fish species caught by commercial fishing fleets in the Bay of Biscay and the North-East Atlantic. These indices were built using annual data, meaning that species composition is taken into account, but not seasonality. Tveterås et al. (2012) constructed an index of global seafood prices using international trade data. As the collection of data on fish prices remains challenging in many regions, considering trade data appears helpful to update on a regular basis a price index. At the same time, this sets up some challenges related to the selection of fish species to include in the price index, the different forms of seafood products as well as the prices used for the calculations.

The purpose of our contribution is to provide new evidence on first-sale price trends of seafood products in the medium run. For that purpose, we rely on a unique database with more than 126 million transactions collected in fish markets in France over the period 1994-2020. The case of France provides a very interesting setting. Indeed, France is the fourth largest producer of fish and aquaculture products in the European Union (EU) after Spain,

the United Kingdom and Denmark, with around 640,000 tons for a value of approximately 1.7 billion euros (INSEE, 2019). The French fishing fleet is one of the largest among EU countries and only the Spanish fleet is ahead of it in terms of vessels, tonnage, landings and sales value. The contribution of the French fishery sector to total employment is estimated at 39,000 direct jobs and 100,000 induced and indirect jobs (MAA, 2020).

Curiously, there is very little information on how prices of seafood products have evolved over the last decades in that country. FranceAgriMer, which is the national establishment for agricultural and seafood products carrying out its missions on behalf of the French State in conjunction with the Ministry of Agriculture and Food, publishes on a monthly basis the average first-sale price of all seafood products defined as the ratio of total value over total volume. Such information is very easy to compute, but it also raises some substantial problems of weighting and seasonality. For instance, if the stock of high-value fish species tends to decrease over time more than the stock of low-value fish species due to overfishing, then the average price of all seafood products could decrease not because prices are going down, but because of the underlying composition effect.

In this paper, we construct different Fish Price Indices (FPI hereafter) so as to know to what extent seafood products sold in first-hand fish markets in France have become more or less expensive over time. As in Tveterås et al. (2012), we rely on the literature of index number and price indices (Diewert, 1976). We consider both the Laspeyres, Paasche and Fisher price indices in our empirical analysis. Those indices are formulae used in price statistics for measuring the price change of a basket of goods consumed in a base period, with different weighting schemes¹. We explain how the issue of seasonality of seafood

¹ The Laspeyres price index indicates the price development of the basket consumed in the base period, the Paasche price index measures the price development of the basket consumed in the current period, and the Fisher price index considers both the baskets from the base and the current periods.

products can be dealt with when constructing price indices. Drawing on Diewert (1983), we consider two different types of seasonality adjusted indices: a year-over-year monthly index and a rolling year annual index. All our indices are chained in order to account for changes observed between successive periods and we end up with price indices which are free from seasonal fluctuations.

According to our indices, first-sale prices of seafood products have increased more than the inflation rate in the medium run in France. Fish prices have nonetheless decreased during the financial crisis from 2007 to 2009 and with the Covid pandemic in 2020. Despite those higher prices, the economic situation of fishermen has not improved over the period because of the regular decrease in fish catches. Since March 2017, the negative quantity effect is more important than the positive price effect. As a consequence, the revenue index decreases and this phenomenon has been amplified by the recent Covid pandemic.

The remainder of our contribution is organized as follows. In Section 2, we describe the transaction data and provide an overview of the French fish market. In Section 3, we explain the construction of seasonally-adjusted fish price indices. In Section 4, we analyze trends in price and revenue indices. Finally, Section 5 concludes.

2. Description of the data

There are 65 fishing ports along the French coasts restricted to the metropolitan area. Among the fishing ports that can be found all along the French coastlines (North Sea, Channel, Atlantic Ocean, and Mediterranean Sea), 37 are equipped with a fish market called "*halle à marée*". It corresponds to the place where the fish is first sold when landed in the fishing port. In France, there exists a sales data system that provides information on products sold in fish markets. All sales are recorded by the Réseau Inter-Criées (RIC) which is

managed by FranceAgriMer on behalf of the *Direction des Pêches Maritimes et de l'Aquaculture* (DPMA).

In this paper, we use the exhaustive RIC data made available by FranceAgriMer from its starting year 1994 to 2020, corresponding to a 27-years period². The dataset includes all the transactions carried out in all markets for seafood products in France either through auctions, over-the-counter sales or contract sales. In the RIC, each transaction gives rise to a specific record which includes for each lot of fish the following information: date of sale, fish market identifier, fish species code, presentation code, quality code, quantity of the lot (expressed in kilograms), and value of the lot (expressed in euros). For a given period, which can be either the day, the month or the year for instance, it is therefore possible to know the total quantity sold of each fish species and the average price of that species.

Table 1 provides a description of all the transactions completed during the 1994-2020 period. The total number of transactions exceeded 126 million over the period, corresponding to 4.67 million transactions per year on average. Transactions increased over the period, from around 2.5 million in the mid-1990s to more than 6 million from 2010 to 2017, but the number of transactions was substantially lower in 2020 (5.4 million). The total quantity sold during the period was 6377.8 thousand tons (236.2 thousand tons per year on average). Due to declining fish stocks (FAO, 2020), the total quantity sold decreased overall with two distinct sub-periods. From 1994 to 2003, the total quantity was around 280 thousand tons per year. Since 2008, the annual quantity sold has been around 200 thousand tons. A minimum of 153.8 thousand tons was reached in 2020, in connection with the Covid pandemic and the lockdown from March to May in France.

Insert Table 1 here

² In France, there was no systematic recording of fish transactions in auction markets before 1994.

From 1994 to 2020, the total value of lots sold was 17.5 billion euros (652.8 million euros on average). The total value has remained relatively stable, around 600 and 700 million euros for almost all years. However, there was a decrease during the economic crisis from 2008 to 2010 and a minimum of 526.1 million euros was reached in 2020. Since annual sales have remained relatively stable in value while total quantities have tended to decrease, this means that prices in fish markets have increased over the period. The quantity per transaction (obtained by dividing the volume by the number of transactions) has globally decreased over the period, which supposes a change in the management of primary market due to the decrease of landings. Figure 1 shows the average price of fish in France calculated on a monthly basis, corresponding to the total value sold each month divided by the total quantity sold each month (all species being pooled).

Insert Figure 1

A first finding is the remarkable regularity of the growth in the average price from 1994 to 2020. The price increased by 79.4% from January 1994 to January 2020, from 1.99 to 3.57 euros per kilo. We estimate a regression explaining the monthly average price P_t as a function of a linear monthly time trend t such that $P_t = c + \gamma * t + \varepsilon$, where ε is a residual. As shown in column 1 of Table 2, we find an average monthly increase of 0.005 cents per kilo (with $t = 32.06$), corresponding to an increase of 6 cents per year. A second result concerns the large monthly price variations. To detect a possible seasonality, we add to the previous regression the different calendar months \mathcal{M}_m as additional controls such that $P_t = c + \gamma * t + \sum \delta_m \mathcal{M}_m + \varepsilon$, January being the reference. As shown in column 2, prices of seafood products are substantially lower in June and from September to November (when landings are important), while they are much higher (more than 50%) in December with the proximity

of Christmas and New Year events when the demand for high-quality seafood products is high.

Insert Table 2

Prices of seafood products depend mainly on their taste and their rarity (Ervynck et al., 2003) as well as on other intrinsic factors like the presence of bones, the ease to cook or the smell of baking. In the long run, the rise of the average price supports several explanations. While part of the growth can be explained by an increase in the average price for most species (which would be itself related to changes in demand as well as decreasing stocks), it can also be explained by some substitution towards species that are better valued by the market. If vessels devote more effort fishing the most expensive species, then the average price per kilo will increase without each species being better valued. By construction, the average price per kilo on the market depends on the prices per kilo of the different species that may have had very different trajectories during the period. This composition effect may lead to an increase in the average price per kilo even if species-specific prices remain unchanged.

We now take a closer look at the evolution of prices by fish species. For this purpose, we retain the nine main species characterized by the most important sales (in value) over the 1994-2020 period. In decreasing order of importance, these are sole (10.5% of total value), monkfish (9.4%), Norway lobster (6.5%), scallop (5.7%), seabass (5.6%), hake (5.4%), squid (4.3%), cuttlefish (4.1%) and whiting (3.0%) (see Table A in the Appendix). Overall, these nine species account for 54.5% of the total value of sales. Annual price and quantity trends for those nine species are shown in Figure 2. Our results highlight the strong heterogeneity in prices among the selected species, suggesting that consumer preferences (demand side) and catches (supply side) differ greatly across species. Over the whole period,

the average price per species ranges from 1.6 euros for whiting to 11.0 euros for sole (10.3 euros for seabass). Between 1994 and 2020, monthly prices have increased for all species except hake. However, not all species have appreciated in similar proportions.

Insert Figure 2

The seasonality of fish catches and therefore of sales is another major element to take into account when studying price dynamics. In the literature dealing with the consequences of seasonality on price measurement (Diewert et al., 2009), two types of seasonal products are distinguished: i) the first category corresponds to strongly seasonal products, which are not available on markets at certain times of the year; ii) the second category corresponds to weakly seasonal products, which are available all over the year, but are characterized by seasonal fluctuations in both prices and quantities sold. Figure 3 shows the seasonality over the year for quantities of the nine major fish species sold. Again, the profiles are very heterogeneous depending on the species.

Sole is fished throughout the year by offshore fleets and fishing is intensified at the end of the winter on the spawning concentrations off the coast, whereas coastal vessels catches this species mainly from spring to autumn. Monkfish, seabass and whiting exhibit similar seasonal fishing patterns as they are characterized by winter spawning periods (SeaWeb, 2016). For the Norway lobster, the landings peak in Spring is linked to spawning period. As seabass which usually live alone are schooling fish at the spawning period, they are highly vulnerable and are easy to catch in large quantities. As a cold water species, squid is always caught more during winter because that species leaves deep waters and moves close to shore. Furthermore, the stock of squid is very variable from year to year. Similar

features applies for cuttlefish. Concerning scallop, fishing is strictly regulated with the season starting from October, 1st and ending on May, 15th³.

Insert Figure 3

To summarize, these descriptive results show a steady increase in the average price per kilo over the period. In order to account for the composition of species sold over time, either due to seasonality or more structural changes in relation to the evolution of fish landings, we now explain the construction of seasonally-adjusted fish price indices.

3. Seasonally-adjusted fish price indices

The literature on price indices has given rise to a very abundant literature, which is mainly based on the original contributions of Diewert (1976; 1983). The main challenge when constructing a fish price index (FPI hereafter) is to account for the seasonality of seafood products. In what follows, we briefly present the different stages of the FPI's construction.

Leaving aside for the moment the issue of seasonality, there are three main types of indices. Let p_n^t be the price of the good n (corresponding to a fish species) at date t and q_n^t be the total quantity sold at date t with $n = 1, \dots, N$ and $t = 0, \dots, T$. We denote by p^t and q^t the corresponding vectors of prices and quantities. Unlike index calculations for consumer prices, both prices and quantities are observed (all transactions are recorded). The Laspeyres index $P_L(p^0, p^t, q^0)$ consists in measuring the evolution of the prices of all goods between the base year 0 and the current year t taking into account as weighting the quantities sold at the initial date 0:

³ The seasonal closing corresponds to the mating periods as well as the strong growth of scallop due to spring peak in phytoplankton abundance.

$$P_L(p^0, p^t, q^0) = \frac{\sum_n p_n^t q_n^0}{\sum_n p_n^0 q_n^0} \quad (1A)$$

which presupposes that the quantities observed in the first period are relevant for subsequent periods. This assumption of a constant composition of fish species seems very unlikely in the context of a FPI. Certain fish species have been subject to intensive fishing over time and their catches have gradually decreased due to depletion and/or TACs. Consequently, overestimated weights will be used for species contributing less and less to total sales. A second measure is the Paasche index $P_P(p^0, p^t, q^t)$ which is based on the quantities of the current period q_n^t :

$$P_P(p^0, p^t, q^t) = \frac{\sum_n p_n^t q_n^t}{\sum_n p_n^0 q_n^t} \quad (1B)$$

The quantities used now change on each calculation date, which also makes this index highly sensitive to changes in catches over time. As both price indices P_L et P_P provide different estimates of the aggregate price changes between periods 0 and t , a solution consists in using weighted averages of those fixed basket–price indices such as the Fisher index:

$$P_F(p^0, p^t, q^0, q^t) = \sqrt{P_L(p^0, p^t, q^0) P_P(p^0, p^t, q^t)} \quad (1C)$$

which corresponds to the geometric mean of the Laspeyres and Paasche indices. The Fisher index, which is the measure used by Tveterås et al. (2012) to construct a global FPI, is recommended by manuals to produce price indices (CPI Manual, 2004; PPI Manual, 2010).

Both (1A), (1B) and (1C) are fixed-base indices, i.e. they are index numbers in which the value of every period is related to the same value of one fixed-base period. However, the use of a fixed-base system of price levels may be problematic in a time-series context especially for seafood products. In the presence of systematic trends on prices and quantities of at least some species in the basket, then the fixed-base Laspeyres and Paasche

indices will diverge more and more. The solution is to consider chained indices, which indicate the price changes from a base period to a current period on the basis of the changes observed between successive periods (the value of any period is thus related to the value of its preceding period). The one-period rates are then cumulated to obtain the overall price evolution over the period (Balk, 2010). Since the base period is modified at each period, the chaining operation will therefore reduce the spread between the Paasche and Laspeyres indices.

For seafood markets, the main difficulty lies in the seasonality of both prices and quantities of fish species sold. As Szulc (1983) and Hill (1993) have pointed out, chained indices are problematic in the case of price oscillations. In particular, the comparison between two successive months t and $t - 1$ will be difficult when there are large variations in catches or prices, for instance because of peak of demand at the end of the year especially for high-valued seafood products as Norway lobster or seabass. The issue of seasonality has received considerable attention in the literature (CPI Manual 2004, Chapter XX; PPI Manual 2010, Chapter 22; Diewert et al., 2009). Diewert (1983) has proposed two monthly price indices to account for seasonality (either weak or strong) of products on the market. In what follows, the price indices taking into account seasonality will be denoted by \mathcal{P} and the unit of time t will be replaced by the couple (y, m) with y the year and m the month.

The first indicator is a year-over-year monthly index \mathcal{P}^{YYM} . Rather than comparing months two by two successively, the idea is to compare price changes between month m of year y and month m of the previous year $y - 1$ in a chained index (or month m of year 0 in an unchained index). Then, the comparison of that month over two successive years will leave out variations in the quantities sold during the remainder of the year. Intuitively, the

index is based on a constant seasonal market basket (Zarnowitz, 1961). The Laspeyres, Paasche and Fisher indices \mathcal{P}^{YYM} are (PPI Manual, 2010, p. 559):

$$\mathcal{P}_L^{YYM}(p^{y,m}, p^{y+1,m}, q^{y,m}) = \frac{\sum_n p_n^{y+1,m} q_n^{y,m}}{\sum_n p_n^{y,m} q_n^{y,m}} \quad (2A)$$

$$\mathcal{P}_P^{YYM}(p^{y,m}, p^{y+1,m}, q^{y+1,m}) = \frac{\sum_n p_n^{y+1,m} q_n^{y+1,m}}{\sum_n p_n^{y,m} q_n^{y+1,m}} \quad (2B)$$

$$\mathcal{P}_F^{YYM}(p^{y,m}, p^{y+1,m}, q^{y,m}, q^{y+1,m}) = \sqrt{\frac{\mathcal{P}_L^{YYM}(p^{y,m}, p^{y+1,m}, q^{y,m}) *}{\mathcal{P}_P^{YYM}(p^{y,m}, p^{y+1,m}, q^{y+1,m})}} \quad (2C)$$

with $m = 1, \dots, 12$. Using these different year-over-year monthly indices \mathcal{P}_L^{YYM} , \mathcal{P}_P^{YYM} and \mathcal{P}_F^{YYM} , it is then possible to calculate year-over-year monthly chained indices. We denote by C as subscript the chained version of the price index. These chained indices \mathcal{P}_{LC}^{YYM} , \mathcal{P}_{PC}^{YYM} and \mathcal{P}_{FC}^{YYM} will reduce the gap between the Laspeyres and Paasche indices compared to the unchained versions of these same indices presented in (2A), (2B) and (2C)⁴. The main limitation of this approach is that the comparison is made by construction between the same months of two calendar years. If some species are closer to shore one year in April and the following year in May, then the weights associated with quantities will vary significantly when calculating the index.

The second indicator corresponds to a rolling year annual index denoted by \mathcal{P}^{RYA} , which is based on comparisons over 12-month periods to avoid the influence of seasonality on prices and quantities. Let us first consider the case of a fixed-base index. The \mathcal{P}^{RYA} index is equal to 1 for the last month of base year 0. Then, the base period varies according to the first month of the current year. For example, for January of year 1, the index takes for current period the months from February of year 0 to January of year 1 and for base period

⁴ A chained index provides a more accurate estimate of changes from one period to the next by using the baskets of seafood products related to each period. More precisely, the price changes between two adjacent periods are weighted with the value shares of the most recent period (the base period is move forward by one every period).

January to December of year 0. Thus, the index for January of year 1 compares prices and quantities for January of year 1 with prices and quantities for January of year 0, while the comparison is for the same months from February to December of year 0 for the current year and for the base year. For each publication of the index, the same calendar months are compared, but these months can be on two distinct years for both the current and base years:

$$\mathcal{P}_L^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}, p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{0,1}}, \dots, q^{\mathcal{R}^{0,12}}) = \frac{\sum_{m \in \mathcal{R}^1} \sum_n p_n^{\mathcal{R}^{1,m}} q_n^{\mathcal{R}^{0,m}}}{\sum_{m \in \mathcal{R}^0} \sum_n p_n^{\mathcal{R}^{0,m}} q_n^{\mathcal{R}^{0,m}}} \quad (3A)$$

$$\mathcal{P}_P^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}, p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{1,1}}, \dots, q^{\mathcal{R}^{1,12}}) = \frac{\sum_{m \in \mathcal{R}^1} \sum_n p_n^{\mathcal{R}^{1,m}} q_n^{\mathcal{R}^{1,m}}}{\sum_{m \in \mathcal{R}^0} \sum_n p_n^{\mathcal{R}^{0,m}} q_n^{\mathcal{R}^{1,m}}} \quad (3B)$$

$$\mathcal{P}_F^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}, p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{0,1}}, \dots, q^{\mathcal{R}^{0,12}}, q^{\mathcal{R}^{1,1}}, \dots, q^{\mathcal{R}^{1,12}}) = \sqrt{\frac{\mathcal{P}_L^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}; p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{0,1}}, \dots, q^{\mathcal{R}^{0,12}}) * \mathcal{P}_P^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}; p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{1,1}}, \dots, q^{\mathcal{R}^{1,12}})}{\mathcal{P}_P^{RYA}(p^{\mathcal{R}^{0,1}}, \dots, p^{\mathcal{R}^{0,12}}; p^{\mathcal{R}^{1,1}}, \dots, p^{\mathcal{R}^{1,12}}, q^{\mathcal{R}^{1,1}}, \dots, q^{\mathcal{R}^{1,12}})}} \quad (3C)$$

where \mathcal{R}^0 and \mathcal{R}^1 are the base and current periods, respectively. The length of these periods is always twelve months, but the beginning of each period is not necessarily in January. Each calendar month of \mathcal{R}^1 will be compared with each calendar month of \mathcal{R}^0 . Again, it is possible to construct a set of chained indices \mathcal{P}_{LC}^{RYA} , \mathcal{P}_{PC}^{RYA} and \mathcal{P}_{FC}^{RYA} . These rolling-year indices are free from seasonal fluctuations. They are objective and their construction is replicable by all, unlike the time series methods of seasonal adjustment (Diewert, 1999). According to the PPI Manual (2010, p. 569), “the chained Fisher rolling-year index is regarded as the target seasonally adjusted annual index when seasonal products are in the scope of the CPI”: such rolling-year indices avoid erratic trajectories in the indices due to seasonality. In what follows, we will describe results from year-over-year monthly and rolling-year annual chained FPI calculated using the 50 most important fish species in value.

4. Results

We first start by calculating year-over-year monthly indices, each product in the basket of seafood products corresponding to a given species. For each month and species, we calculate an average price corresponding to the total amount of sales divided by the total quantity sold. Results for the versions of the chained indices \mathcal{P}_{LC}^{YYM} , \mathcal{P}_{PC}^{YYM} and \mathcal{P}_{FC}^{YYM} are presented in Figure 4.

Insert Figure 4

A first finding is the significant increase of the price index over the period under consideration, although the beginning of the period is characterized by a deterioration. Starting from a base of 100 for the 12 months of 1994, the overall level of the index fell until April 1996, when it was close to a value of 90. Following the economic recession in France in 1993, prices of seafood products have declined despite the decrease of landings. This decline was further accentuated in 1995 and at the beginning of 1996. According to Steinmetz et al. (2008), the crisis was due to the European markets liberalization of trade for seafood products, which modified the conditions of competition between seafood products on these markets. Furthermore, there was an increased sensitivity of trade to exchange rates between European currencies, especially with the devaluation of the Spanish peseta in 1995 and of the Italian lira in 1992⁵. In the middle of 1996, the situation improved and the price index increases relatively steadily until mid-2007, with values ranging between 140 and 160 depending on the formula used for the index. This is followed by a period of decrease in the general level of prices on fish markets until early 2009 (the indices being between 120 and 130), before the index rises somewhat towards the end of the year. The index then changes

⁵ The decrease in international seafood prices combined with the appreciation of the French Franc is the major cause of the French seafood market crisis in the early 1990s (Guillotreau and Périody, 2000).

relatively little until mid-2014. Since then, the price level has tended to increase in fish markets except for 2020.

A second finding is that the \mathcal{P}^{YYM} indices are quite volatile and the different trends highlight strong seasonality. Estimation of a linear regression explaining the index value as a function of the different calendar months (the base year 1994 being excluded) reveals that monthly fixed effects explain 8.2% of price changes for the Laspeyres index, 38.5% for the Paasche index and 9.9% for the Fisher index. In all cases, the value of the FPI is relatively higher from July to December compared to the other months of the year. For instance, compared to January, the gap for the Laspeyres index is about 20 points in August and September, 8 points in October, 17 points in November, and 9 points in December. While the \mathcal{P}^{YYM} indices are relevant for discussing price changes in a given month compared to the previous year, they do not allow for proper monitoring of price changes throughout the year since the baskets of species under consideration vary each month.

A third result is the existence of a systematic difference between the Laspeyres and Paasche indices. The Laspeyres chained index is on average 66.2 points higher than the Paasche chained index, with a standard deviation of 48.7. The Laspeyres index always exceeds the Paasche index, while the Fisher index is by construction between the Laspeyres and Paasche indices. Two reasons explain the positive gap between the Laspeyres and Paasche indices. First, the purchase pattern changes from period to period depending on the availability of the various fish species. Second, buyers are expected to purchase fish species that become relatively less expensive than those purchased in the initial period. As a consequence, products whose prices have increased relatively more will tend to have smaller weights in the current period than in the base period (so a smaller weight in a Paasche index than in a Laspeyres index).

~~On the other hand, there are gaps between the chained and unchained (not reported) indices, which are much higher for the Laspeyres and Paasche indices than for the Fisher index. The average deviations are 40.8 points for the Laspeyres index (the index in its chained version is higher than the non-chained index), 15.3 points for the Paasche index (the index in its chained version is lower than the non-chained index), and only 8.0 points for the Fisher index. This last index therefore appears much less sensitive to the chaining decision.~~

The rolling year indices \mathcal{P}^{RYM} calculated on a monthly basis are shown in Figure 5. Compared to the \mathcal{P}^{YYM} indices presented in Figure 4, the high seasonality of the price indices has now disappeared. This is due to the fact that the base period includes 12 months in the calculation of the \mathcal{P}^{RYM} indices. Unlike the inflation rate which grows very steadily overall at a low rate throughout the period (around 0.112% per month), the evolution of the FPI is less regular. With the exception of the beginning of the period (until the end of 1997), the chained Fisher price index is always higher than the CPI. We implement a test for structural break with unknown break date (Perron, 2006). After estimating a linear model explaining the chained Fisher index as a function of a monthly trend, we reject the null hypothesis with a Wald statistic equal to 386.4 ($p = 0.000$), the estimated break date being February 2009. Over the recent period, the gap between the Fisher price index and the CPI has returned to fairly high levels since 2017 although it has substantially reduced with the Covid pandemic (from 43.4 in February 2020 to 35.4 in December 2020).

Insert Figure 5

As emphasized in Guillen and Franquesa (2015), price movements on fish markets are related to disequilibrium between demand and supply. On the demand side, economic growth leads to a high level of seafood products consumption, especially in the French case

(Jang and Chang, 2014): France is characterized by a positive long-term causal relationship between national income and fish demand. It is therefore not surprising to see that the FPI is strongly related to economic cycles. In France, GDP slowed sharply in 2008 (+0.2%) and decreased in 2009 (-2.9%), followed by a recovery in 2010 and 2011 with very slow growth from 2012 to 2014 (+0.2%, +0.6%, and +0.9%). Growth has accelerated since then (+2.3% in 2017, +1.8% in 2018, and +1.5% in 2019) except for 2020 (-8.3%) due to the Covid pandemic. We find that the FPI decreases during the financial crisis after 2007, the slowdown in growth in 2012, and more recently the COVID pandemic.

Figure 6 describes changes in the Fisher price index in 2020 using a monthly scale. The recent situation is dramatic as the FPI has been characterized by a continuous decrease over 10 consecutive months, from March to December 2020. In France, the mandatory home lockdown due to COVID-19 pandemic began in the mid of March. It led to the closure of all restaurants as well as collective catering. This strong decrease in demand resulted in some temporary cessation of fishing activities. After a huge decline the days just after the lockdown, the market prices decreased moderately during this period because of both the strong reduction of landings and the decrease in demand (especially for high-valued fish species). Despite the end of lockdown by the mid of May and the reopening of restaurant at the end of June, the FPI continued to decline. The recovery was slow and only partial during the summer. By the end of October, a second lockdown was decided because of the recovery of the pandemic. Again, restaurants and caterings as well as non-essential shops were closed, but food shops, supermarkets, and schools remained open. In December 2020, the FPI was almost at the same level to May 2018.

Insert Figure 6

By construction, the FPI discussed above corresponds to a weighted average of price changes between the different fish markets. As emphasized in Gobillon and Wolff (2016), there exists spatial heterogeneity in fish prices in France which is mainly related to geography. Net of the influence of fish characteristics (species, size, presentation, quality) and buyer as well as seller time-invariant heterogeneity, fish prices are substantially higher in markets located along the Mediterranean coast compared to markets located either along the Bay of Biscay or the English Channel. To further investigate those differences, we decide to calculate chained Fisher price indices for groups of fish markets and also for each fish market. For that purpose, we consider the subset of 31 fish markets for which the dataset includes all transactions for the 324 months of the 1994-2020 period.

We begin by looking at differences along coastlines. For that purpose, we construct three groups of fish markets: English Channel (8 markets), Bay of Biscay (19 markets), and Mediterranean Sea (4 markets). As highlighted in Figure 7, fish prices are substantially higher in the Mediterranean area than along the Atlantic Ocean or English Channel coasts. From 1995 to 2020 (1994 is excluded as the FPI is 100 in the three areas by construction), the FPI was 24.6% higher in the Mediterranean than in the English Channel and also 15.9% higher in the Mediterranean than in the Bay of Biscay. A first explanation is the much smaller quantity of fish sold in the French markets located in the Mediterranean along with the small number (four) of fish markets. A second explanation is that the composition of species is different between coastlines. Monkfish, sole or hake are the main species in value in the Atlantic Ocean compared to octopuses, hake and gilthead seabream in the Mediterranean.

Insert Figure 7

Still, there are substantial differences between fish markets even within each area (English Channel, Bay of Biscay and Mediterranean). We study whether the various French

fish markets have converged in terms of FPI. For that purpose, we rely on the econometric convergence test proposed by Phillips and Sul (2007). Drawing a non-linear factor model which comprises a growth component and a time-varying idiosyncratic component, these authors develop a regression t test for the null hypothesis of convergence called the “log t” test (Phillips and Sul, 2007, p. 1774). The “log t” approach allows for heterogeneous market evolution and does not impose any restriction on stationarity of time-series. We proceed as follows. First, we discard the first 25% of monthly FPI values. By construction, the FPI values are similar (equal to 100) for all markets during the first year of the period. Second, we extract the trend component of each market FPI time-series. Third, we run the “log t” regression on the trend time-series. We find a coefficient of -1.298 with a t-statistic equal to -22.82. As the t-statistic is less than -1.65, the null hypothesis of convergence is strongly rejected.

In a final step, we investigate whether the increase in fish prices observed over from 1994 to 2020 in France has led to an improvement in the economic situation of fishermen. The revenue of fishermen can be highly variable due to natural variation in the productivity and distribution of fish stocks, variation in prices, seasonal variation, and fishers’ knowledge as well as luck at finding and catching fish (Owusu and Andriessse, 2020). We focus on the revenue generated by the first sales of fish caught and disregard the incurred costs⁶. Let R be the sales revenue, P the price and Q the quantities sold. The revenue resulting from fish sales can be expressed as:

$$R = Q * P(Q) \tag{4}$$

where $P(Q)$ corresponds to the inverse demand function with $dP/dQ < 0$. It is difficult to know to what extent fishermen's first-sale revenues have changed over time. While our

⁶ These costs will vary mainly according to the financial interest rate (cost of acquiring the vessels, terms of repayment) and the variable costs related to fuel.

results show that fish prices have increased, Table 1 reveals that at the same time quantities have decreased significantly. Depending on the relative magnitude of the price effect (positive) and the quantity effect (negative), the sign of the revenue effect remains indeterminate. Following the methodology described in Section 3, we construct different volume indices (Laspeyres, Paasche, Fisher). These indices indicate how quantities have varied over time and we account for prices of fish species as weights. In what follows, we will discuss results from the rolling-year Fisher quantity index Q_{FC}^{RYA} . Using equation (4), it follows that the Fisher revenue index \mathcal{R}_{FC}^{RYA} is such that $\mathcal{R}_{FC}^{RYA} = Q_{FC}^{RYA} * \mathcal{P}_{FC}^{RYA}$.

In Figure 8, we report the profiles obtained for \mathcal{P}_{FC}^{RYA} , Q_{FC}^{RYA} and \mathcal{R}_{FC}^{RYA} when considering all fish markets. The Fisher quantity index Q_{FC}^{RYA} decreases substantially over the period, from 100 in 1994 to 52 in 2020, but the decline is not linear. While volumes have decreased slightly during the first ten years, it is especially between 2004 and 2010 that a sharp decline is observed. Then, the index remains stable at around 75 until mid-2015, but since then, the index has been falling steadily with nearly 5 points less each year. The impact on revenue depends on the contributions of the price and quantity effects. While the economic situation of fishermen has improved between 1994 and 2007, the financial crisis of 2008 and 2009 had a strong impact since the index at the end of 2010 was lower than its value in 1994. The situation in 2016 has returned to that of the early 2000s, but since March 2017 the index has contracted sharply (from 121.6 in March 2017 to 91.6 in December 2020). This decrease is primarily explained by reduced quantities of fish caught, but with the Covid pandemic both the price and quantity indices have decreased. This explains the sharp drop in revenue observed since March 2020.

Insert Figure 8

In Figure 9, we replicate the same analysis by coastline and evidence substantial differences between the three areas. First, we find that the Fisher price index has increased much more in the Mediterranean (with an index of 250 in 2020) than in the Bay of Biscay and in the English Channel. Second, the quantity indices have reached rather similar levels at the end of the period (at around 50) in the three areas, but with different profiles. For instance, the index has sharply decreased from 2007 to 2013 in the Mediterranean, while the index was already at a value of 50 in 2010 in the Bay of Biscay. Third, indices of sales revenue have very little in common. In the Bay of Biscay, we observe two main shocks: one related to the financial crisis starting from 2008 till the end of 2010, and another one since 2017 due to the decrease in the volume index. In the English Channel, the economic situation was better in terms of revenue in the long run, but it has strongly deteriorated with the pandemic (from 109.9 in March 2020 to 97.8 in December 2020). Finally, the revenue index reached a peak of 290 points in February 2008 in the Mediterranean. After that, the index strongly fell till the end of 2012 due to a large reduction in the quantity index. Nevertheless, the revenue index remained above 150 till March 2020 but the index lose around 10 points in 9 months (141.1 in December 2020).

Insert Figure 9

5. Conclusion

In this paper, we provide new results concerning price trends of seafood products in the medium run. For that purpose, we rely on a unique database containing more than 126 million transactions collected in all French seafood markets over the period 1994-2020. Drawing on fish prices indices, we study to what extent seafood products sold in first-hand markets have become more or less expensive over time in a context of regular decrease in

landings. Our various indices are chained in order to account for changes observed between successive periods and are also free from seasonal fluctuations. Our main results are twofold.

On the one hand, we find that first-sale prices of seafood products have substantially increased in the medium run in France, more than the inflation rate. There are two main exceptions which is first the period during the financial crisis from 2007 to 2009 and second the more recent Covid pandemic in 2020. Our results are in line with the existing literature according to which fish price indices are strongly related to economic cycles (Guillen and Franquesa, 2015). Nevertheless, there remains spatial heterogeneity with prices having increased more in fish markets located in the Mediterranean than in Bay of Biscay or English Channel.

On the other hand, the increase in fish prices has not led to an improvement in the economic situation of fishermen. By construction, the revenue generated by fish sales corresponds to the product of price by quantity. Calculation of quantity indices shows that fish catches have substantially decreased between 1994 and 2020, especially since 2015 (with 5 points less each year). We find that the economic situation of fishermen has first improved between 1994 and 2007, but it was then severely affected by the financial crisis of 2008 and 2009. Since March 2017, the revenue index is going down essentially because of lower quantities which are not compensated by sufficiently higher prices. With the recent Covid pandemic, the revenue index is falling further because both lower prices and lower quantities on markets. Again, there is spatial heterogeneity with a better situation in the Mediterranean area.

Several extensions could be considered to further study the evolution of prices in fish markets. For example, it could be useful to construct indices by fish species in addition to the

global price index based on the 50 main species by value. It would also be appropriate to investigate the definition of a product in the construction of the index. In our analysis, the focus is on fish species without taking into account quality, size or presentation. Clearly, prices can be modified if quality changes over time. Finally, it would be useful to be able to compare the evolution of the French FPI with similar indices for neighboring countries such as Spain or England. However, such a comparison raises the question of the availability of transaction data for these countries.

As they stand, our results are important from a public policy perspective. The fact that the overall economic situation of fisheries in terms of revenue has worsen over the last three years is challenging. Admittedly, we have only considered revenues generated by first-hand sales without looking at the evolution of fishing costs. Nevertheless, as they stands, our results suggest that quota policies aimed at reducing fishing catches even further can only contribute to reducing the global revenue of fishermen.

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Figures and Tables

Table 1. Transactions, quantity and value of fish – France 1994-2020

Year	Number of transactions	Quantity (in thousand tonnes)	Value (in million euros)
1994	2,603,676	283.3	575.4
1995	2,591,760	283.9	576.8
1996	2,622,342	279.6	598.2
1997	2,738,435	286.9	635.2
1998	2,808,701	297.9	669.1
1999	2,806,092	283.9	657.5
2000	2,971,191	290.3	692.0
2001	2,967,762	293.3	716.9
2002	3,794,757	284.1	721.7
2003	4,592,567	283.8	736.2
2004	4,657,254	259.3	710.6
2005	4,564,060	233.6	672.7
2006	4,538,899	235.5	693.1
2007	4,678,748	236.5	700.6
2008	5,108,516	203.4	622.9
2009	5,745,852	187.1	546.7
2010	6,014,575	200.5	591.0
2011	6,226,653	212.2	662.0
2012	6,010,743	214.3	645.1
2013	6,007,028	205.0	622.2
2014	6,375,679	210.8	641.2
2015	6,151,378	205.2	678.1
2016	6,221,563	201.3	683.0
2017	6,013,458	190.7	662.6
2018	5,915,730	189.1	640.2
2019	5,948,886	172.5	602.5
2020	5,414,369	153.8	526.1
All years	126,090,674	6377.8	17479.6

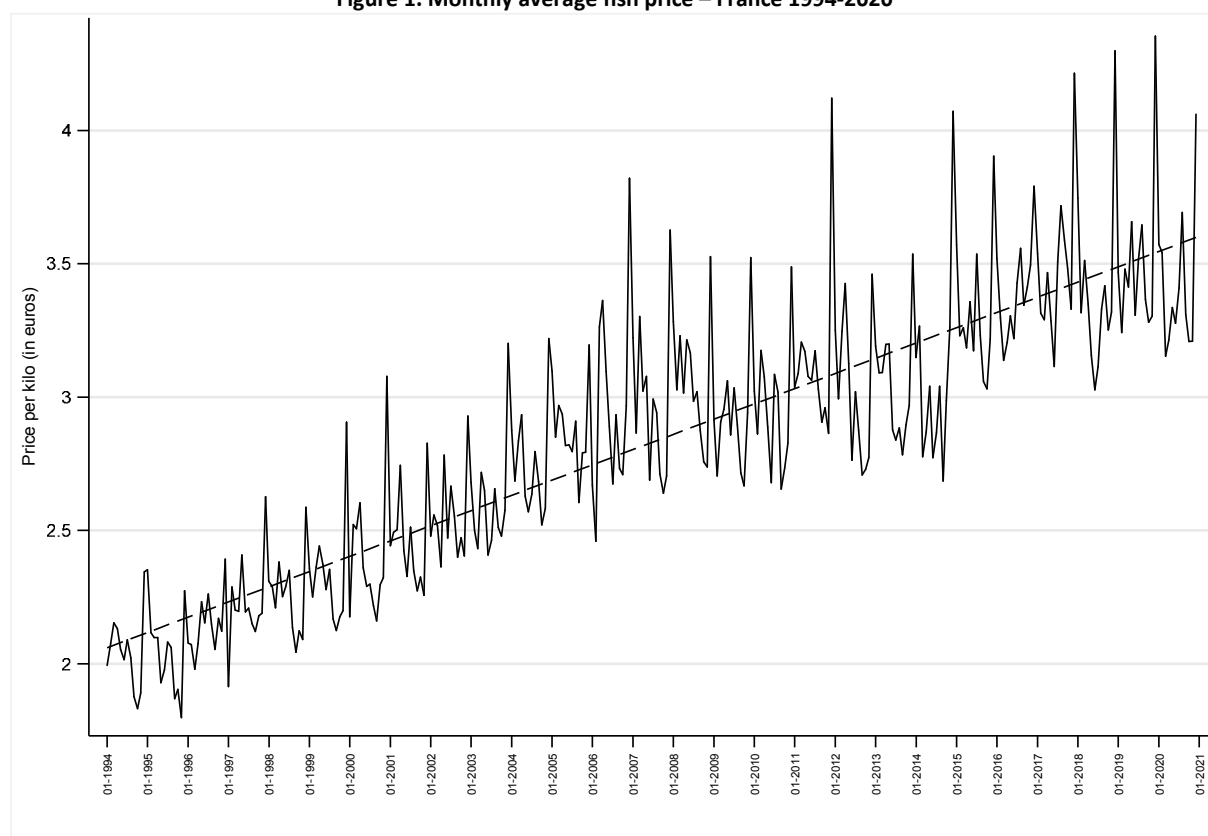
Source: authors' calculations, RIC data 1994-2020.

Table 2. Estimates of changes in prices – France 1994-2020

Variables	(1)		(2)	
	coef	t-value	coef	t-value
Monthly trend	0.005***	(32.06)	0.005***	(46.13)
February (ref: January)			-0.112**	(-2.38)
March			-0.050	(-1.07)
April			-0.027	(-0.58)
May			-0.060	(-1.28)
June			-0.218***	(-4.61)
July			-0.103**	(-2.18)
August			-0.105**	(-2.22)
September			-0.272***	(-5.77)
October			-0.261***	(-5.52)
November			-0.224***	(-4.74)
December			0.446***	(9.46)
Constant	2.056***	(73.84)	2.139***	(57.67)
Observations	324		324	
R-squared	0.761		0.889	

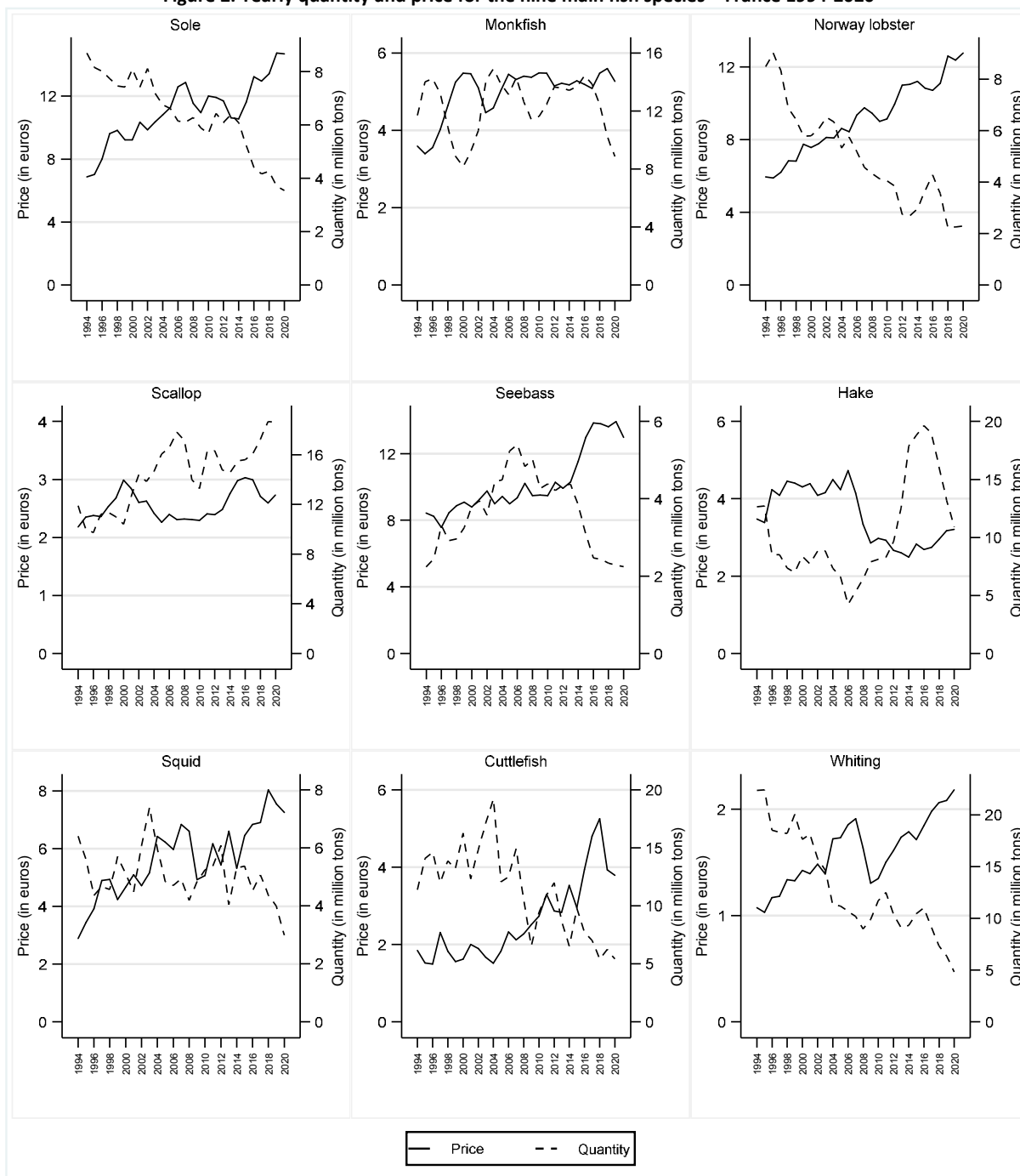
Source: authors' calculations, RIC data 1994-2020.

Figure 1. Monthly average fish price – France 1994-2020



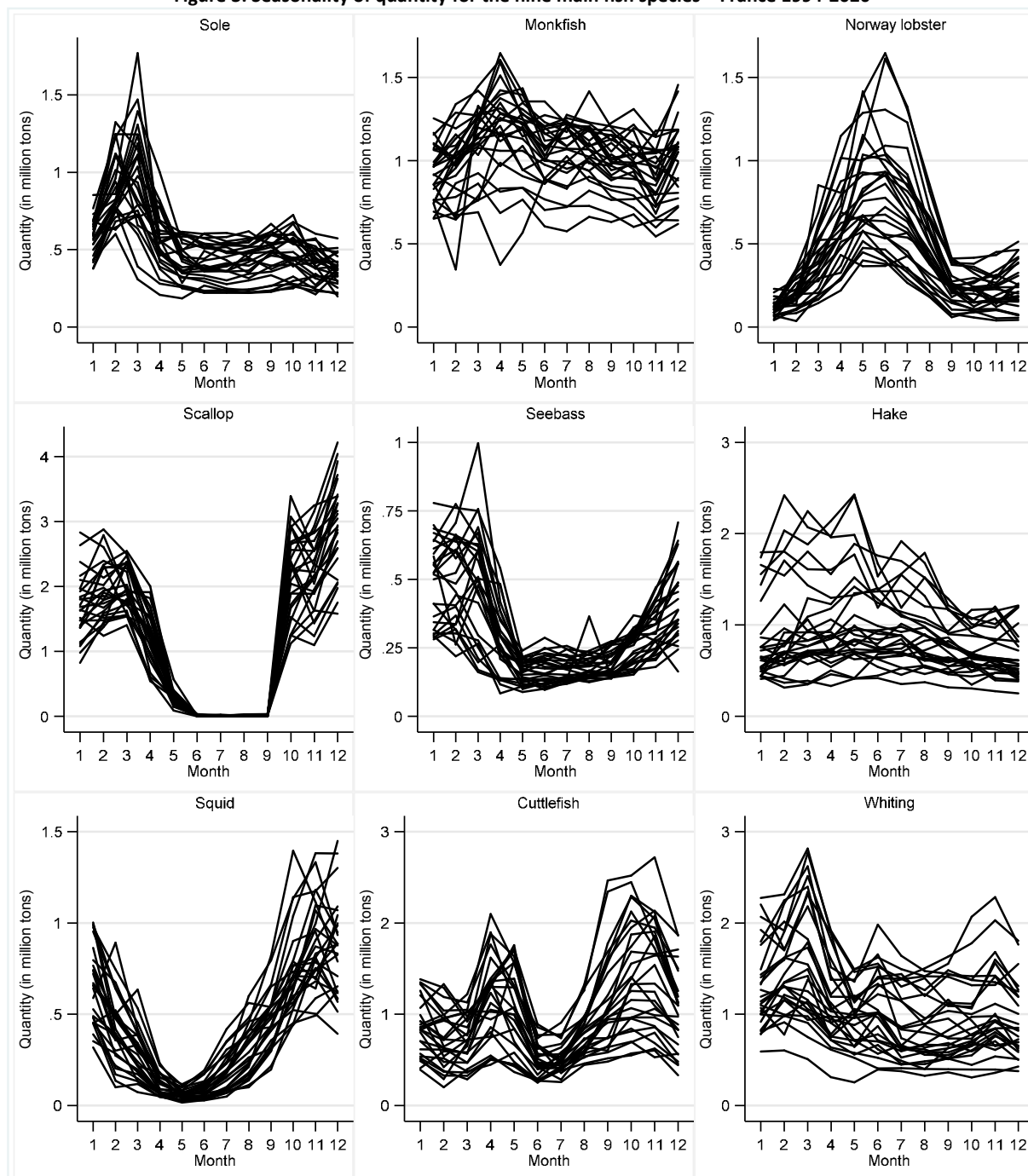
Source: author's calculations, RIC data 1994-2020.

Figure 2. Yearly quantity and price for the nine main fish species – France 1994-2020



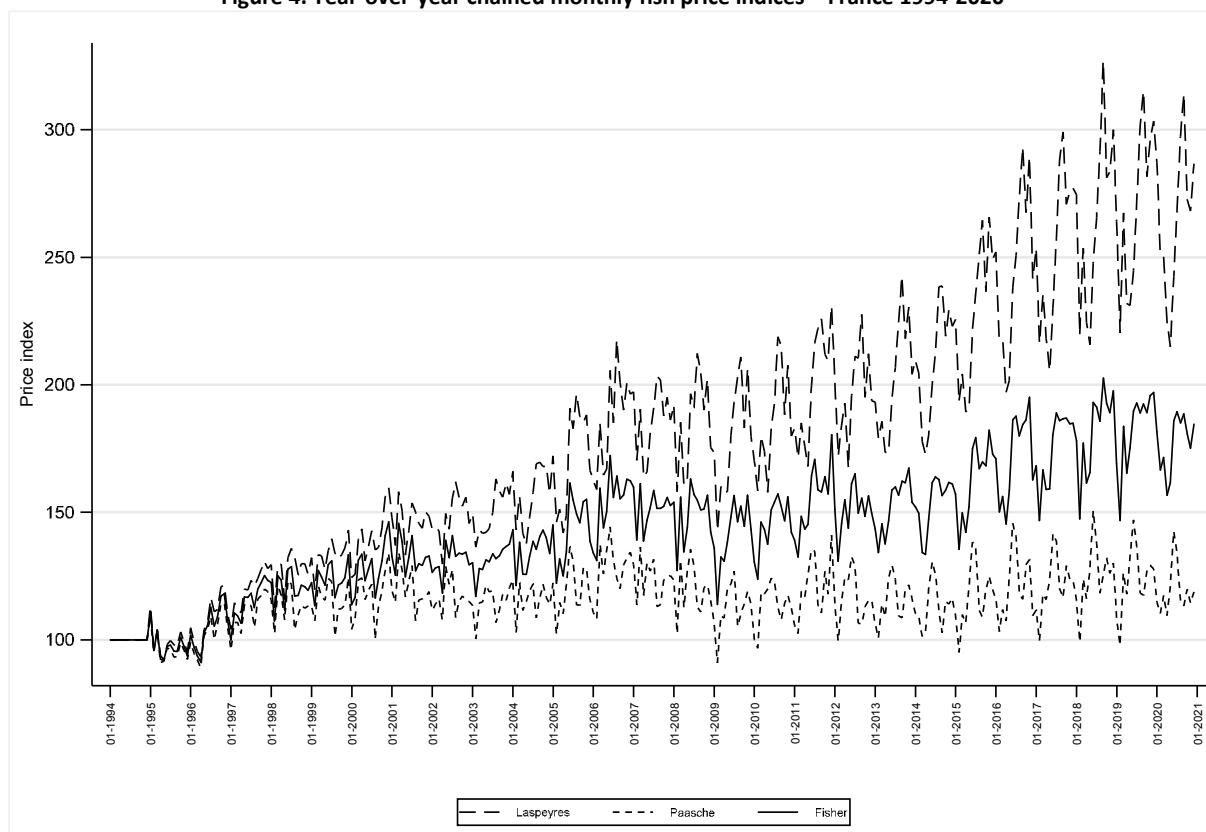
Source: author's calculations, RIC data 1994-2020.

Figure 3. Seasonality of quantity for the nine main fish species – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

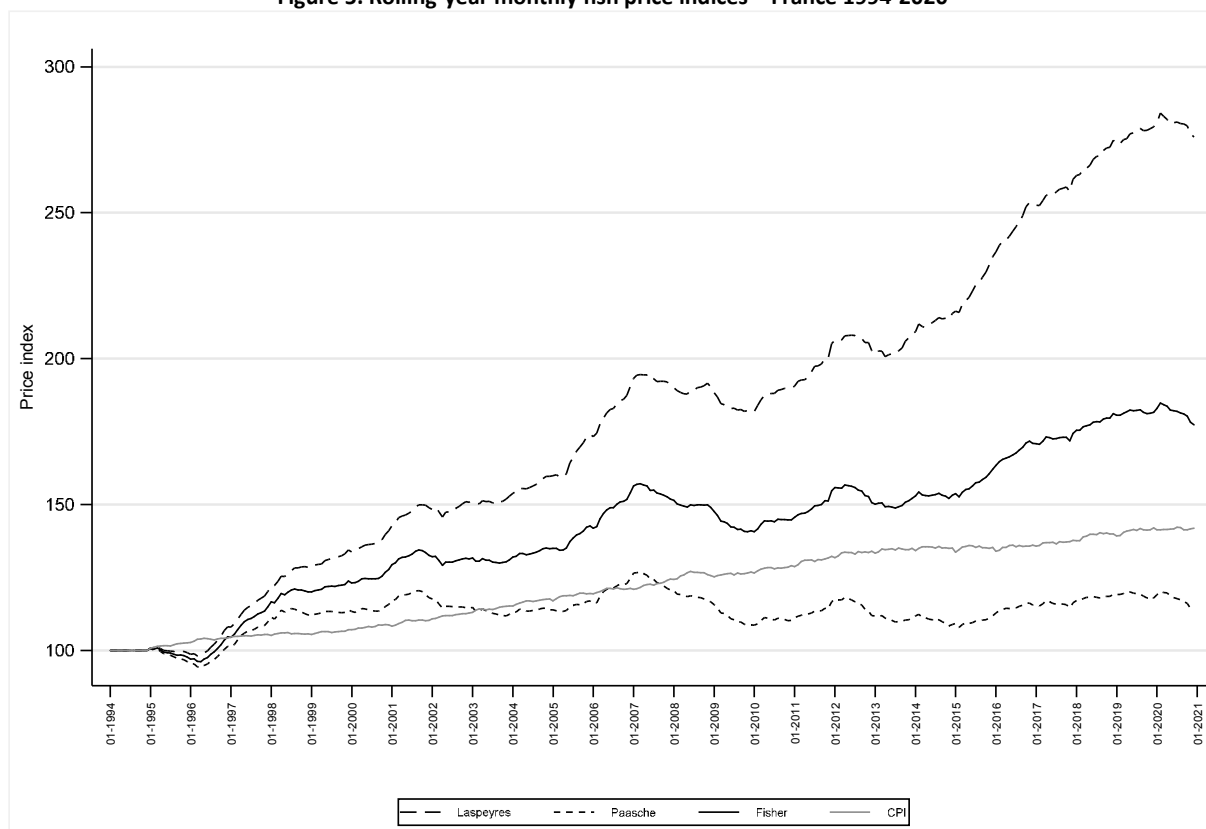
Figure 4. Year-over-year chained monthly fish price indices – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

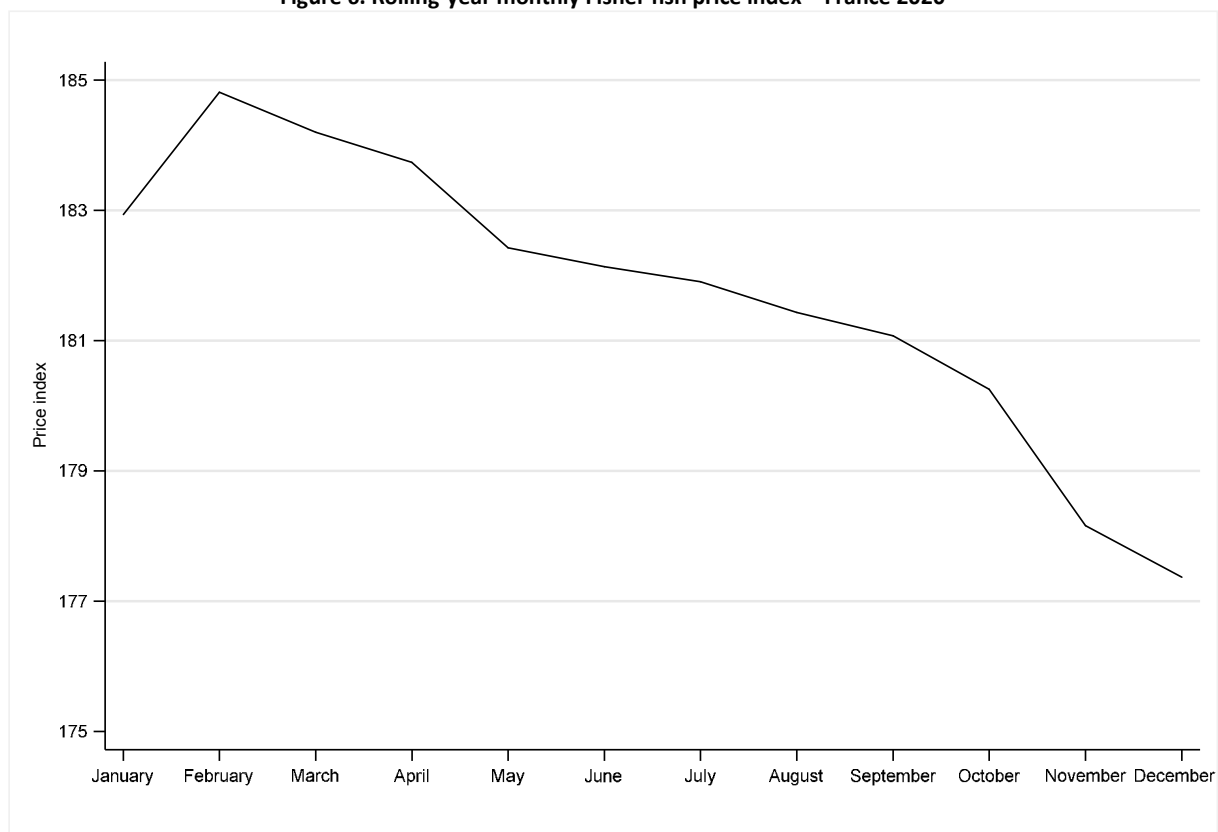
Note: the FPI is based on the 50 most important species in value.

Figure 5. Rolling-year monthly fish price indices – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

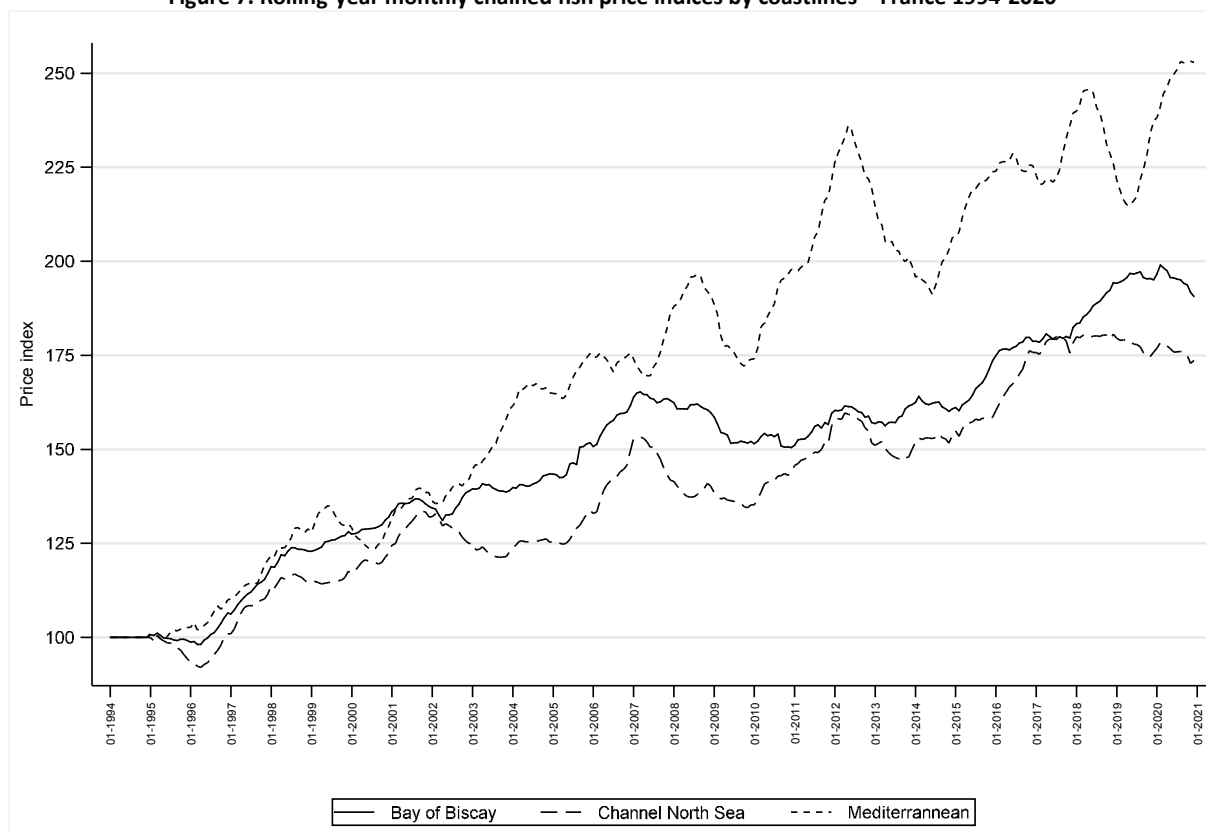
Note: the FPI is based on the 50 most important species in value.

Figure 6. Rolling-year monthly Fisher fish price index – France 2020

Source: author's calculations, RIC data 1994-2020.

Note: the FPI is based on the 50 most important species in value.

Figure 7. Rolling-year monthly chained fish price indices by coastlines – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

Note: the FPI is based on the 50 most important species in value.

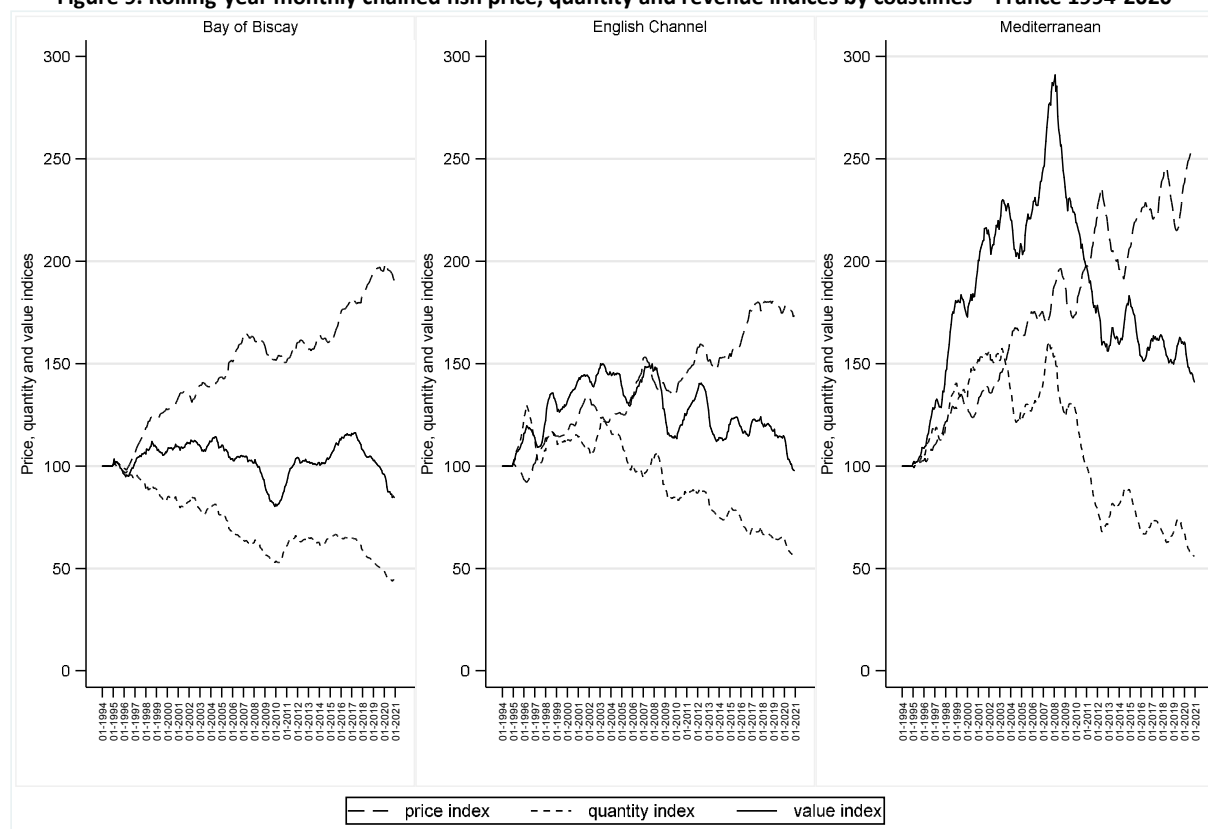
Figure 8. Rolling-year monthly chained fish price, quantity and revenue indices – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

Note: the FPI is based on the 50 most important species in value.

Figure 9. Rolling-year monthly chained fish price, quantity and revenue indices by coastlines – France 1994-2020



Source: author's calculations, RIC data 1994-2020.

Note: the FPI is based on the 50 most important species in value.

Appendix

Table A. Description of price, quantity and value by species

Fish species	Average price (in euros)				Quantity (in tons)				Value (in million euros)	
	1994-2020	1994	2020	Δ in %	1994-2020	1994	2020	Δ in %	Total	Cumulated %
Sole	11.0	6.9	14.7	113.0	6377.4	8700.4	3539.4	-59.3	1830.1	10.5
Monkfish	5.0	3.6	5.3	47.2	12350.1	11689.0	8859.4	-24.2	1649.9	19.9
Norway lobster	9.2	5.9	12.8	116.9	4946.1	8485.8	2291.3	-73.0	1130.8	26.4
Scallop	2.6	2.2	2.7	22.7	14431.3	11896.8	18632.8	56.6	995.5	32.1
Seabass	10.3	8.4	13.0	54.8	3635.1	2238.6	2244.7	0.3	984.6	37.7
Hake	3.6	3.5	3.2	-8.6	10458.4	12645.9	10887.3	-13.9	944.9	43.1
Squids	5.7	2.9	7.3	151.7	5041.6	6401.8	2983.5	-53.4	754.7	47.4
Cuttlefish	2.6	1.8	3.8	111.1	11283.2	11391.4	5416.8	-52.4	708.3	51.5
Whiting	1.6	1.1	2.2	100.0	12982.3	22353.3	4810.7	-78.5	520.5	54.5
Cod	3.3	2.0	4.4	120.0	6092.9	11748.9	607.2	-94.8	451.4	57.0
Anchovy	1.9	1.4	1.1	-21.4	9292.6	15645.1	381.4	-97.6	432.0	59.5
Surmullet	5.9	6.8	5.8	-14.7	2819.1	1136.9	1865.7	64.1	421.6	61.9
Pilchard	0.7	0.5	0.8	60.0	18991.0	12005.8	18143.3	51.1	343.0	63.9
John dory	9.7	6.3	12.1	92.1	1216.5	626.6	1030.3	64.4	326.6	65.8
Pollack	4.1	2.6	7.0	169.2	2848.0	3482.6	1598.4	-54.1	302.8	67.5
Saithe (Pollock)	1.2	0.8	1.5	87.5	9613.3	21041.1	4306.4	-79.5	288.0	69.1
Megrim	3.4	2.9	3.7	27.6	2638.5	3587.9	2075.5	-42.2	237.5	70.5
Albacore	2.5	2.2	3.0	36.4	3549.1	6458.9	3157.2	-51.1	236.1	71.8
Mackerel	1.0	0.6	1.7	183.3	9176.3	11178.9	6272.1	-43.9	226.6	73.1
Ling	2.3	1.7	2.5	47.1	3586.8	4685.0	2603.3	-44.4	215.1	74.4
Haddock	1.7	1.1	2.2	100.0	4678.8	2716.2	3219.8	18.5	209.3	75.6
Whelk	1.5	0.6	1.9	216.7	4816.2	1314.3	4076.6	210.2	198.4	76.7
Turbot	13.7	9.1	16.8	84.6	520.6	627.5	338.0	-46.1	190.0	77.8
Black seabream	2.4	2.0	3.3	65.0	2719.8	2479.1	1790.9	-27.8	170.5	78.8
Conger	1.6	1.6	1.3	-18.8	3644.9	3689.3	3468.5	-6.0	156.9	79.7
Black scabbardfish	3.3	2.2	4.6	109.1	1780.2	2778.5	462.3	-83.4	150.7	80.5
Roundnose grenadier	1.8	1.1	1.7	54.5	3317.1	7286.7	164.4	-97.7	138.9	81.3
Gilthead seabream	8.5	6.2	10.8	74.2	558.8	180.4	822.3	355.8	135.9	82.1
Cuckoo ray	1.8	1.7	1.8	5.9	2661.4	2772.6	1768.0	-36.2	129.0	82.8
Blue ling	2.1	1.7	2.0	17.6	2211.9	2894.9	967.8	-66.6	124.8	83.6
Edible crab	2.6	2.2	4.0	81.8	1692.5	1003.6	775.2	-22.8	112.9	84.2
Plaice	1.6	1.2	2.6	116.7	2638.3	3744.7	855.0	-77.2	106.2	84.8
Lemon sole	3.9	2.7	4.9	81.5	1076.0	1583.1	515.6	-67.4	105.8	85.4
Raja rays	2.5	2.1	2.6	23.8	1615.7	2330.2	53.4	-97.7	105.1	86.0
Brill	9.4	6.5	12.5	92.3	400.8	366.4	319.2	-12.9	102.6	86.6
Pawn	17.4	10.8	19.3	78.7	216.9	362.5	202.2	-44.2	97.5	87.2
Lobster	19.0	16.6	21.3	28.3	178.1	59.7	257.3	331.0	92.4	87.7
Red gurnard	1.0	1.1	0.8	-27.3	3522.7	3707.8	2183.6	-41.1	91.9	88.2
Meagre	6.0	5.4	8.1	50.0	579.3	85.1	561.8	560.2	89.3	88.7
Mackerel	0.8	0.6	0.8	33.3	3412.9	5487.6	1355.6	-75.3	77.5	89.2
Pouting (Bib)	0.7	0.5	0.9	80.0	4285.5	4708.5	2228.3	-52.7	76.9	89.6
Octopuses	2.5	1.2	3.4	183.3	1159.7	968.9	609.5	-37.1	75.3	90.0
Bluefin tuna	5.6	2.6	9.1	250.0	571.3	441.4	623.3	41.2	74.0	90.5
Thornback ray	2.5	2.1	2.1	0.0	1097.1	1401.6	1604.1	14.4	71.5	90.9
Smooth-hounds	1.4	1.1	1.3	18.2	1800.5	255.2	2155.2	744.5	71.0	91.3
Spinous spider crab	1.9	1.9	2.0	5.3	1370.1	838.7	1234.1	47.1	69.9	91.7
Warty venus	4.8	5.0	4.1	-18.0	543.0	465.9	426.2	-8.5	69.7	92.1
Spotted ray	2.5	2.1	2.3	9.5	985.2	804.0	645.6	-19.7	66.7	92.5
Marine fishes	1.8	1.7	6.5	282.4	1288.1	4550.3	0.4	-100.0	64.5	92.8
Catshark	0.5	0.6	0.5	-16.7	4201.4	4305.5	2481.6	-42.4	60.2	93.2
All	2.7	2.0	3.4	70.0	236215.1	283342.2	153813.8	-45.7	17479.3	100.0

Source: author's calculations, RIC data 1994-2020.