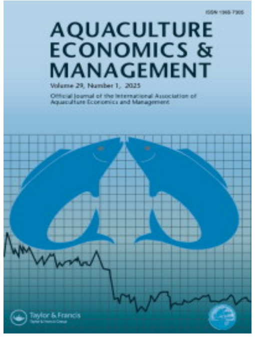

Taylor & Francis
Taylor & Francis Group

Aquaculture Economics & Management

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/uaqm20

Price transmission and asymmetry in a changing seafood supply chain

Dejene Gizaw Kidane

To cite this article: Dejene Gizaw Kidane (08 Jan 2025): Price transmission and asymmetry in a changing seafood supply chain, Aquaculture Economics & Management, DOI: 10.1080/13657305.2024.2447443

To link to this article: https://doi.org/10.1080/13657305.2024.2447443

Published online: 08 Jan 2025.

AQUACULTURE ECONOMICS & MANAGEMENT
https://doi.org/10.1080/13657305.2024.2447443

Price transmission and asymmetry in a changing seafood supply chain

Dejene Gizaw Kidane

School of Business and Economics, UiT The Arctic University of Norway, Tromsø, Norway

ABSTRACT
This study investigates price transmission and asymmetry in the cod value chain between the export market of Norway and the retail market of Portugal. Using monthly data from January 2011 to December 2022, it analyzes the value chains of salted dried cod, salted wet cod, and the relationship between the export price of salted wet cod and the retail price of salted dried cod using a non-linear ARDL model. The findings reveal that price transmission occurs across all investigated value chains, though the timing and extent of adjustments vary. Furthermore, the findings indicate that the export market plays a leading role along the value chains. Notably, no evidence of price asymmetry is observed in any of the product chains, indicating efficient price transmission mechanisms.

KEYWORDS
Asymmetry; cod; NARDL model; price transmission; seafood

Introduction

Recent literature highlights significant transformations in the global seafood industry, particularly in key European markets. A prominent change is the increasing consolidation of intermediaries within downstream segments of seafood supply chains (Acharjee et al., 2023; Ankamah-Yeboah & Bronnmann, 2017; Fernández-Polanco & Llorente, 2015; Purcell et al., 2017), as well as third country processing (Asche et al., 2022; Svanidze et al., 2023).[1] This trend has raised concerns among researchers and policymakers about its potential to disrupt market dynamics and reduce overall efficiency (Ankamah-Yeboah & Bronnmann, 2017; Fernández-Polanco & Llorente, 2015; Purcell et al., 2017; Simioni et al., 2013). Intermediaries with market power tend to adopt pricing strategies that lead to faster and more complete pass-through of price increases but slower and less complete pass-through of price decreases (Peltzman, 2000; von Cramon-Taubadel & Meyer, 2004). At

CONTACT Dejene Gizaw Kidane dejene.g.kidane@uit.no School of Business and Economics, The Arctic University of Norway, Tromsø, Norway.

the same time, the continuous development of new product forms and transaction methods has added complexity to seafood value chains, further influencing pricing and supply chain efficiency (Asche et al., 2014; Landazuri-Tveteraas et al., 2018; Straume, Asche, Landazuri-Tveteraas, et al., 2024).

The cod supply chain between Norway and Portugal offers a compelling case for studying broader market trend. As one of the world's largest cod exporters, Norway plays a crucial role in meeting Portugal's demand for cod (Asche et al., 2007; EUMOFA, 2018), which is one of the main fish species consumed in the country. Portugal has the highest seafood consumption in Europe, with an annual per capita intake of more than 60 kg (Almeida et al., 2015; Food & Agriculture Organization, 2008). A significant portion of this consumption is in the form of salted dried cod, although imports also include salted wet cod and frozen cod, the latter of which is processed into salted dried cod locally (Asche et al., 2007). Norway and Portugal are the only countries in the world that produce salted dried cod at industrial scale, though the world market for frozen cod and the broader European market for salted wet cod ensure that the Portuguese industry has unrestricted access to raw materials (Almeida et al. 2015; Asche & Gordon, 2015; Asche et al., 2007).

While previous studies (e.g., Asche et al., 2007) demonstrated the efficiency of the cod supply chain between Norway and Portugal, recent literature has raised concerns about whether this efficiency remains intact given the increasing consolidation of the Portuguese retail market. With three major retailers (Continente, Pingo Doce, and Intermarché) now controlling 80% of the Portuguese cod market (EUMOFA, 2018), this high level of concentration could disrupt the previously efficient transmission of price changes from Norwegian producers to Portuguese consumers. Such consolidation may introduce barriers to the full and fair reflection of price movements throughout the supply chain, potentially creating inefficiencies that distort market dynamics. The focus of this study is to determine whether the increasing consolidation of retailers in Portugal has impacted the efficiency of the cod supply chain between these countries.

Often, economists assess market efficiency by analyzing the price transmission process (Assefa et al., 2015; von Cramon-Taubadel & Meyer, 2004); Price transmission refers to how changes in prices at one stage of the supply chain—such as the production or export level—are reflected at subsequent stages, including retail prices (von Cramon-Taubadel & Meyer, 2004). Ideally, in an efficient supply chain, price fluctuations at one stage should propagate quickly and fully to all other stages (Ankamah-Yeboah & Bronnmann, 2017). Moreover, price shocks at one stage should provoke proportional responses across the chain, regardless of whether prices rise or fall (Simioni et al., 2013; von Cramon-Taubadel & Meyer, 2004). However, when intermediaries wield significant market power or have significant adjustment costs, price transmission can become asymmetric, with price increases being passed through more quickly or fully than decreases (Oglend et al., 2022; Straume, Asche, & Oglend, 2024; Vavra & Goodwin, 2005).[2] Product characteristics can also contribute to this asymmetry (Frey & Manera, 2007).

Research on price transmission in seafood supply chains has gained traction in recent years (Acharjee et al., 2023; Ankamah-Yeboah & Bronnmann, 2017; Asche et al., 2002; Bukenya & Ssebisubi, 2015; Deb et al., 2022; Jaffry, 2004, 2007; Gizaw et al., 2021; Simioni et al., 2013, 2014) although firm-level data recently has allowed for even more detailed analysis of the roles of intermediaries (Oglend et al., 2022; Straume, Asche, & Oglend, 2024). Most of these studies focus on European markets. For example, Asche et al. (2007) investigated price transmission within the cod product supply chain between Norway and Portugal, and their findings indicate a generally complete price transmission. Ankamah-Yeboah and Bronnmann (2017) examined price transmission in the German value chains for Alaska pollack, cod, and salmon, finding that the degree of transmission varies by species and retailer.

Fernández-Polanco and Llorente (2015) investigated the Spanish market for fresh, unprocessed hake, anchovy, and mackerel, focusing on whether the supply was dominated by local or imported products. Their findings revealed that price transmission was absent along the supply chain for domestic seafood. In contrast, for imports, price transmission was evident, driven by the power exerted by traders over producers in the origin countries. Asche et al. (2014) analyzed price transmission along the value chain of fresh and smoked salmon from Norway to France, finding complete pass-through for fresh salmon but incomplete pass-through for smoked salmon. Similarly, Landazuri-Tveteraas et al. (2018) studied salmon products in the UK and French retail markets, showing that price transmission varies by product form, with higher transmission for less processed products. Building on this, Straume, Asche, Landazuri-Tveteraas, et al. (2024) extended the study by including more salmon products and expanding to additional markets—specifically the four largest European countries in terms of salmon consumption: France, Germany, Spain, and the UK—finding similar results. These findings emphasize the importance of considering product form when investigating price transmission.

Studies examining asymmetric price transmission in the seafood supply chain are limited. However, for some markets in the European Union, asymmetric price transmission has been documented. For example, Jaffry (2004) found asymmetric price transmission in the French hake market, driven by retailer market power. Simioni et al. (2013) documented similar patterns in the cod and salmon supply chains between import and retail markets in France. Ankamah-Yeboah and Bronnmann (2017) found price asymmetry in the German Alaska pollack, cod, and salmon value chains, though the strength of this relationship varied by species and retailer. Gizaw et al. (2021) also identified asymmetric price transmission in the fresh salmon supply chain from the export market of Norway to the retail markets of France and Spain but found no such transmission for smoked salmon. Overall, the articles reviewed above show that price transmission and asymmetry for fish products vary by species and product form, highlighting the need for further studies across different markets, products, and econometric methods.

The main objective of this study is to examine price transmission and asymmetry in the cod supply chain from Norway to Portugal. The analysis primarily focuses on the salted dried cod supply chain, as this is the main retail product form of cod in Portugal. Additionally, the supply chain of salted wet cod is analyzed to explore how price signals may be distorted at various processing stages and to examine price transmission between the export price of salted wet cod and the retail price of salted dried cod.[3] The study employs the non-linear autoregressive distributed lag (NARDL) model, as developed by Shin et al. (2014), as the main method. A key advantage of the NARDL approach is its ability to model both short- and long-run asymmetries through positive and negative partial sum decompositions of changes in the independent variables. Additionally, this method is flexible, allowing for the use of a mix of I(0) and I(1) processes, with the potential for cointegration among some I(1) variables.[4]

There are few studies that use the NARDL approach to analyze price transmission in food markets. Fousekis et al. (2016) applied it to the U.S. beef sector, while Rezitis (2019) investigated price transmission in Finland's dairy sector. To the best of our knowledge, only Bronnmann and Bittmann (2019) have applied the NARDL approach to seafood markets, specifically to study asymmetric price transmission in the German cod and herring markets.

The remainder of this paper is organized as follows: "An Overview of Cod Supply Chain from Norway to Portugal" section provides a brief overview of the cod supply chain between Norway and Portugal, followed by "Methodology" section, which discusses the methodology. "Data" section presents the data, "Empirical Results" section outlines the empirical results, and the final section offers a discussion and conclusion.

An overview of cod supply chain from Norway to Portugal

Norway is a leading producer and exporter of seafood, with cod being a significant component of its export portfolio (Seafood Council, Norwegian, 2023;

Straume, Asche, Oglend, et al., 2024). According to Seafood Council, Norwegian (2023), in 2022, Norway exported over 200 thousand tonnes of cod products.[5] Key export products included frozen cod, dried salted cod, also known as klipfish, and salted wet cod. Approximately 40% of Norway's cod production is processed into dried salted cod, which are then exported to international markets, primarily within the European Union. Major markets include Portugal, Denmark, the Netherlands, Spain, Italy, and France (Bjørndal et al., 2016; Seafood Council, Norwegian, 2023; Xie & Øystein, 2015).

Portugal stands out as a major destination; in 2022, it imported about one-third of Norway's total cod exports and 78% of the salted dried cod (Seafood Council, Norwegian, 2023).[6] In the Portuguese market, cod is primarily consumed as salted dried cod. According to EUMOFA (2018), three processors (Fjordlaks, Jangaard, Møre Codfish) account for almost 90% of Norwegian exports of salted dried cod to Portugal. Portuguese large-scale retailers are the main clients of Norwegian exporters, with the top three retailers (Continente, Pingo, and Intermarché) covering 80% of the market share for salted dried cod (EUMOFA, 2018).

While Portugal is a major importer of Norwegian salted dried cod products, it also produces its own salted dried cod using imported salted wet cod (mainly from Norway and, to a lesser extent, from China) or frozen cod imported mainly from Norway and Russia.[7] Lower production and labor costs are some of the explanations why Portugal chose to produce salted dried cod (EUMOFA, 2018). Despite this, however, the substantial rise in the cost of raw materials (including imported salted wet cod and frozen cod) in recent years has posed a challenge for domestic production, making it increasingly reliant on imports from Norway. Given this strong trade relationship between Norway and Portugal, one can anticipate significant price transmission along the cod supply chain between these two countries. Furthermore, literature suggests that intermediaries with significant market power along a commodity supply chain may strategically adjust prices (Ankamah-Yeboah & Bronnmann, 2017; Simioni et al., 2013). Consequently, the three major retailers in the Portuguese cod market are likely to exert considerable influence over both pricing and supply dynamics. This study, therefore, aims to investigate asymmetric price transmission along the cod supply chain from Norway's export market to the retail markets in Portugal.

Methodology

Following the standard approach in the literature (e.g., Asche et al., 2007, 2014; Landazuri-Tveteraas et al., 2018; Kinnucan & Forker, 1987;

Larsen & Kinnucan, 2009), the basic relationship in the empirical analysis of price transmission between the retail price ($p_{r,t}$) and export price ($p_{e,t}$) (expressed in log form) can be expressed as follows:

$$p_{r,t} = \beta_0 + \beta p_{e,t} + \varepsilon_t \tag{1}$$

where ε_t is the error term, assumed to be independently and identically distributed with a mean zero. The constant term β_0 captures the margin, while the parameter β, is interpreted as the elasticity of price transmission, indicates the degree of price transmission between the markets. When $\beta = 1$, price transmission is complete, meaning any change in export-level prices is fully reflected in retail prices. On the other hand, if $\beta = 0$, there is no relationship, indicating no price transmission. For values of $0 < \beta < 1$, there is a relationship between the prices, but the transmission is incomplete.[8]

The model presented in Equation (1) appears relatively simple and straightforward; however, its econometric estimation is often challenging. One challenge is that it creates a simultaneity problem because economic theory does not specify the direction of the relationship (or causality) between $p_{r,t}$ and $p_{e,t}$ (Fackler & Goodwin, 2001). To address this issue, empirical literature employs various strategies. One approach is to identify causality based on the specific characteristics of the market being studied. For instance, in agricultural product markets, it is commonly assumed that prices originate at the farm level and then propagate through wholesale to retail markets (e.g., Kinnucan & Forker, 1987). This assumption is often justified by the prevalence of supply shocks over demand shocks and the tendency of sellers to use fixed markup pricing. Another widely used approach is the weak exogeneity test, which helps determine whether a variable can be treated as exogenous in a multivariate framework (Asche et al., 2007). The weak exogeneity test can be performed using methods such as the Johansen likelihood cointegration test (Johansen, 1992; Johansen & Juselius, 1990). Additionally, some studies simply assume bidirectional price transmission and estimate the model in both directions to identify the relationship (Fackler & Goodwin, 2001). In this study, we rely on the weak exogeneity test to determine the direction of price transmission.

Another challenge in estimating Equation (1) is that it describes a static model, while price adjustment is a dynamic process (Fackler & Goodwin, 2001). This dynamic nature means that temporary deviations from the long-run equilibrium are common. Moreover, agricultural product prices frequently exhibit non-stationarity (Ardeni, 1989). Estimating Equation (1) with non-stationary price data can result in spurious findings, implying a relationship between prices that does not actually exist (Engle & Granger, 1987). A cointegration test provides a means to distinguish a true relationship from one that is spurious (Engle & Granger, 1987; Johansen & Juselius, 1990).

In this study, a non-linear ARDL (NARDL) bound testing approach to cointegration within a conditional error correction framework is used (Shin et al., 2014). The approach allows to test for both long-run and short-run asymmetries from the export price to retail price. Shin et al. (2014) developed the NARDL model based on the autoregressive distributed lag (ARDL) model, which is expressed as follows:

$$\Delta p_{r,t} = \alpha_0 + \rho p_{r,t-1} + \theta p_{e,t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta p_{r,t-j} + \sum_{j=0}^{q-1} \pi_j \Delta p_{e,t-j} + u_t \tag{2}$$

where $p_{r,t-j}$ and $p_{e,t-j}$ represent the j^{th} lags of the retail and export prices, respectively, u_t is an independently and identically distributed error term, Δ is difference operator, p and q represent lag lengths for retail and export prices, respectively. The long-run elasticity of price transmission β given in Equation (1) can then be expressed as $\beta = -\theta/\rho$.

The ARDL model assumes a linear relationship between prices. Consequently, if the data exhibit nonlinearity or asymmetry, such as due intermediaries market power, applying ARDL model may produce biased results. To develop NARDL model, Shin et al. (2014) decomposes the independent variable in the ARDL model (the export price in this case) into positive and negative partial sums, which is given as follows:

$$p^+_{e,t} = \sum_{j=1}^{t} \Delta p^+_{e,j-1} = \sum_{j=1}^{t} \max(\Delta p_{e,j}, 0)$$

$$p^-_{e,t} = \sum_{j=1}^{t} \Delta p^-_{e,j-1} = \sum_{j=1}^{t} \min(\Delta p_{e,j}, 0)$$

and write the long-run equilibrium relationship given in Equation (1) as follows:

$$p_{r,t} = \beta_0 + \beta^+ p^+_{e,t} + \beta^- p^-_{e,t} + v_t \tag{3}$$

where β^+ and β^- are the asymmetric long-run parameters associated with positive and negative changes in $p_{e,t}$, respectively.[9] Combining Equation (2) and (3), Shin et al. (2014) developed the NARDL model in error correction framework, which is given as follows:

$$\Delta p_{r,t} = \alpha_0 + \rho\ p_{r,t-1} + \theta^+ p^+_{e,t-1} + \theta^- p^-_{e,t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta p_{r,t-j}$$

$$+ \sum_{j=0}^{q-1} (\pi_j{}^+ \Delta p^+_{e,t-j} + \pi_j{}^- \Delta p^-_{e,t-j}) + \varepsilon_t \tag{4}$$

where the parameter $\beta^{+}(=\frac{-\theta^{+}}{\rho})$ and $\beta^{-}(=\frac{-\theta^{-}}{\rho})$. The parameters $\pi_j{}^{+}$ and $\pi_j{}^{-}$ capture the positive and negative short-run changes in $p_{e,t}$.

To implement the NARDL model in Equation (4) empirically, several key steps must be followed. First, unit root tests must be conducted to ensure that the variables $p_{r,t}$ and $p_{e,t}$ used in the empirical model are either stationary in level or in first difference, but not integrated of order two. Meaning that when estimating the ARDL model, it is essential to recognize that the price series are integrated of order zero, one, or both. However, the model is not applicable to price series integrated of order two (Pesaran et al., 2001). The Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1981) and the Perron test (Perron, 1997) are employed to check for stationarity in the individual price series.

Next the NARDL model specified in Equation (4) is estimated using the standard Ordinary Least Squares (OLS) technique. The lag length p and q are determined using the Akaike Information Criterion (AIC) to ensure the best model fit. The validity of the estimated model is then assessed through a series of diagnostic tests. The Lagrangean Multiplier (LM) test is used to assess serial correlation in the residuals. The null hypothesis states that there is no serial correlation, while the alternative hypothesis suggests the presence of serial correlation. The Breusch-Pagan (BP) test is used to test the null hypothesis of homoscedasticity against the alternative hypothesis of heteroscedasticity. Finally, the Jarque-Bera (JB) test is conducted to test the null hypothesis of normality of the residuals against the alternative hypothesis of non-normality.

The third step involves testing for the existence of an asymmetric cointegrating relationship between $p_{r,t}$, $p^{+}_{e,t}$ and $p^{-}_{e,t}$. The null hypothesis states that the coefficients of the lagged level the prices in Equation (4) are jointly equal to zero (i.e., $\rho = \theta^{+} = \theta^{-} = 0$). As noted by Pesaran et al. (2001) the null hypothesis can be tested by means of a modified F-test, denoted F_{PSS}, or for cases where certain classical assumptions are violated by means of a Wald-test, denoted W_{PSS}. The testing procedure relies on two critical bounds: the upper and the lower critical values. If the calculated F_{PSS} (or the W_{PSS}) exceeds the upper bound, the null hypothesis is rejected, indicating cointegration. If they fall below the lower bound, the null hypothesis cannot be rejected, suggesting a lack of cointegration. If they fall within the critical bounds, the result is considered inconclusive.

Another approach is to evaluate the null hypothesis of an asymmetric cointegrating relationship is using the t_{BDM} statistic (Banerjee et al., 1998), which is designed to test the null hypothesis of no cointegration ($\rho = 0$) against the alternative hypothesis of cointegration ($\rho < 0$). Like the other tests above, the t_{BDM} test utilizes two critical bounds: a lower bound and an upper bound. If the calculated value of the t_{BDM} statistic exceeds the upper bound, the null hypothesis is rejected. If it falls below the lower bound, the null hypothesis is not rejected. If the value falls between the bounds, the test results are inconclusive. If the null hypothesis of no (asymmetric) cointegration is rejected, further tests are conducted for long-run asymmetry and short-run asymmetry.

If the null hypothesis of no cointegration is rejected, the next step is to test whether the price transmission is symmetric or asymmetric in both the long run and short run. For long-run asymmetry, the null hypothesis of symmetry relationship (i.e., $-\theta^{+} = -\theta^{-}$) is tested. For short-run asymmetry the null hypothesis can take either the strong form or weak form. In the strong form (pairwise) symmetry requires $\pi_j^{+} = \pi_j^{-}$ for all $j = 1, \ldots, q-1$ whereas in the weak form (additive) short-run symmetry requires $\sum_{j=0}^{q-1} \pi_j{}^{+} = \sum_{j=0}^{q-1} \pi_j{}^{-}$. The Walda tests are employed to examine both the long-run and short-run asymmetries (Shin et al., 2014). If the null hypothesis of either long-run or short-run symmetry is rejected, then we can conclude that the price transmission is asymmetric.

Data

Retail prices in the Portuguese market were used to represent prices in downstream market, while the export prices from Norway were utilized to proxy the upstream market. The study spans the period from January 2011 to December 2022, with price data sourced from Europanel (2022) via the Norwegian Seafood Council (NSC), and exchange rates obtained from Statistics Norway (SSB). The selection of products and the study duration were influenced by the availability of data.

Table 1 provides descriptive statistics of the prices. Over the study period, the average export prices of the two cod product forms originating from Norway reveal a consistent pattern: salted dried cod consistently commands a higher mean value compared to salted wet cod. This higher export price for salted dried cod is justified by the additional processing and preservation costs incurred at the production level. However, at the retail level in Portugal, descriptive statistics indicate that salted wet cod is priced higher than salted dried cod. This is expected, as salted dried cod is the primary retail product in Portugal, making salted wet cod less accessible in the market. Even when available, the handling and storage requirements for salted wet cod contribute to higher prices. Being more perishable, salted

Table 1. Price statistics (in EU/kg), 2011–2022.

Products	Prices	Obs.	min	Max	Mean	St.Dev.
Salted dried cod	Export	140	4.27	10.85	6.81	1.45
	Retail	140	5.53	10.76	7.86	1.19
Salted wet cod	Export	140	2.85	7.68	4.88	1.07
	Retail	140	7.35	10.95	8.58	0.52

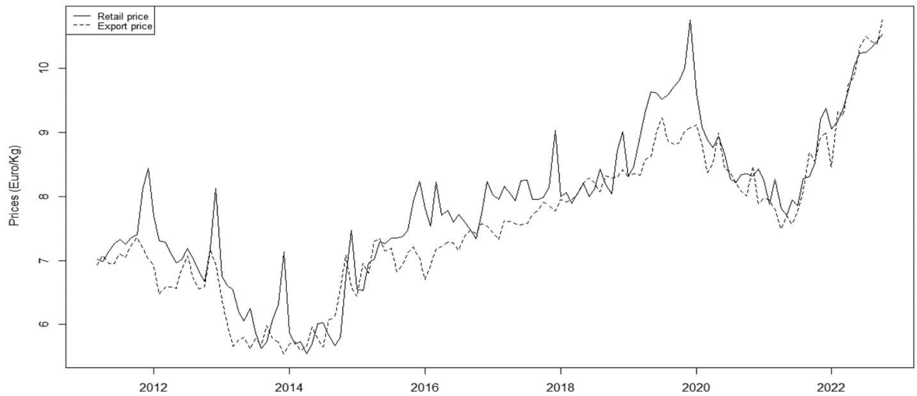

Figure 1. Export prices of salted dried cod from Norway & retail prices of salted dried cod in Portugal.

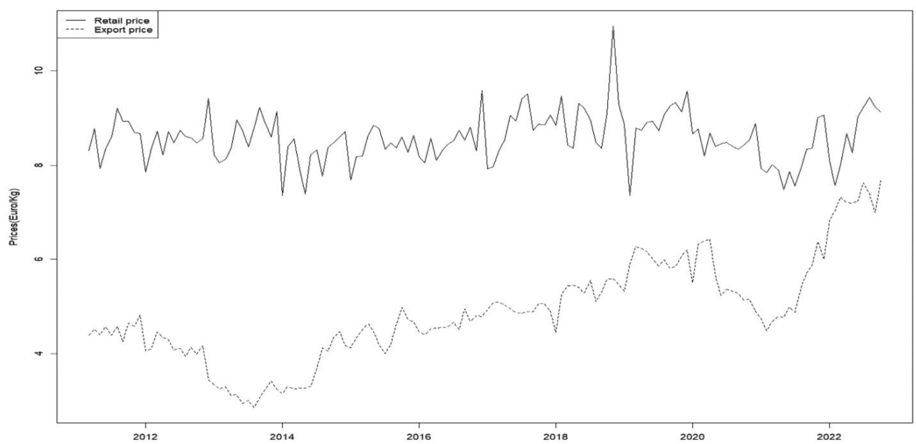

Figure 2. Export prices of salted wet cod from Norway & retail prices of salted wet cod in Portugal.

wet cod necessitates careful handling, refrigeration, and quicker distribution, all of which increase retail costs. These additional expenses are ultimately passed on to consumers, resulting in a higher retail price. In contrast, since salted dried cod undergoes extensive processing before export, retailers do not need to price it as high to maintain profitability (Figure 1).

Figure 1 show the plot of the export and retail prices of salted dried cod, while Figure 2 depicts the same for salted wet cod. The figures suggest that for salted dried cod, the retail price and export price closely track each other. Conversely, salted wet cod typically exhibit distinct behavior most of the time. Consequently, the price transmission along the supply chain of salted dried cod and salted wet cod is anticipated to exhibit different relationships.

Empirical results

The analysis begins with unit root tests on the price series, as detailed in Table 2, which includes results from the Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1981) and Phillips-Perron (PP) (Perron, 1997) tests. The results from both tests indicated that all price series, except for the retail price of salted wet cod, were non-stationary in their original levels but achieved stationarity after differencing, indicating they are integrated of order one. The retail price of salted wet cod was stationary at its original level, classifying it as integrated of order zero. Importantly, there is no evidence of integration of order two. These findings allow for the estimation of NARDL models to analyze price transmission processes along the supply chains of each cod product.[10]

The causal relationship between export and retail prices in each product chain was examined using the weak exogeneity test, with the results presented in Table 3. The findings indicate that within each cod product supply chain, the export price is exogenous, whereas the retail price is not. This suggests that export prices drive retail price dynamics, while retail prices do not influence export prices. These results align with the common assumption in agricultural product supply chain literature that prices often originate at the farm (export) level and then propagate to wholesale and retail markets (e.g., Kinnucan & Forker, 1987).

The NARDL model in Equation (4) was estimated for each product chain. The Akaike Information Criterion (AIC) suggesting an optimal lag order of $p = 2$ and $q = 1$ for all chains. The estimated results are presented in Table 4. The models were evaluated using various diagnostic tests (results are presented in the lower section of Table 4). The Lagrange

Table 2. Unit root tests.

		ADF test		PP test	
Products	Prices	Level	First differences	Level	First differences
Salted dried cod	Export	−2.42(1)	−12.40(0) **	−9.02(4)	−136.81**(4)
	Retail	−3.79(12)	−1.94(11) **	−13.52(4)	−120.46**(4)
Salted wet cod	Export	−2.75(1)	−13.10(0) **	−10.12(4)	−148.37(4) **
	Retail	−5.38(1) **	−16.72(0) **	−81.51(4) **	−151.16(4) **

Note: Asterisk ** denotes significance at 5% statistical level. Price series are expressed in logarithm. Numbers of lags in ADF and PP tests in parenthesis.

Table 3. Weak exogeneity tests from multivariate systems.

Supply chain	Export price	Retail price
Salted dried cod	0.46(0.500)	37.39***(0.000)
Salted wet cod	2.21(0.140)	30.42***(0.000)
Salted wet cod (Export) & Salted dried cod (Retail)	1.53(0.220)	36.16***(0.000)

Notes: Asterisk *** denotes significance at 1% statistical level. Numbers in parenthesis are p-values. Weak exogeneity test is performed using Johansen likelihood test (see Johansen (1992) for more on weak exogeneity test).

Table 4. Estimates of non-linear ARDL model in the cod products supply chain.

Variables	Salted dried cod	Salted wet cod	Salted wet cod(export) $\rightarrow$ Salted dried (retail)cod
const	0.96***	1.33***	0.75***
$p_{r,t-1}$	−0.48***	−0.60***	−0.37***
$p^{+}_{e,t-1}$	0.36***	0.09***	0.27***
$p^{-}_{e,t-1}$	0.37***	0.12***	0.28***
$\Delta p_{r,t-1}$	0.04	−0.03	−0.002
$\Delta p_{r,t-2}$	−0.14**	0.03	−0.16*
$\Delta p^{+}_{e,t}$	−0.21	−0.04	−0.05
$\Delta p^{-}_{e,t}$	− 0.21	0.002	−0.23*
$\Delta p^{+}_{e,t-1}$	0.08	−0.21	−0.28
$\Delta p^{-}_{e,t-1}$	0.16	0.27	0.31**
R^2	0.41	0.35	0.39
Lagrangean-multiplier			
Lag 1	0.08(0.772)	0.78(0.375)	0.002(0.967)
Lag 2	0.98(0.613)	1.34(0.512)	2.13(0.344)
Lag 3	1.01(0.799)	2.74(0.433)	2.14(0.545)
Lag 10	9.41(0.493)	10.39(0.407)	11.99(0.285)
Breusch-Pagan (B-P) test	26.66(0.002)	9.31(0.409)	28.62(0.0008)
Jarque-Bera (JB) test	45.92(0.000)	34.26(0.000)	17.53(0.000)
Bound cointegration test			
F_{PSS}	7.92***	8.25***	7.03***
W_{PSS}	23.76***	24.76***	21.09***
t_{BDM}	−4.86***	−5.49***	−5.50***
Long-run coefficient			
β^{+}	0.75***	0.15***	0.73***
β^{-}	0.77***	0.20***	0.76***
Asymmetry cointegration test			
Long-run	1.38(0.242)	2.66(0.190)	0.63(0.428)
Short run	0.06(0.802)	2.36 (0.127)	1.11(0.294)

Note: ***, ** and * denote significance at 1%, 5% and 10% levels, respectively. Numbers in bracket in the diagnostic and asymmetric cointegration tests are p-values. For bound tests: for k = 1 and at the 1% (5%) level of significance, the pair of critical values (bounds) for the FPSS, the WPSS and the tBDM statistics are 6.84 to 7.84 (4.94 to 5.73), 14.11 to15.63 (9.86 to11.52) and −3.43 to −3.82 (−2.86 to −3.22), respectively. The critical values have been obtained from Pesaran et al. (2001).

Multiplier (LM) test indicated no serial correlation, while the Breusch-Pagan (BP) test confirmed the presence of heteroskedasticity in the salted dried cod model and the model analyzing the relationship between the export price of salted wet cod and the retail price of salted dried cod. Consequently, heteroskedasticity-robust standard errors were employed. Additionally, the Jarque-Bera (JB) test suggested deviations from normality in the residuals across all models. Furthermore, the Cumulative Sum (CUSUM) test was conducted for each estimated model to assess their stability. The results indicated that the relationships specified in the models remained stable throughout the study period. The corresponding CUSUM plots are presented in Figures 3 through 5.

The results of the test statistics for bound cointegration are provided at the bottom of Table 4. The results from the different tests (i.e., F_{PSS}, W_{PSS} and t_{BDM}) reject the null hypothesis of no cointegration ($\rho = \theta^{+} = \theta^{-} = 0$) at any conventional statistical significance level across the value chains investigated. However, the application of Wald tests to assess the presence of asymmetric transmission did not yield evidence to reject the null hypothesis of symmetry in either the long run or short run for any product

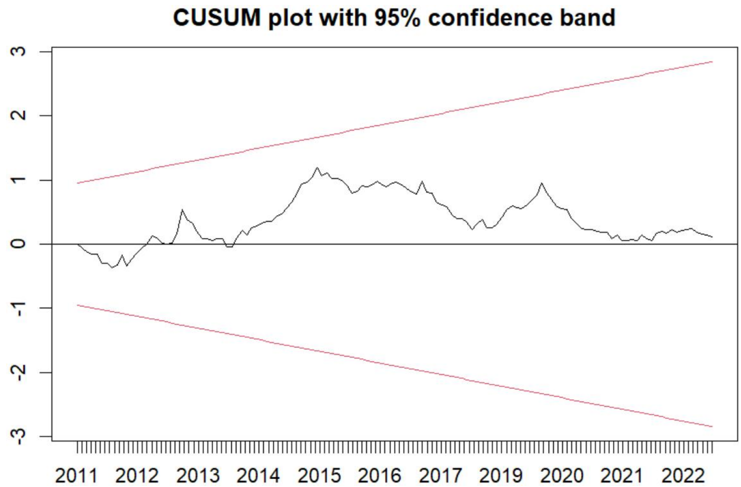

Figure 3. Cumulative sum (CUSUM) test on the salted dried cod model.

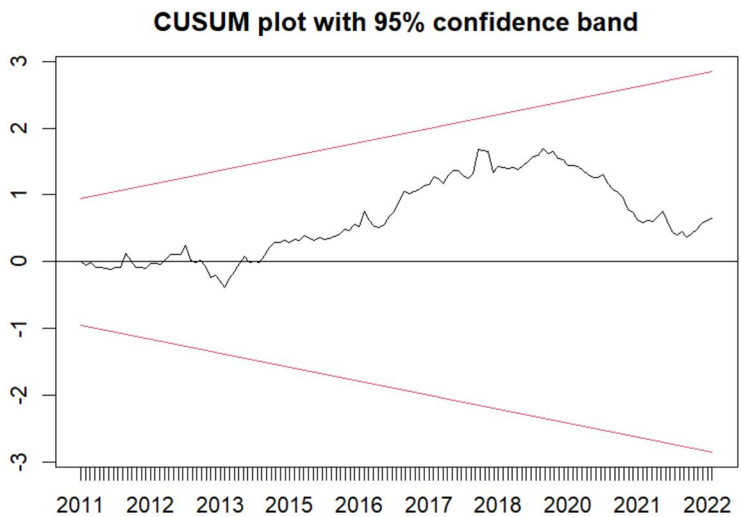

Figure 4. Cumulative sum (CUSUM) test on the salted wet cod model.

supply chain at conventional statistical significance levels.[11] Therefore, it can be reasonably concluded that asymmetric price transmission does not play a significant role in the cod products price relationship between the Norwegian export market and the Portuguese retail market.

Hence, the findings indicate that retail market prices in Portugal respond symmetrically to both increases and decreases in Norwegian export prices, regardless of the cod product form. This symmetric price transmission may suggest an efficient cod supply chain (e.g., von Cramon-Taubadel & Meyer, 2004), where market forces, rather than intermediary manipulation, govern price changes. The absence of evidence for price distortion by

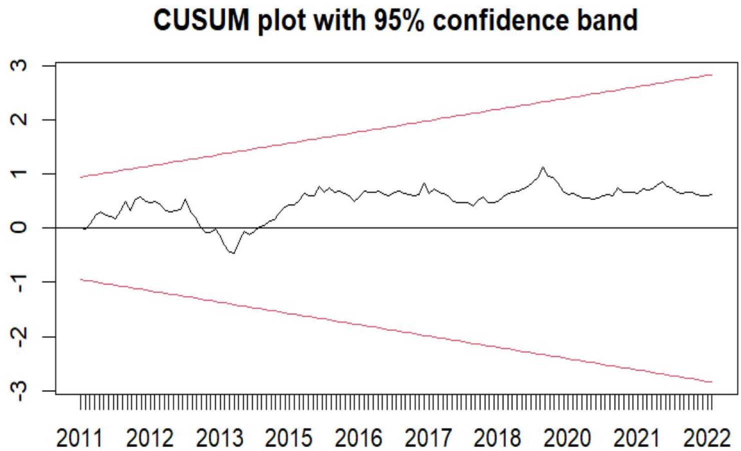

Figure 5. Cumulative sum (CUSUM) test on the model between the export price of salted wet cod & retail price of salted dried cod.

intermediaries contradicts concerns about potential profit-maximizing behaviors that could harm producers and consumers (e.g., Ankamah-Yeboah & Bronnmann, 2017; Simioni et al., 2013). Consequently, this efficient pass-through of prices demonstrates that competitive dynamics are at play, ensuring that both price hikes and reductions are fairly reflected in the retail market. This insight is valuable for policymakers and industry stakeholders, indicating that regulatory intervention to curb price manipulation may not be necessary, allowing a focus on enhancing other facets of the supply chain, such as improving quality or reducing costs.

Discussion and conclusion

In recent years, there has been growing interest in examining price adjustments within seafood value chains, driven by evolving market dynamics and the increasing consolidation of intermediaries. This study examines short- and long-run asymmetries in the supply chains of salted dried cod and salted wet cod between Norway's export market and Portugal's retail market, including the dynamics between the export price of salted wet cod and the retail price of salted dried cod. To explore the asymmetric cointegration, the NARDL bounds testing approach developed by Shin et al. (2014) is employed. Although this model has been applied to various commodity supply chains (e.g., Fousekis et al., 2016; Rezitis, 2019), the seafood sector remains underexplored, with Bronnmann and Bittmann (2019) being the only study to apply it to seafood markets. This study builds on this limited body of research by extending the model to analyze asymmetric price transmission in new products and markets. Furthermore, studies examining price asymmetry in the seafood value chain, especially using on disaggregated products, are limited.

The findings of this study are notable. First, they demonstrate that in cod product supply chains, prices are determined at the export market and then propagate to the retail market, suggesting that the export market plays a leading role. In particular, price changes at the export market in Norway influence retail prices in Portugal, while the reverse does not hold. This result aligns with previous studies (e.g., Asche et al., 2007 and 2014a). Additionally, the study shows that price transmission is faster and more efficient for highly processed products than for less processed ones. Specifically, the supply chain for salted dried cod exhibits quicker and more complete price transmission compared to salted wet cod. This outcome is expected, as salted dried cod is exported from Norway as a final consumer product and directly enters the retail market for consumption in Portugal.

In contrast, salted wet cod exported from Norway is used as an input for producing salted dried cod in Portugal. Hence, processing salted wet cod into the final salted dried cod product involves additional inputs, such as labor, capital, marketing, and packaging costs (Landazuri-Tveteraas et al., 2018). These non-raw material costs diminish the impact of the salted wet cod price on the final consumer price of salted dried cod. Similar differences in price transmission by processing degree have been found in previous studies (Asche et al., 2014; Kidane et al., 2021; Landazuri-Tveteraas et al., 2018).

Moreover, the findings indicate symmetric price adjustments in both the long and short run across all investigated cod supply chains. This indicates that price shocks at one stage of the supply chain consistently pass through to subsequent stages with uniform speed and magnitude. Surprisingly, despite recent literature highlighting the consolidation of intermediaries within the broader seafood supply chain (Ankamah-Yeboah & Bronnmann, 2017; Fernández-Polanco & Llorente, 2015) and particularly in the retail cod market in Portugal (EUMOFA, 2018), this study found no evidence of disproportionate price adjustments by intermediaries. This suggests that even with increasing market concentration, the cod supply chain between Norway and Portugal remains efficient, with no observable asymmetries in price transmission.

Despite the findings of this study, however, several similar previous empirical investigations have documented asymmetric price transmission in different European seafood markets. For instance, Jaffry (2004) reported price asymmetry along the supply chain of fresh whole hake between auction and retail markets in France. Similarly, Simioni et al. (2013) identified asymmetries in the cod and salmon value chains from ex-vessel to retail levels. Ankamah-Yeboah and Bronnmann (2017) observed asymmetric price transmission in the supply chains of Alaska pollock, cod, and salmon in Germany. Gizaw et al. (2021) also found asymmetry in the fresh salmon chain, though none was present in the smoked salmon chain between Norway and France. However, unlike previous studies that often focus on aggregate products like cod and salmon, this study analyzes disaggregated cod products, which likely explains the absence of asymmetry in the findings. As shown by Gizaw et al. (2021) and Landazuri-Tveteraas et al. (2018), price transmission or asymmetry in aggregate products may level out when examined at a more detailed, disaggregated level. However, more comprehensive studies may be needed to gain a clearer understanding of price asymmetry in these markets.

Looking at the international empirical studies on asymmetric price transmission in seafood markets reveals mixed results. For instance, Singh et al. (2015) found mixed outcomes in their investigation of price asymmetry along the supply chains of shrimp, seabass, catfish, and tilapia between farm, wholesale, and retail markets in Thailand. Similarly, Sapkota et al. (2015) examined five species, including hilsa, catla, pangas, rohu, and tilapia in Bangladesh and observed inconsistent price transmission between wholesale and retail levels. Similarly, Acharjee et al. (2023) explored price asymmetry along the supply chains of Rui, catla, tilapia, and pangas in Bangladesh and found varying results across the farm, wholesale, and retail stages. In contrast, Bukenya and Ssebisubi (2015) identified a clear asymmetric relationship in the catfish supply chain between ex-vessel, wholesale, and retail markets in Uganda. These varied findings suggest that the degree of price asymmetry may depend on specific factors such as species type, market structure, and regional economic conditions.

While this study offers valuable insights into price transmission within the cod supply chain, future research could expand by examining other seafood products, particularly by disaggregating categories like fresh, frozen or filleted products as price transmission and asymmetry for fish products can vary based on species and product form (Landazuri-Tveteraas et al, 2018; Straume, Asche, Landazuri-Tveteraas, et al., 2024). Using consistent methodologies would ensure comparability across studies. Furthermore, analyzing different markets could help determine if the findings apply to a wider range of seafood value chains. Cross-regional studies involving various species could also provide a deeper understanding of the factors driving price asymmetry in seafood markets.

In conclusion, the findings of this study align closely with those of Asche et al. (2007), reaffirming the presence of efficient price transmission within the supply chains of salted dried and salted wet cod, from Norway's export market to Portugal's retail market. Similarly, efficient price transmission is observed between the export price of salted wet cod and the retail price of salted dried cod. This efficiency suggests that intermediaries do not disproportionately adjust prices in response to changes at the export price. Consequently, concerns about potential price manipulation by intermediaries in the cod supply chain appear to be largely unfounded.

Notes

1. The author(s) would like to thank the journal editor Dr. Frank Asche for his insightful comments and suggestions here and in several other subsequent paragraphs.
2. Oglend et al. (2022) show how contracts with imperfect information can cause delays in the updating of prices, and Straume et al. (2024a) show how large exporters have more flexible than smaller exporter in the supply chains for salmon.
3. I thank the anonymous reviewer for highlighting the investigation of price transmission between the export market for salted wet cod and the retail price of salted dried cod.
4. "I(0)" refers to a time series that is stationary, meaning its statistical properties do not change over time. "I(1)" refers to a time series that becomes stationary only after differencing once.
5. While most of the landings are wild cod, there is also aquaculture production (Bronnmann et al., 2023; Pettersen et al., 2023).
6. Portugal has a long history of fishing cod but the introduction of the exclusive economic zone (EEZ) in 1977 imposed by many costal states reduced drastically the cod harvest by the Portuguese fleet and increased Portuguese imports of cod products (Bjørndal et al., 2016).
7. Portugal is the only country other than Norway which produces salted dried cod at industrial scale (Asche et al., 2007).
8. While the above model is the standard specification when only price data are available, the constant term β_0, which captures the margin, can be made a function of different costs variables (for example marketing cost) if such data is available (Asche et al., 2007; Kinnucan & Forker, 1987). In this study, however, marketing costs are assumed constant and included in the intercept term β_0.
9. The use of positive and negative sums is considered with zero threshold. As noted by Granger and Yoon (2002) the zero threshold makes the interpretation of the estimation results easy and natural.
10. When estimating ARDL model, it's important to note that the price series could be integrated of order zero, one, or both. However, it is not applicable to price series integrated at order two (e.g., Pesaran et al., 2001).
11. In the case of short-run asymmetry, the null hypothesis tested is the weak form (additive) short-run symmetry, i.e., $\sum_{j=0}^{q-1} \pi_j^{+} = \sum_{j=0}^{q-1} \pi_j^{-}$.

Acknowledgment

The author would like to thank the Norwegian Seafood Council for providing the cod data.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

References

Acharjee, D. C., Kamal, G., Alam, M., Haque, M., Sayem, S. M., & Hossain, M. I. (2023). Price transmission asymmetry of selected fishes in Bangladesh: An econometric and value chain analysis. *Aquaculture Economics & Management*, *27*(4), 638–665. https://doi.org/10.1080/13657305.2022.2163720

Almeida, C., Karadzic, V., & Vaz, S. (2015). The seafood market in Portugal: Driving forces and consequences. *Marine Policy*, *61*, 87–94. https://doi.org/10.1016/j.marpol.2015.07.012

Ankamah-Yeboah, I., & Bronnmann, J. (2017). Asymmetries in import-retail cost pass-thorugh:an analysis of the seafood value chain in Germany. *Aquaculture Economics & Management*, *21*(1), 71–87. https://doi.org/10.1080/13657305.2016.1262478

Ardeni, P. G. (1989). Does the law of one price really hold for commodity prices? *American Journal of Agricultural Economics*, *71*(3), 661–669. https://doi.org/10.2307/1242021

Asche, F., Dahl, R. E., Valderrama, D., & Zhang, D. (2014a). Price transmission in new supply chains – the case of Salmon in France. *Aquaculture Economics & Management*, *18*(2), 205–219. https://doi.org/10.1080/13657305.2014.903309

Asche, F., Flaaten, O., Isaksen, J. R., & Vassdal, T. (2002). Derived demand and relationships between prices at different levels in the value chain: a note. *Journal of Agricultural Economics*, *53*(1), 101–107. https://doi.org/10.1111/j.1477-9552.2002.tb00008.x

Asche, F., & Gordon, D. V. (2015). Demand characteristics for imported cod products in Portugal: Frozen, salted & dried and salted. Working Paper 09/15, SNF Center for Applied Research.

Asche, F., Menezes, R., & Dias, J. F. (2007). Price transmission in cross boundary supply *chains*. *Empirica*, *34*(5), 477–489. https://doi.org/10.1007/s10663-007-9045-0

Asche, F., Yang, B., Gephart, J. A., Smith, M. D., Anderson, J. L., Camp, E. V., Garlock, T. M., Love, D. C., Oglend, A., & Straume, H.-M. (2022). China's seafood imports—not for domestic consumption? *Science (New York, N.Y.)*, *375*(6579), 386–388. https://doi.org/10.1126/science.abl4756

Assefa, T. T., Meuwissen, M. P. M., & Lansink, G. J. M. (2015). Price volatility transmission in food supply chains: a literature review. *Agribusiness*, *31*(1), 3–13. https://doi.org/10.1002/agr.21380

Banerjee, A., Dolado, J., & Mestre, R. (1998). Error correction mechanism tests for cointegration in a single equation framework. *Journal of Time Series Analysis*, *19*(3), 267–283. https://doi.org/10.1111/1467-9892.00091

Bjørndal, T., Brasao, A., Ramos, J., & Tusvik, A. (2016). Fish processing in Portugal:An industryin expansion. Working Paper, Center for applied research at NHH.

Bronnmann, J., Asche, F., Pettersen, I. K., & Sogn-Grundvåg, G. (2023). Certify or not? The effect of the MSC certification on the ex-vessel prices for Atlantic cod in Norway. *Ecological Economics*, *212*, 107940. https://doi.org/10.1016/j.ecolecon.2023.107940

Bronnmann, J., & Bittmann, T. (2019). Asymmetric adjustment of retail cod and herring prices in Germany: A NARDL approach. *Marine Policy*, *106*(2019), 103513. https://doi.org/10.1016/j.marpol.2019.103513

Bukenya, J. O., & Ssebisubi, M. (2015). Price transmission and threshold behavior in the African catfish supply chain in Uganda. *Journal of African Business*, *16*(1-2), 180–197. https://doi.org/10.1080/15228916.2015.1035598

Deb, P., Dey, M. M., & Surathkal, P. (2022). Price transmission and market integration of Bandladish fish markets. *Aquaculture*, *560*(2022), 738592. https://doi.org/10.1016/j.aquaculture.2022.738592

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, *49*(4), 1057–1072. https://doi.org/10.2307/1912517

Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction: Representation, estimation and testing. *Econometrica*, *55*(2), 251–276. https://doi.org/10.2307/1913236

EUMOFA. (2018). Price structure in the supply chain from Norway to Portugal, case study of *EUMOFA*. Dried salted cod in Norway. https://eumofa.eu/documents/20178/113218/Cod+in+NO_EN.pdf?

Europanel. (2022). Data file. http://www.europanel.com/

Fackler, P. L., & Goodwin, B. K. (2001). Spatial price analysis. In Gardner, B., & Rausser, G. (Eds.) *Handbook of agricultural economics* (pp. 971–1024). Elsevier Science B.V.

Fernández-Polanco, J., & Llorente, I. (2015). Price transmission in the Spanish fresh wild fish market. *Aquaculture Economics & Management*, *19*(1), 104–124. https://doi.org/10.1080/13657305.2015.994238.

Food and Agriculture Organization. (2008). *Fishery and aquaculture statistics 2008. Statistics and Information Service of the Fisheries and Aquaculture Department, FAO Yearbook*. Food and Agriculture Organization.

Fousekis, K. P., Katrakilides., & E., Trachanas. (2016). Vertical price transmission in the US beef sector: evidence from the nonlinear ARDL model. *Economic Modelling*, *52*, 499–506.

Frey, G., & Manera, M. (2007). Econometric models of asymmetric price transmission. *Journal of Economic Surveys*, *21*(2), 349–415. https://doi.org/10.1111/j.1467-6419.2007.00507.x

Gizaw, D., Myrland, Ø., & Xie, J. (2021). Asymmetric price transmission in a changing food supply chain. *Aquaculture Economics & Management*, *25*(1), 89–105. https://doi.org/10.1080/13657305.2020.1810172

Granger, Clive W. J. and Yoon, Gawon, Hidden Cointegration (January 2002). U of California, Economics Working Paper No. 2002-02, Available at SSRN: https://ssrn.com/abstract=313831 or http://dx.doi.org/10.2139/ssrn.313831

Jaffry, S. (2004). Asymmetric price transmission: A case study of the French Hake value chain. *Marine Resource Economics*, *19*(4), 511–523. https://doi.org/10.1086/mre.19.4.42629450

Johansen, S. (1992). Testing weak exogeneity and the order of cointegration in UK money demand data. *Journal of Policy Modeling*, *14*(3), 313–334. https://doi.org/10.1016/0161-8938(92)90003-U

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration. *Oxford Bulletin of Economics and Statistics*, *52*(2), 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kinnucan, H. W., & Forker, O. D. (1987). Asymmetry in farm-retail price transmission for major dairy products. *American Journal of Agricultural Economics*, *69*(2), 285–292. https://doi.org/10.2307/1242278

Landazuri-Tveteraas, U., Asche, F., Gordon, D. V., & Tveteraas, S. L. (2018). Farmed fish to supermarket: Testing for price leadership and price transmission in the salmon supply chain. *Aquaculture Economics & Management*, *22*(1), 131–149. https://doi.org/10.1080/13657305.2017.1284943

Larsen, T. A., & Kinnucan, H. W. (2009). The effect of exchange rates on international marketing margins. *Aquaculture Economics & Management*, *13*(2), 124–137. https://doi.org/10.1080/13657300902885220
Oglend, A., Asche, F., & Straume, H. M. (2022). Estimating pricing rigidities in bilateral transactions markets. *American Journal of Agricultural Economics*, *104*(1), 209–227. https://doi.org/10.1111/ajae.12230
Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy*, *108*(3), 466–502. https://doi.org/10.1086/262126
Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics*, *80*(2), 355–385. https://doi.org/10.1016/S0304-4076(97)00049-3
Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the anlysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616
Pettersen, I. K., Asche, F., Bronnmann, J., Sogn-Grundvåg, G., & Straume, H. M. (2023). Is capture-based aquaculture viable? The case of Atlantic cod in Norway. *Aquaculture*, *572*, 739520. https://doi.org/10.1016/j.aquaculture.2023.739520
Purcell, S. W., Crona, B. I., Lalavanua, W., & Eriksson, H. (2017). Distribution of economic returns in small-scale fisheries for international markets: a value chain analysis. *Marine Policy*, *86*, 9–16. https://doi.org/10.1016/j.marpol.2017.09.001
Rezitis, A. N. (2019). Investigating price transmission in the Finnish dairy sector: an asymmetric NARDL approach. *Empirical Economics*, *57*(3), 861–900. https://doi.org/10.1007/s00181-018-1482-z
Sapkota, P., Dey, M. M., Alam, M. F., & Singh, K. (2015). Price transmission relationships along the seafood value chain in Bangladesh: Aquaculture and capture fisheries. *Aquaculture Economics & Management*, *19*(1), 82–103. https://doi.org/10.1080/13657305.2015.994237
Seafood Council, Norwegian. (2023). Norway's seafood exports worth Nok 151.4 billion in 2022, https://en.seafood.no/news-and-media/news-archive/norways-seafood-exports-worth-nok-151.4-billion-in-2022/
Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modeling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In *Festschrift in honor of Peter Schmidt* (pp. 281–314). Springer.
Simioni, M., Gonzales, F., Guillotreau, P., & Le Grel, L. (2013). Detecting asymmetric price transmission with consistent threshold along the fish supply chain. *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie*, *61*(1), 37–60. https://doi.org/10.1111/j.1744-7976.2012.01257.x
Singh, K., Dey, M. M., Laowapong, A., & Bastola, U. (2015). Price transmission in Thai aquaculture product markets: An analysis along value chain and across species. *Aquaculture Economics & Management*, *19*(1), 51–81. https://doi.org/10.1080/13657305.2015.994236
Straume, H. M., Asche, F., Landazuri-Tveteraas, U., Misund, B., Pettersen, I. K., & Zhang, D. (2024). Product forms and price transmission in major European salmon markets. *Aquaculture*, *582*, 740508. https://doi.org/10.1016/j.aquaculture.2023.740508
Straume, H. M., Asche, F., & Oglend, A. (2024). Intermediaries in Norwegian salmon exports. *Aquaculture*, *581*, 740437. https://doi.org/10.1016/j.aquaculture.2023.740437
Straume, H. M., Asche, F., Oglend, A., Gaasland, I., Pettersen, I. K., & Sogn-Grundvåg, G. (2024). The structure of Norwegian seafood trade. *Marine Policy*, *159*, 105921. https://doi.org/10.1016/j.marpol.2023.105921

Svanidze, M., Ólafsdóttir, G., Đurić, I., & Thakur, M. (2023). Price relationships along the Norwegian salmon value chains: A comparative study of the leading consumption market in France and the largest processing industry in Poland. *Aquaculture Economics & Management*, *27*(3), 382–404. https://doi.org/10.1080/13657305.2022.2104403

Vavra, P., & Goodwin, B. K. (2005). Analysis of price transmission along the food chain, OECD Food. Agriculture and Fisheries Working Paper No. 3, OECD Publishing.

von Cramon-Taubadel, S., & Meyer, J. (2004). Asymmetric price transmission: A survey. *Journal of Agricultural Economics*, *55*(3), 581–611. https://doi.org/10.1111/j.1477-9552.2004.tb00116.x

Xie, J., & Øystein, M. (2015). Challenges of the Norwegian Salted Fish Industry in the Spanish Market. *Nordic-Iberian Cod Value Chains: Explaining salted fish trade patterns*, (pp. 137–153).