Marine Policy 165 (2024) 106166

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Persistence of fisheries production: a disaggregated analysis in 31 OECD Countries☆

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ARTICLE INFO

JEL classification in this article:
C22
O57
Q22

Keywords:
Fisheries production
Aquaculture production
Capture fisheries production
Persistence
Fractional integration
Fisheries management policy

ABSTRACT

Previous studies have focussed on different aspects of fisheries production in several countries. However, the literature has been largely silent on the persistence of fisheries production, which has numerous important policy implications. In this article, we examine time series data corresponding to fisheries production in a group of 31 OECD countries. The analysis focuses on three distinct production series for each country: total fisheries production, aquaculture production, and capture fisheries production, and the time period spans from 1960 to 2020. Using fractional integration methods, the empirical findings provide evidence for persistence in fisheries production and its two components in the majority of the OECD countries examined. Persistence is observed in 29 countries in the case of the total fisheries production, 28 countries in the case of capture fisheries production, and 28 countries in the case of aquaculture production. Evidence of mean reversion is observed in Chile and Colombia for the total fisheries production, and in Belgium, Colombia, and Israel for the capture fisheries production. There is support for mean reversion in aquaculture production data for France, the Netherlands and Poland. An implication of the results is that shocks to the fisheries production or its components are permanent or long-term in nature. Therefore, long-term measures are need to address any disruptions in the fishery sector.

1. Introduction

The total production of fisheries (capture and aquaculture) worldwide has increased at an annual growth rate of 3.3 % since 1950, with the primary driver of this growth being aquaculture since the 1980s (Food and Agriculture Organization, [6]). Since 1961, the average yearly growth of fish supply doubles the population growth across the globe [35]. Fisheries supply is a major vital source of animal protein as it is responsible for about 17 % of global animal protein [35]. Not surprisingly, countries have invested in sustainable technologies and practices for more efficient cultivation and sustainable fish population management. Technological innovation in fishing equipment, monitoring and control systems, and aquaculture techniques have played a significant role in production, efficiency improvement, and sustainability of global fisheries and aquaculture. The support of governments to the fisheries sectors in 40 countries amounted to USD 13.4 billion annually, which translated into USD 518 of support per fisherman between 2012 and 2014.[2] Between 2018 and 2020, the same governments spent USD 10.4 billion annually to support the fisheries sector, which amounted to about USD 421 of support per fisherman [20].

Partly due to the importance of the fisheries sector worldwide and the huge government spending in the sector, several aspects of fisheries production have been examined in the literature. The topics covered include fisheries production diversity [7], determinants of fisheries production [34], and economic impact of fisheries production [16]. However, the direction or pattern over time shown by fishery production data has not been adequately researched in the extant literature. Understanding the behavior, persistence, or lack thereof, of fishery and aquaculture production series is valuable information for governments, industries, scientists, and organizations committed to responsible management and sustainable use of marine resource. Persistence connotes the extent at which current (and short term) shocks produce lasting

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☆ Comments from the Editor and two anonymous reviewers are gratefully acknowledged.

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[1] Luis A. Gil-Alana gratefully acknowledges financial support from the Grant PID2020–113691RB-I00 funded by MCIN/AEI/ 10.13039/501100011033.

[2] USD implies United States dollars.

https://doi.org/10.1016/j.marpol.2024.106166
Received 12 February 2024; Received in revised form 12 April 2024; Accepted 20 April 2024

changes. The longer the impact of the shocks, the more the persistence of such shocks. A shock is viewed as having a temporary or short-term effect if, after a momentary period, the series reverts to its original value [12].

First, the issue of whether fisheries production is persistent or not is essential as this determines whether shocks have permanent or temporary impacts. If fisheries production series are persistent, shocks to fisheries production will have a long-term effect. The logic is that if fisheries production has a unit root, a shock will generate a permanent deviation from the long-run growth trajectory of the production, which is consistent with hysteresis in fisheries production. This would indicate that fishing production tends to maintain a certain inertia and does not adjust quickly to changes in the environment or in resource management.

In the case of a long-term shock and when fisheries production and the several other macroeconomic variables are related, the shock is expected to diffuse to other sectors and facilitate persistence in numerous macroeconomic variables. An adverse shock to fisheries production engenders a rise in the unemployment rate and, in an effort, to revert to previous unemployment rate, policy interventions are required [12]. Fishery shocks can influence beyond nutrition and trade, spill over adversely into other resource systems, and affect biodiversity conservation [9].

Moreover, the magnitude of persistence in the fisheries production process is an essential issue for countries, especially net exporting countries. Expansion in fisheries production yields an increase in income generating opportunity in fisheries exporting economies. For instance, if fisheries production is persistent and there is a decrease in fisheries production, fisheries exporting countries are likely to witness a situation in which revenues from fisheries exports will not return to their past status and that other income sources must be devised to maintain their previous income profiles [30].

The persistence of fisheries production implies that accurate projection of subsequent fisheries production figures cannot be achieved by merely counting on the past figures of fisheries production. In this case, there is a need to consider other factors, including the possible determinants of fisheries production. Possible determinants of fisheries production that have been established in the literature include institutional quality, spread of knowledge and adoption of innovations, corporate governance, likelihood of floods [7,22].

There are several bodies and organisations involved in the forecasting of fisheries production including the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) of the United Nations (UN). A joint publication of OECD and FAO predicts fisheries production in the globe will grow from about 178 metric ton or Mt in 2020–201 Mt by 2030 [21]. The publication uses AGLINK-COSIMO model, which relies on several sources of information, including possible determinants of fisheries production, in the process of forecasting the future values of the fisheries production. The variables taken into consideration and that are treated as exogenous variables include energy prices, inflation, gross domestic production (GDP) growth, population, and exchange rates. There are also instances, where the forecasting of fisheries production has been largely based on only the past figures of fisheries production ([14,33]; etc.).

The main objective of this paper is to add to the existing literature on fisheries production in three unique ways. The first contribution of this paper is the examination of the persistence of total fisheries production in 31 OECD countries during the period 1960–2020. According to our knowledge, this is the seminal study to examine the persistence of fisheries production, despite its importance. The second addition of this study is that a disaggregated analysis has been conducted by separately examining the persistence of the two components of fisheries production- aquaculture production and capture fisheries production. Ignoring the different characteristics of fisheries production may not only conceal the differential effect associated with different forms of fisheries production, but also lead to erroneous policy implications for each element of fisheries production. The two major components of fisheries production have different characteristics. Shocks are more common in aquaculture production than in capture fisheries production [9]. This is because aquaculture production is more susceptible to shocks from outbreaks of diseases [9]. Hence, aquaculture production should be more persistent than capture fisheries production.

Third, we use fractional integration techniques, specifically the approach used is the one employed in Gil-Alana and Robinson [11], because it is a suitable method for studying the persistence of series that do not fit well with traditional stationary / unit roots models. The use of fractional integration appears to be a more flexible procedure than other methods based on integer differentiation orders for capturing long-term persistence patterns. Fractional differentiation allows these long-term persistence patterns to be captured by considering differences in past values in a more continuous sense, using fractional powers instead of integers. This allows more complex, subtle, and accurate dependence relationships to be modeled. A theoretical contribution of this study is that it tends to lend credence (or otherwise) to theories that assume that it is possible to forecast fisheries production by merely relying on their past figures. A practical contribution of this study is that it tends to provide guide to policy makers on whether to implement short-term or long-term measures to boost fisheries production.

We have focussed on OECD countries for many reasons. First, OECD countries have more capacity to improve different economic sectors [26–28] including the fisheries sector. Second, government spending to support the fisheries sectors appear to be higher in OECD than in most non-OECD countries. The intensity of spending on support to inputs is substantially greater in the OECD countries. The support amounted to an average of USD 465 per fisherman in OECD countries, while the support was USD 113 per fisherman in emerging countries, during 2018–2020 [20]. Support is routinely provided through programmes that aim to assist the functioning of fishing businesses more effectively [20]. Third, OECD countries are among the countries with the highest mean of shocks in recent times [9]. This suggests that fisheries production was affected more in OECD countries than many other regional economic blocs. Third, fisheries sectors play a vital role in the OECD countries. In 2020, the fisheries sector employed about one million people in OECD countries [20]. The fisheries sector, therefore, plays a particularly an important role in providing livelihoods in the OECD countries.

The other sections of this manuscript are structured in the following pattern: Section 2 of the present study undertakes an examination of the extant body of literature pertaining to the persistence of different production series as well as to different aspects of fisheries production. In Section 3, data description is undertaken while in Section 4, the modelling strategy, and the empirical findings are detailed. The discussion of the results is presented in Section 5. Section 6 of the research paper provides a synthesis of the findings and their corresponding policy implications.

2. Literature review

Although the number of papers on the persistence of fisheries production is virtually non-existent in the literature, there are several papers on the persistence of other different series. Persistence in gross output has been a widely examined area of research in the last 40 years, starting from the seminal paper of Nelson and Plosser [18]. Cheung and Lai [4] found evidence of GDP being more persistent in Canada, France, Germany, Italy, Japan than the UK and the US. Gil-Alana et al. [12] focused on the persistence of GDP in a group of 23 developing and developed countries. The results suggest persistence of output in 19 countries with the exceptions being Chile, the Netherlands, New Zealand, and Germany.

Persistence in other production series have also been investigated in the existing literature. Barros et al. [2] investigated the persistence of energy production in Brazil using fractional integration methods. The results indicate mean reversion in the energy production series. Solarin et al. [29] examined persistence in the production of both shale gas and shale oil. The results exhibit that the series are persistent with very limited evidence of mean reversion. Non-linear quantile and Fourier unit-root tests were used in Lee et al. [15], which analyzed the persistence of renewable energy production in the US. The results in that paper show that renewable energy production series are not persistent.

Despite the absence of papers on the persistence of fisheries production, several aspects of fisheries production have been explored in the literature. Leung and Pooley [16] examined the economic impact of a reduction in fisheries production. The results indicate that a supply-driven approach is more appropriate in assessing the economy-wide impact of fisheries production reduction. Unsworth et al. [34] focussed on the role of Seagrass meadows on fisheries productivity. The results indicate that well managed seagrasses can lead to significant increase in fisheries production across the globe. Ng'onga et al. [19] explored the contribution of fish production to the local economy and the results suggest that fisheries production contribute positively to the local economy. Elzaki [5] examined the economic impact of fisheries production. The results indicate an insignificant effect of fisheries production on GDP in the long run.

Sim and Nam [24] investigated the factors that influence fisheries production and observe that the amount of feed input is among the factors that raise the production of shallow-sea aquaculture. Garlock et al. [7] considered the global and regional diversity of fisheries production. The results reveal that social, biophysical, and economic factors are important for a successfully diverse fisheries production programme. The findings further suggest that aquaculture production is the least diversified among the different components of fisheries production.

The foregoing literature reveal that although there are papers on fisheries production no paper has attempted to examine the persistence of fisheries production. There are also papers that have considered specific forms of fisheries production, but none have focussed on the persistence of aquaculture production and capture fisheries production. Although there are papers that have used fractional integration in the extant literature to examine different series, (e.g., [36] in climatological data; [1] in finance; [17] in energy prices; etc.) there are none that have used fractional integration on fisheries production or any of its components.

3. Data description

In this study, we conduct an analysis of fisheries production in 31 OECD countries spanning the period from 1960 to 2020. Our analysis encompasses three distinct production series for each country: total fisheries production, aquaculture production, and capture fisheries production. The data for capture fisheries production, aquaculture production, and total fisheries production (which are all in metric tons) have been sourced from the *World Development Indicators* of the World Bank [35].

Over the period 1960–2020, aquaculture production experienced substantial expansion in OECD countries. New Zealand is the only exception, with a negative growth trend in aquaculture production (-48. 5 % over the entire period) (see Table 1). As the aquaculture sector grew, several OECD countries began to show signs of stabilization or decline in their catches of wild fish, known as capture fisheries. Table 1 provides data on the rate of decline in capture production in countries such as Austria (-90.15), Belgium (-68.7), Canada (-20.3 %), France (-28.5 %), Germany (-72.4 %), Greece (-17.9 %), Israel (-62.7 %), Italy (-33.7 %), Japan (-45.7 %), Portugal (-67.3 %), Spain (-11.3 %), Sweden (-28 %), Switzerland (-40.6 %) and United Kingdom (-38.3 %). This reduction in capture fisheries production is attributed to concerns about overfishing and the imperative need to manage marine resources sustainably.

In certain instances, the reduction in capture fisheries production surpasses the expansion seen in aquaculture production, as evidenced by countries including Belgium (-215.9 %), Canada (-2.2 %), France (-16 %), Germany (-222.4 %), Japan (-48 %), Portugal (-180.7 %), Sweden (-30.4 %), and United Kingdom (-19.9 %), which have reported negative growth in total fisheries production (the aggregate of capture fisheries production and aquaculture production).

Table 1
Growth rate in fish production (1960–2020).

COUNTRY	Growth rate for 1960–2020 (%)		
	CAPTURE	AQUACULTURE	TOTAL PRODUCTION
AUSTRALIA	223.2	1761.2	78.5
AUSTRIA	**-90.1**	596.5	13.9
BELGIUM	**-68.7 (*)**	5125.0	**-215.9**
CANADA	**-20.3**	5648.1	**-2.2**
CHILE	529.5	1,881,757.5	90.6
COLOMBIA	159.4 (*)	4,483,674.8	88.4
COSTA RICA	690.7 (*)	813,347.5	93.5
DENMARK	28.9	605.2	25.9
FINLAND	115.5 (*)	30,005.8	58.0
FRANCE	**-28.5**	72.2	**-16.0**
GERMANY	**-72.4**	62.8	**-222.4**
GREECE	**-17.9**	39,820.4	**57.0**
HUNGARY	10.3	83.7	37.3
ICELAND	64.2 (*)	2,029,653.0	41.4
IRELAND	412.3	1697.7	82.6
ISRAEL	**-62.7**	58.6	12.2
ITALY	**-33.7**	4294.4	18.1
JAPAN	**-45.7**	223.4	**-48.0**
KOREA	306.2	12,390.8	90.4
MEXICO	669.8	278,593.8	89.0
NETHERLANDS	35.1	**-48.5**	12.1
NORWAY	636.5	4135.1	89.2
NEW ZEALAND	87.8	78,342.7	66.1
POLAND	17.3	488.9	27.6
PORTUGAL	**-67.3 (*)**	1,455,075.0	**-180.7**
SPAIN	**-11.3**	4290.0	15.5
SWEDEN	**-28.0**	2270.6	**-30.4**
SWITZERLAND	**-40.6 (*)**	40,862.0	29.1
TURKEY	315.0	702,251.7	88.8
UK	**-38.3**	631,328.1	**-19.9**
US	56.7	329.5	40.0

(*) reference period: Belgium (1975–2020);Colombia (1971–2020); Costa Rica (1975–2020);
Finland(1965–2020); Iceland(1975–2020); Portugal (1965–2020) and Switzerland (1972–2020)

The stacked area graph (Fig. 1) shows the trend in the evolution of the three-production series (capture, aquaculture and total production). Clearly seen, for example, is the decreasing trend in Belgium in the three series analyzed (consistent with the comments provided on the data in Table 1), as well as the decreasing trend in catch and the increasing trend in aquaculture in Austria, together with the upward trend in total fishing production.

As earlier argued the methodology used is based on fractional integration. This is a general approach as it permits fractional degrees of differentiation in contrast with the classical stationary/nonstationary methods based on unit roots and integer orders of integration.

4. Modelling and empirical results

The model under investigation is the following one:

$$y(t) = \beta_0 + \beta_1 t + x(t), (1 - L)^d x(t) = u(t), t = 1, 2, \ldots \qquad (1)$$

where y(t) represents the series under investigation, β_0 and β_1 are the coefficients corresponding of the intercept and time trend, and x(t) is based on the assumption that it is I(d), where d is a parameter that is computed from the series. The error term u(t) is assumed to fulfil the classical assumption of zero mean and constant variance. Note that if u (t) in (1) is an AutoRegressive Moving Average (ARMA(p, q)), x(t) becomes an AutoRegressive Fractionally Integrated Moving Average (ARFIMA(p, *d*, q)) model, where d = 0 implies an ARMA structure and

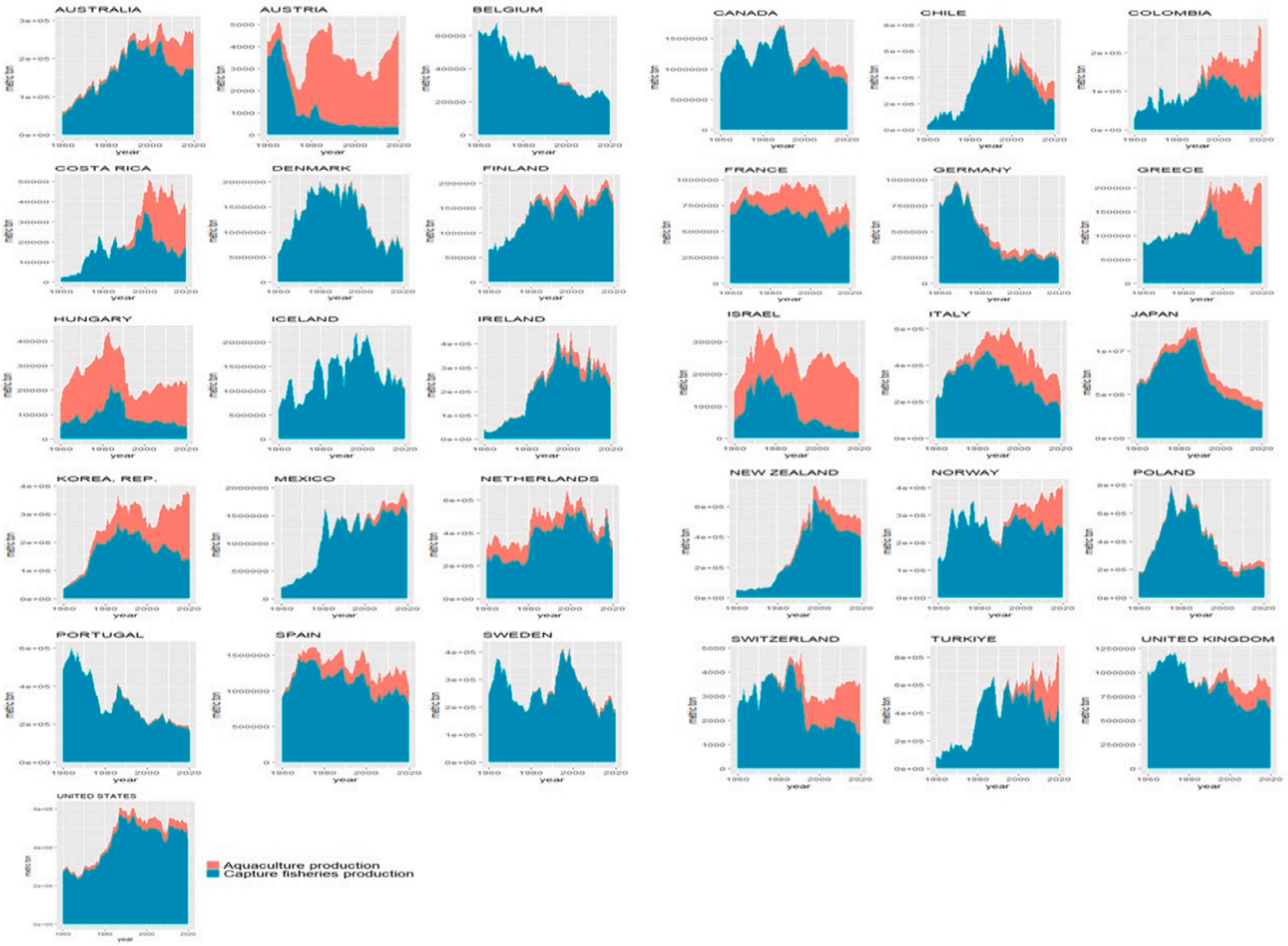

Fig. 1. Trends in countries production fisheries (capture and aquaculture).

d = 1 implies an ARIMA(p, 1, q) model. In this context, the possibility of fractional degrees of differentiation permits us to consider a wider degree of flexibility in the dynamic specification of the data.

We estimate the parameters in (1) by using a version of a Lagrange Multiplier test due to Robinson [23] (see, [11] for its functional form) and that is very convenient for our purposes. Firstly, stationarity is not a pre-condition. In fact, the method is valid for any real d, including those values which are outside the stationary region (i.e., $d \geq 0.5$). Secondly, this method has a standard N(0,1) limit distribution, which is another distinguish feature of this approach in comparison with other methods; moreover, this standard behaviour holds whether or not deterministic terms (like those based on the first equality in (1)) are included in the model; finally, this method is most efficient one when directed against local departures, which is clearly of interest based on the potential fractional nature of d.

Table 2 displays the estimates of d under the three standard specifications in relation with the deterministic terms, i.e., the cases of i) no terms, ii) a model with a constant, and iii) a model with a constant and a linear time trend for the total fisheries production. The values reported in bold in the table indicate the preferred model for each series. This selection is made by looking at the t-values of the estimated coefficients of the deterministic terms. Thus, we started with the model with a constant and a linear trend, and, if both coefficients are statistically significant we choose that model; otherwise we move to the model with an intercept, and if this coefficient is significant we choose that model, while if not, we choose the model with no terms. Looking at the results in Table 2, we first notice that the time trend is needed in 11 out of the 31 countries examined. The estimated values of the selected models are reported in Table 3. It can be seen that the trend is significantly positive in nine countries (Australia, Colombia, Greece, Ireland, Korea, Mexico, Norway, New Zealand and Turkey) and negative for Belgium and Canada. In the rest of the cases, the intercept is sufficient to describe the deterministic components. Focussing now on the differencing parameter d, mean reversion, i.e., statistical evidence of d below unity is found in only four countries. They are Colombia (d = 0.57), Belgium (0.62), Greece (0.77) and Ireland (0.82). On the other extreme, four countries display values of d considerably above 1: Austria, Canada, Hungary and Japan. For the other nations, the null hypothesis of unit root (i.e., d = 1) cannot be rejected.

Tables 4 and 5 are similar to the previous two tables but using logged values. The results though quantitatively different, are qualitatively very similar. There are eleven countries with significant trends: Australia, Chile, Colombia, Costa Rica, Finland, Greece, Korea, New Zealand, Turkey, Belgium, and Germany, the last two with negative coefficients. Mean reversion now takes place in the cases of Belgium, Chile, Colombia, and Greece. That is, the same countries as with the original data except for Chile that is found to be mean reverting with the logged data, and Ireland with the original data.

Tables 6 and 7 deal with the capture fisheries production and the aquaculture production respectively. The results differ in both cases. For the capture fisheries production, mean reversion takes place in Israel (0.51), Colombia (0.54) and Belgium (d = 0.72), while for the aquaculture production, the mean reverting countries are Poland (0.59), France (0.85) and particularly the Netherlands (0.33).

Table 2
Estimates of d. Total Fisheries Production. Original values.

Country	No deterministic terms	An intercept	An intercept with a linear time trend
AUSTRIA	1.11 (0.95, 1.33)	**1.27 (1.08, 1.52)**	1.27 (1.08, 1.53)
AUSTRALIA	0.82 (0.57, 1.15)	0.77 (0.65, 1.04)	**0.80 (0.66, 1.04)**
BELGIUM	0.91 (0.77, 1.12)	0.71 (0.63, 0.90)	**0.62 (0.42, 0.91)**
CANADA	1.08 (0.91, 1.31)	**1.24 (1.02, 1.50)**	1.23 (1.02, 1.49)
CHILE	**0.83 (0.72, 0.98)**	0.83 (0.72, 0.98)	0.84 (0.73, 0.98)
COLOMBIA	0.63 (0.49, 0.84)	0.61 (0.52, 0.77)	**0.57 (0.40, 0.79)**
COSTA RICA	**0.93 (0.77, 1.18)**	0.95 (0.80, 1.20)	0.95 (0.78, 1.20)
DENMARK	0.91 (0.81, 1.06)	**0.87 (0.77, 1.01)**	0.87 (0.77, 1.01)
FINLAND	0.76 (0.57, 1.00)	**0.94 (0.78, 1.17)**	0.93 (0.76, 1.17)
FRANCE	0.92 (0.78, 1.11)	**0.93 (0.79, 1.14)**	0.93 (0.78, 1.14)
GERMANY	0.98 (0.85, 1.17)	**1.10 (0.93, 1.40)**	1.10 (0.93, 1.40)
GREECE	0.75 (0.57, 0.98)	0.80 (0.69, 0.98)	**0.77 (0.63, 0.98)**
HUNGARY	1.20 (1.05, 1.44)	**1.17 (1.01, 1.40)**	1.17 (1.01, 1.38)
ICELAND	0.80 (0.59, 1.12)	**0.78 (0.59, 1.10)**	0.78 (0.60, 1.09)
IRELAND	0.78 (0.66, 0.94)	0.82 (0.72, 0.98)	**0.81 (0.70, 0.97)**
ISRAEL	0.98 (0.84, 1.17)	**0.99 (0.83, 1.20)**	0.99 (0.84, 1.20)
ITALY	0.92 (0.81, 1.07)	**0.94 (0.84, 1.09)**	0.95 (0.84, 1.09)
JAPAN	1.13 (1.00, 1.33)	**1.32 (1.21, 1.49)**	1.32 (1.21, 1.47)
KOREA	1.01 (0.87, 1.19)	1.01 (0.87, 1.20)	**1.01 (0.89, 1.19)**
MEXICO	0.95 (0.68, 1.45)	1.01 (0.76, 1.50)	**1.00 (0.73, 1.50)**
NETHERLANDS	0.81 (0.61, 1.08)	**0.84 (0.68, 1.09)**	0.84 (0.67, 1.09)
NORWAY	0.98 (0.80, 1.27)	0.90 (0.63, 1.25)	**0.91 (0.71, 1.24)**
NEW ZEALAND	0.90 (0.80, 1.03)	0.92 (0.83, 1.05)	**0.92 (0.81, 1.05)**
POLAND	1.11 (0.99, 1.29)	**1.12 (0.99, 1.32)**	1.12 (0.99, 1.31)
PORTUGAL	1.01 (0.86, 1.23)	**1.05 (0.86, 1.32)**	1.05 (0.85, 1.32)
SPAIN	0.96 (0.83, 1.13)	**0.96 (0.81, 1.16)**	0.96 (0.82, 1.16)
SWEDEN	1.04 (0.87, 1.26)	**1.06 (0.88, 1.29)**	1.06 (0.88, 1.29)
SWITZERLAND	0.97 (0.80, 1.24)	**0.85 (0.65, 1.14)**	0.85 (0.67, 1.14)
TURKEY	0.75 (0.55, 1.05)	0.76 (0.61, 1.05)	**0.76 (0.57, 1.05)**
UK	0.92 (0.79, 1.12)	**0.90 (0.74, 1.13)**	0.90 (0.73, 1.13)
US	0.83 (0.65, 1.05)	**1.07 (0.93, 1.29)**	1.07 (0.93, 1.29)

The values are the estimates of the differencing parameters for the three cases of i) no terms, iii) with a constant, and iii) with a constant and a time trend. The values in parenthesis are the 95% confidence intervals. The values in bold refer to the selected model for each series.

Table 8 summarizes the results in terms of d. We see that most of the estimates of the differencing parameters d are around 1. However, evidence of mean reversion is found in a number of cases. Thus, for total production, this happens in the cases of Chile and Colombia; for capture fisheries production, the countries with reversion to the mean are Belgium, Colombia, and Israel, while for aquaculture production this occurs with France, Netherlands and Poland.

5. Discussion of the results

The foregoing results suggest evidence for persistence of fisheries production except for Chile and Colombia. The foregoing empirical findings indicate evidence for capture fisheries production except for Colombia, Belgium and Israel and aquaculture production except for Poland, France, the Netherlands. The overwhelming support for high levels of persistence and permanency of shocks of fisheries production and its two components can be attributed to many causes.

Though not reported, we also conducted the analysis allowing for autocorrelation in the error term. In particular, we repeat the procedure supposing that u(t) in (1) was weakly autocorrelated by using a non-parametric approach due to Bloomfield [3]. The results were very similar to those reported across the tables, though with wider confidence bands. Using other approaches like the parametric approach of Sowell [31] produced essentially the same results.

As there is lack of extant papers on the persistence of fisheries production, it is difficult to directly compare the empirical findings of the current study with the previous papers on the persistence of fisheries production. However, the persistence of the factors or events that determine the fisheries production have been established in the literature. According to Smyth [25], a variable which is dependent on other variables that are persistent will imbibe this persistence from these other variables within a nation. These persistent events, which are likely to have a long-term impact on fisheries production and its components include climate change, natural disasters, fishery collapses, policy changes, and aquaculture disease outbreaks [8]. For instance, there are several channels through which climate change can have a long-term impact on fisheries production. Ocean circulation and temperature changes have the capacity to alter geographical distribution of different fish products. Steadily rising ocean temperatures force fish to leave their historic territories and migrate to conducive waters.

Table 3
Estimated coefficients in the selected models. Total Fisheries Production. Original values.

Country	D (95% band)	Intercept (tvalue)	Time trend (tvalue)
AUSTRIA	1.27 (1.08, 1.52)	4180.70 (13.40)	—
AUSTRALIA	0.80 (0.66, 1.04)	58,684.64 (4.20)	3719.88 (3.17)
BELGIUM	0.62 (0.42, 0.91)	64,142.80 (27.29)	-735.16 (-8.01)
CANADA	1.24 (1.02, 1.50)	901,122.31 (11.24)	-735.16 (-8.01)
CHILE	0.83 (0.72, 0.98)	—	—
COLOMBIA	0.57 (0.40, 0.79)	29,334.36 (1.78)	3287.11 (5.67)
COSTA RICA	0.93 (0.77, 1.18)	—	—
DENMARK	0.87 (0.77, 1.01)	619,738.75 (3.54)	—
FINLAND	0.94 (0.78, 1.17)	66,473.17 (5.75)	—
FRANCE	0.93 (0.79, 1.14)	765,881.00 (20.27)	—
GERMANY	1.10 (0.93, 1.40)	789,540.50 (19.58)	—
GREECE	0.77 (0.63, 0.98)	83,045.93 (7.46)	2072.89 (3.20)
HUNGARY	1.17 (1.01, 1.40)	14,037.89 (101.61)	—
ICELAND	0.78 (0.59, 1.10)	714,141.06 (3.28)	—
IRELAND	0.82 (0.72, 0.98)	36,598.43 (2.09)	4242.44 (1.92)
ISRAEL	0.99 (0.83, 1.20)	14,709.52 (6.20)	—
ITALY	0.94 (0.84, 1.09)	220,207.21 (6.51)	—
JAPAN	1.32 (1.21, 1.49)	608,163.50 (17.15)	—
KOREA	1.01 (0.89, 1.19)	300,776.56 (1.66)	55,806.40 (2.18)
MEXICO	1.00 (0.73, 1.50)	169,945.11 (2.42)	26,567.88 (1.94)
NETHERLANDS	0.84 (0.68, 1.09)	313,640.84 (6.69)	—
NORWAY	0.91 (0.71, 1.24)	136,480.86 (4.85)	43,255.67 (1.98)
NEW ZEALAND	0.92 (0.81, 1.05)	43,020.58 (2.96)	7727.96 (1.91)
POLAND	1.12 (0.99, 1.32)	1,709,950.38 (3.74)	—
PORTUGAL	1.05 (0.86, 1.32)	488,553.17 (17.32)	—
SPAIN	0.96 (0.81, 1.16)	921,035.62 (10.74)	—
SWEDEN	1.06 (0.88, 1.29)	247,935.86 (9.05)	—
SWITZERLAND	0.85 (0.65, 1.14)	2588.99 (7.95)	—
TURKEY	0.76 (0.57, 1.05)	72,092.14 (9.11)	11,470.65 (3.15)
UK	0.90 (0.74, 1.13)	101,350.71 (19.79)	—
US	1.07 (0.93, 1.29)	2,808,611.18 (11.48)	—

The values in column 2 are the estimates of d and the 95 % confidence bands. Those in columns 3 and 4 are the estimates of the intercept and the time trend coefficient. In parenthesis, the t-values.

Another reason for the persistence of the series is that beyond its past values, fisheries production continues to be influenced by an increasingly number of variables. Several additional variables continue to affect fisheries production and its components [7]. According to Hobday et al. [14], the higher the number of the determinants of fisheries production, the less predictable and more persistent fisheries production is. Some determinants of fisheries production, such as natural disasters or outbreak diseases, are, to a large extent, less predictable [9]. This lower predictability of the determinants is likely to be transferred to fisheries production and its components.

The similarity of the persistence of both aquaculture fisheries production and capture fisheries production in most cases can be attributed to the similarity in the shock magnitude and recovery in many OECD countries. According to Gephart et al. [9], when fisheries production is disaggregated into aquaculture production and capture fisheries production, the shock scale and recovery appear to be the same for capture and aquaculture production systems in the OECD countries.

The results show that fisheries production and its components in some countries are partially consistent with the hypothesis of Smyth [25]. According to the hypothesis, production series with smaller figures

Table 4

Estimates of d. Total Fisheries Production. Logged values.

Country	No deterministic terms	An intercept	An intercept with a linear time trend
AUSTRIA	0.96 (0.80, 1.19)	**1.28 (1.09, 1.53)**	1.28 (1.09, 1.53)
AUSTRALIA	0.95 (0.78, 1.18)	0.83 (0.67, 1.09)	**0.89 (0.77, 1.08)**
BELGIUM	0.94 (0.78, 1.16)	0.78 (0.67, 1.00)	**0.72 (0.51, 1.01)**
CANADA	0.95 (0.79, 1.18)	**1.24 (1.02, 1.51)**	1.24 (1.02, 1.50)
CHILE	0.96 (0.80, 1.19)	0.81 (0.67, 0.98)	**0.84 (0.74, 0.99)**
COLOMBIA	0.97 (0.80, 1.20)	0.51 (0.43, 0.62)	**0.41 (0.23, 0.69)**
COSTA RICA	0.92 (0.76, 1.15)	0.98 (0.81, 1.20)	**0.98 (0.84, 1.18)**
DENMARK	0.96 (0.80, 1.19)	**0.90 (0.79, 1.06)**	0.91 (0.80, 1.06)
FINLAND	0.93 (0.77, 1.15)	0.84 (0.72, 1.01)	**0.84 (0.73, 1.01)**
FRANCE	0.94 (0.78, 1.17)	**0.92 (0.78, 1.13)**	0.92 (0.77, 1.14)
GERMANY	0.94 (0.79, 1.17)	0.95 (0.81, 1.21)	**0.95 (0.79, 1.21)**
GREECE	0.93 (0.77, 1.16)	0.82 (0.72, 1.01)	**0.80 (0.66, 1.00)**
HUNGARY	0.98 (0.82, 1.21)	**1.17 (1.01, 1.39)**	1.16 (1.01, 1.36)
ICELAND	0.95 (0.78, 1.18)	**0.77 (0.57, 1.12)**	0.78 (0.59, 1.11)
IRELAND	0.89 (0.73, 1.12)	**1.04 (0.91, 1.23)**	1.03 (0.90, 1.23)
ISRAEL	0.93 (0.75, 1.17)	**1.03 (0.88, 1.24)**	1.03 (0.88, 1.23)
ITALY	0.94 (0.78, 1.16)	**0.98 (0.87, 1.14)**	0.98 (0.87, 1.14)
JAPAN	0.95 (0.79, 1.18)	**1.29 (1.18, 1.46)**	1.29 (1.19, 1.44)
KOREA	0.95 (0.80, 1.18)	1.27 (1.15, 1.44)	**1.24 (1.13, 1.38)**
MEXICO	0.95 (0.78, 1.17)	**1.19 (0.98, 1.54)**	1.17 (0.98, 1.52)
NETHERLANDS	0.93 (0.77, 1.17)	**0.86 (0.69, 1.11)**	0.86 (0.69, 1.11)
NORWAY	0.95 (0.79, 1.18)	**1.02 (0.77, 1.37)**	1.03 (0.82, 1.36)
NEW ZEALAND	0.91 (0.74, 1.15)	1.10 (1.00, 1.25)	**1.10 (0.99, 1.24)**
POLAND	0.95 (0.80, 1.17)	**1.10 (0.99, 1.24)**	1.09 (0.99, 1.23)
PORTUGAL	0.94 (0.79, 1.17)	**1.05 (0.84, 1.33)**	1.05 (0.84, 1.33)
SPAIN	0.94 (0.78, 1.17)	**0.96 (0.82, 1.16)**	0.96 (0.82, 1.15)
SWEDEN	0.95 (0.78, 1.18)	**1.04 (0.86, 1.27)**	1.04 (0.86, 1.27)
SWITZERLAND	0.95 (0.79, 1.19)	**0.81 (0.61, 1.12)**	0.82 (0.64, 1.11)
TURKEY	0.93 (0.77, 1.16)	0.81 (0.65, 1.03)	**0.82 (0.68, 1.03)**
UK	0.94 (0.78, 1.17)	**0.89 (0.73, 1.13)**	0.89 (0.72, 1.13)
US	0.93 (0.77, 1.16)	**1.09 (0.95, 1.29)**	1.08 (0.94, 1.29)

The values are the estimates of the differencing parameters for the three cases of (i) no terms, (iii) with a constant, and (iii) with a constant and a time trend. The values in parenthesis are the 95 % confidence intervals. The values in bold refer to the selected model for each series.

are likely to be less persistent. With an average of 125,441 metric tons of fisheries production, Colombia has the seventh smallest aquaculture fisheries production among the countries under examination during the study period. With an average of 8934, 40,035, and 89,303 metric tons of capture fisheries production, Israel, Belgium, and Colombia have the third, sixth and seventh smallest capture fisheries production. Poland, with an average of 23,959 metric tons of aquaculture production has the eleventh smallest aquaculture production [35]

6. Conclusions

We have examined the persistence of total fisheries production and its two main components- capture fisheries production and aquaculture production in 31 OECD countries using annual data from 1960 to 2020. With respect to the order of integration, evidence of mean reversion and thus transitory shocks are observed in the cases of Chile and Colombia for total fisheries production; again in Colombia along with Belgium and Israel for the capture fisheries production, and in France, the Netherlands and Poland for the aquaculture production. In the rest of the cases, the unit root hypothesis or estimates of d significantly above 1 are observed suggesting lack of mean reversion and thus, supporting permanency of the shocks.

The results suggest the existence of persistence or hysteresis in fisheries production of several OECD countries. It means that shocks to the fisheries production or its components are permanent or long-term in nature. Long-term measures should be introduced in the cases of disruptions in the fishery sector such as those caused by health shocks, including the COVID-19 episode. Long term interventions rather than short term policies are necessary to address any changes in persistent series, while long-term management and sustainable measures are more pertinent to fisheries production in these countries. In the OECD report "Sustainable Oceans for All" (2020), several long-term measures are outlined, such as the development and improvement of existing technologies, as well as encouraging their use to reduce the capture of unwanted species. It also emphasizes the need to educate and raise awareness among fishermen and consumers about the importance of marine conservation, to promote greater international cooperation for the management of shared resources, and to implement policies aimed at further promoting aquaculture, among other strategies.

Table 5

Estimated coefficients in the selected models. Total Fisheries Production. Logged values.

Country	D (95% band)	Intercept (tvalue)	Time trend (tvalue)
AUSTRIA	1.28 (1.09, 1.53)	8.3388 (92.65)	—
AUSTRALIA	0.89 (0.77, 1.08)	11.0106 (13.861)	0.0253 (3.70)
BELGIUM	0.72 (0.51, 1.01)	11.0987 (190.73)	-0.0187 (-6.43)
CANADA	1.24 (1.02, 1.51)	13.7134 (216.66)	—
CHILE	0.84 (0.74, 0.99)	12.8236 (55.55)	0.0382 (2.27)
COLOMBIA	0.41 (0.23, 0.69)	10.6166 (80.04)	0.0299 (7.86)
COSTA RICA	0.98 (0.84, 1.18)	7.6537 (43.93)	0.0456 (2.20)
DENMARK	0.90 (0.79, 1.06)	13.2894 (91.18)	—
FINLAND	0.84 (0.73, 1.01)	11.0857 (125.15)	0.0159 (2.46)
FRANCE	0.92 (0.78, 1.13)	13.5491 (289.37)	—
GERMANY	0.95 (0.79, 1.21)	13.5996 (161.73)	-0.0197 (-2.19)
GREECE	0.80 (0.66, 1.00)	11.3491 (163.10)	0.0151 (3.39)
HUNGARY	1.17 (1.01, 1.39)	9.5637 (107.08)	—
ICELAND	0.77 (0.57, 1.12)	13.4516 (76.67)	—
IRELAND	1.04 (0.91, 1.23)	10.6440 (76.16)	—
ISRAEL	1.03 (0.88, 1.24)	9.5878 (112.52)	—
ITALY	0.98 (0.87, 1.14)	12.2910 (143.03)	—
JAPAN	1.29 (1.18, 1.46)	15.6241 (375.07)	—
KOREA	1.24 (1.13, 1.38)	12.7034 (170.80)	0.0483 (2.06)
MEXICO	1.19 (0.98, 1.54)	12.1570 (123.04)	—
NETHERLANDS	0.86 (0.69, 1.11)	12.6477 (121.25)	—
NORWAY	1.02 (0.77, 1.37)	14.1382 (133.30)	—
NEW ZEALAND	1.10 (0.99, 1.24)	10.8376 (101.02)	0.0344 (124.72)
POLAND	1.10 (0.99, 1.24)	12.1106 (104.43)	—
PORTUGAL	1.05 (0.84, 1.33)	13.0998 (162.89)	—
SPAIN	0.96 (0.82, 1.16)	13.7320 (208.68)	—
SWEDEN	1.04 (0.86, 1.27)	12.4243 (123.19)	—
SWITZERLAND	0.81 (0.61, 1.12)	7.8500 (81.89)	—
TURKEY	0.82 (0.68, 1.03)	11.3504 (61.43)	0.0368 (2.93)
UK	0.89 (0.73, 1.13)	13.8283 (260.52)	—
US	1.09 (0.95, 1.29)	14.8423 (280.11)	—

The values in column 2 are the estimates of d and the 95 % confidence bands. Those in columns 3 and 4 are the estimates of the intercept and the time trend coefficient. In parenthesis, the t-values.

Examples of long-term policies or measures that have been used in the OECD countries in the past include training programmes that result in new skills for fishermen and increase the fishermen's efficiency in several OECD countries. Cost-reducing or benefit-enhancing research and development, such as improved technology, are being frequently introduced in the OECD countries. Moreover, infrastructural support which includes funding to improve facilities such as ports, accounted for USD 0.97 billion in 2018–20 in OECD nations. Relative to fleet size, this spending translates into USD 213 per gross tonnage in the OECD countries. The support to research and development activities associated with fisheries production was valued at USD 0.45 billion in 2018–20 [20].

The results also indicate that it is not viable to forecast the future values of fisheries production or its components by simply depending on their previous figures. There is a need to consider the role of other possible determinants in forecasting fisheries production. Hence the AGLINK-COSIMO model, which is used to predict fisheries production, can be augmented by incorporating more possible determinants of fisheries production within the framework. As the results suggest that fisheries production is generally less predictable in the OECD countries, this means there is less time for any management preparation for intervention. The resilience of the fishery system could be diversified with additional fishery sources, retaining backup distribution

Table 6
Estimated coefficients in the selected models. Captured Fisheries Production. Logged values.

Country	D (95 % band)	Intercept (tvalue)	Time trend (tvalue)
AUSTRIA	1.18 (0.97, 1.47)	8.1791 (62.42)	—
AUSTRALIA	0.99 (0.87, 1.16)	10.9081 (103.10)	0.0195 (1.98)
BELGIUM	0.72 (0.52, 0.99)	11.0897 (191.23)	-0.0189 (-6.51)
CANADA	1.22 (1.02, 1.49)	13.7128 (206.00)	—
CHILE	0.86 (0.79, 1.01)	12.8750 (53.98)	—
COLOMBIA	0.54 (0.41, 0.75)	10.6474 (59.65)	0.0142 (2.38)
COSTA RICA	1.01 (0.85, 1.22)	7.6929 (40.27)	—
DENMARK	0.90 (0.79, 1.06)	13.2811 (88.74)	—
FINLAND	0.83 (0.70, 1.01)	11.0888 (120.57)	0.0142 (2.20)
FRANCE	0.86 (0.70, 1.11)	13.3948 (224.36)	—
GERMANY	1.04 (0.88, 1.30)	13.5532 (150.14)	—
GREECE	0.95 (0.83, 1.13)	11.3739 (127.05)	—
HUNGARY	0.95 (0.81, 1.15)	8.5171 (55.92)	—
ICELAND	0.77 (0.57, 1.11)	13.4511 (76.37)	—
IRELAND	1.01 (0.88, 1.20)	10.6139 (71.50)	—
ISRAEL	0.51 (0.36, 0.69)	9.1582 (30.30)	-0.0238 (-2.47)
ITALY	1.02 (0.90, 1.22)	12.2685 (138.63)	—
JAPAN	1.31 (1.20, 1.47)	15.5739 (358.19)	—
KOREA	1.21 (1.10, 1.37)	12.6853 (15.267)	—
MEXICO	1.20 (0.99, 1.55)	12.1556 (121.12)	—
NETHERLANDS	0.99 (0.82, 1.24)	12.3287 (11.570)	—
NORWAY	1.02 (0.79, 1.35)	14.1386 (126.00)	
NEW ZEALAND	1.07 (0.96, 1.21)	10.7812 (93.72)	0.0315 (1.77)
POLAND	1.08 (0.98, 1.23)	12.0656 (95.00)	—
PORTUGAL	1.03 (0.83, 1.31)	13.1007 (160.90)	—
SPAIN	0.95 (0.81, 1.15)	13.7249 (204.27)	—
SWEDEN	1.03 (0.86, 1.26)	12.4236 (119.36)	—
SWITZERLAND	0.96 (0.78, 1.25)	7.8308 (62.08)	—
TURKEY	0.84 (0.71, 1.01)	11.3704 (55.15)	0.0252 (1.88)
UK	0.92 (0.78, 1.14)	13.8271 (238.21)	—
US	1.07 (0.93, 1.28)	14.8112 (258.00)	—

The values in column 2 are the estimates of d and the 95 % confidence bands. Those in columns 3 and 4 are the estimates of the intercept and the time trend coefficient. In parenthesis, the t-values.

Table 7
Estimated coefficients in the selected models. Aquaculture Production. Logged values.

Country	D (95 % band)	Intercept (tvalue)	Time trend (tvalue)
AUSTRIA	1.18 (1.01, 1.44)	6.4680 (56.64)	—
AUSTRALIA	0.91 (0.79, 1.08)	8.5948 (89.64)	0.0489 (5.52)
BELGIUM	1.10 (0.97, 1.31)	-2.3276 (-3.56)	—
CANADA	1.33 (1.16, 1.53)	7.9884 (65.58)	—
CHILE	0.91 (0.82, 1.03)	4.1806 (13.71)	0.1701 (7.18)
COLOMBIA	1.19 (1.04, 1.43)	-2.4795 (-5.13)	0.2266 (1.99)
COSTA RICA	1.17 (1.04, 1.37)	-2.3224 (-5.19)	—
DENMARK	0.89 (0.78, 1.08)	8.7040 (81.88)	0.0318 (3.47)
FINLAND	1.15 (0.98, 1.39)	-2.4322 (-3.09)	—
FRANCE	0.85 (0.75, 0.98)	11.6337 (128.17)	—
GERMANY	0.85 (0.71, 1.07)	9.8803 (47.99)	—
GREECE	1.34 (1.20, 1.54)	5.7903 (45.61)	—
HUNGARY	1.01 (0.86, 1.21)	9.2036 (77.70)	—
ICELAND	1.28 (1.10, 1.55)	-2.3272 (-5.39)	—
IRELAND	0.94 (0.77, 1.21)	7.5448 (28.62)	0.0512 (1.99)
ISRAEL	1.00 (0.82, 1.26)	9.1360 (127.38)	—
ITALY	1.10 (1.00, 1.23)	7.8053 (52.30)	0.0678 (2.44)
JAPAN	1.02 (0.93, 1.14)	12.6144 (162.38)	0.0197 (1.84)
KOREA	1.00 (0.87, 1.18)	9.7524 (47.07)	0.0804 (3.03)
MEXICO	0.99 (0.87, 1.17)	4.4721 (17.32)	0.1324 (4.15)
NETHERLANDS	0.33 (0.15, 0.61)	11.5825 (92.14)	-0.0117 (-3.40)
NORWAY	1.01 (0.85, 1.22)	7.4545 (18.39)	0.1098 (2.04
NEW ZEALAND	1.00 (0.87, 1.20)	7.9373 (12.36)	—
POLAND	0.59 (0.40, 0.89)	8.9926 (78.86)	0.0292 (6.98)
PORTUGAL	1.40 (1.24, 1.63)	-2.3743 (-7.01)	—
SPAIN	1.02 (0.84, 1.28)	8.7220 (30.27)	—
SWEDEN	1.07 (0.91, 1.32)	6.2199 (25.25)	—
SWITZERLAND	1.12 (0.97, 1.33)	-2.3372 (-4.39)	—
TURKEY	1.37 (1.20, 1.59)	3.8916 (46.79)	0.1639 (3.96)
UK	0.84 (0.73, 1.00)	3.5536 (8.48)	0.1482 (4.87)
US	0.86 (0.72, 1.06)	11.5364 (106.59)	0.0253 (3.01)

The values in column 2 are the estimates of d and the 95 % confidence bands. Those in columns 3 and 4 are the estimates of the intercept and the time trend coefficient. In parenthesis, the t-values.

mechanisms, and creating capital to deal with crises in a bid to decrease the societal effects of a shock. Countries consuming fish produced in the OECD should try to diversify their sources of fish as negative shocks on fish production are likely to have a durable impact on the supply of fish from these countries.

For the countries which experienced mean-reverting fisheries production and its components, it means that shocks to the fisheries production or its components are temporary. Overreaching policies can spur negative consequences such as overfishing in these countries. Rolling short terms measures to boost fisheries production in these countries will be more effective. Moreover, short-term measures should be introduced in the cases of disruptions in the fishery sector. Extending the fishing season, fuel tax concessions and subsidized vessel insurance are viable short-term policies relevant for the fishery sector. Other short-term policies include reduction in regulatory burdens and administrative bottlenecks that could constitute short term hindrances to fisheries production. These measures should be systematically introduced in such a way that they do not lead to illegal, unreported, and unregulated (IUU) fishing or overfishing.

This article can be extended in various directions. The current study has concentrated on the persistence of fisheries production in OECD countries. Persistence analysis of fisheries production can also be conducted for other or regional or economic blocs. An assessment of the convergence of fisheries production in OECD countries can also be studied by future papers. The presence of convergence of fisheries production is an indication of the suitability of employing mutual policies to enhance fisheries production among nations under observation. In addition, the potential presence of structural breaks is another issue that should be investigated in future papers, noting that long memory and fractional integration in particular is intimately related with the presence of breaks in the data (Granger and Hyung, 2004). Furthermore,

Table 8
Summary results.

Country	Total production	Captured prod.	Aquaculture prod.
AUSTRIA	1.28 (1.09, 1.53)	1.18 (0.97, 1.47)	1.18 (1.01, 1.44)
AUSTRALIA	0.89 (0.77, 1.08)	0.99 (0.87, 1.16)	0.91 (0.79, 1.08)
BELGIUM	0.72 (0.51, 1.01)	**0.72 (0.52, 0.99)**	1.10 (0.97, 1.31)
CANADA	1.24 (1.02, 1.51)	1.22 (1.02, 1.49)	1.33 (1.16, 1.53)
CHILE	**0.84 (0.74, 0.99)**	0.86 (0.79, 1.01)	0.91 (0.82, 1.03)
COLOMBIA	**0.41 (0.23, 0.69)**	**0.54 (0.41, 0.75)**	1.19 (1.04, 1.43)
COSTA RICA	0.98 (0.84, 1.18)	1.01 (0.85, 1.22)	1.17 (1.04, 1.37)
DENMARK	0.90 (0.79, 1.06)	0.90 (0.79, 1.06)	0.89 (0.78, 1.08)
FINLAND	0.84 (0.73, 1.01)	0.83 (0.70, 1.01)	1.15 (0.98, 1.39)
FRANCE	0.92 (0.78, 1.13)	0.86 (0.70, 1.11)	**0.85 (0.75, 0.98)**
GERMANY	0.95 (0.79, 1.21)	1.04 (0.88, 1.30)	0.85 (0.71, 1.07)
GREECE	0.80 (0.66, 1.00)	0.95 (0.83, 1.13)	1.34 (1.20, 1.54)
HUNGARY	1.17 (1.01, 1.39)	0.95 (0.81, 1.15)	1.01 (0.86, 1.21)
ICELAND	0.77 (0.57, 1.12)	0.77 (0.57, 1.11)	1.28 (1.10, 1.55)
IRELAND	1.04 (0.91, 1.23)	1.01 (0.88, 1.20)	0.94 (0.77, 1.21)
ISRAEL	1.03 (0.88, 1.24)	**0.51 (0.36, 0.69)**	1.00 (0.82, 1.26)
ITALY	0.98 (0.87, 1.14)	1.02 (0.90, 1.22)	1.10 (1.00, 1.23)
JAPAN	1.29 (1.18, 1.46)	1.31 (1.20, 1.47)	1.02 (0.93, 1.14)
KOREA	1.24 (1.13, 1.38)	1.21 (1.10, 1.37)	1.00 (0.87, 1.18)
MEXICO	1.19 (0.98, 1.54)	1.20 (0.99, 1.55)	0.99 (0.87, 1.17)
NETHERLANDS	0.86 (0.69, 1.11)	0.99 (0.82, 1.24)	**0.33 (0.15, 0.61)**
NORWAY	1.02 (0.77, 1.37)	1.02 (0.79, 1.35)	1.01 (0.85, 1.22)
NEW ZEALAND	1.10 (0.99, 1.24)	1.07 (0.96, 1.21)	1.00 (0.87, 1.20)
POLAND	1.10 (0.99, 1.24)	1.08 (0.98, 1.23)	**0.59 (0.40, 0.89)**
PORTUGAL	1.05 (0.84, 1.33)	1.03 (0.83, 1.31)	1.40 (1.24, 1.63)
SPAIN	0.96 (0.82, 1.16)	0.95 (0.81, 1.15)	1.02 (0.84, 1.28)
SWEDEN	1.04 (0.86, 1.27)	1.03 (0.86, 1.26)	1.07 (0.91, 1.32)
SWITZERLAND	0.81 (0.61, 1.12)	0.96 (0.78, 1.25)	1.12 (0.97, 1.33)
TURKEY	0.82 (0.68, 1.03)	0.84 (0.71, 1.01)	1.37 (1.20, 1.59)
UK	0.89 (0.73, 1.13)	0.92 (0.78, 1.14)	0.84 (0.73, 1.00)
US	1.09 (0.95, 1.29)	1.07 (0.93, 1.28)	0.86 (0.72, 1.06)

In bold, evidence of mean reversion

some fish populations exhibit cyclical patterns in response to seasonal changes, spawning cycles, or other natural phenomena. These cyclical patterns can be modelled still in the context of long memory structures like those used in this paper (see the concept of cyclical fractional integration, [10]; Food and Agriculture Organization [6]; Granger et al., [13]; Sustainable Ocean for All [32]) and work in this direction is now in progress.

CRediT authorship contribution statement

Sakiru Solarin: Visualization, Resources, Investigation, Data curation. **Carmen Lafuente:** Writing – original draft, Visualization, Methodology, Investigation, Data curation. **Luis Alberiko Gil-Alana:** Writing – original draft, Validation, Software, Funding acquisition, Formal analysis, Conceptualization. **Maria Goenechea:** Writing – review & editing, Visualization, Validation, Project administration.

Declaration of Competing Interest

There are no competing interests with the publication of the present manuscript.

Data availability

Data will be made available on request.

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