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An Analysis of the Norwegian Cod Sector

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Abstract

In this paper we note that when there is only one variable factor in the intermediaries' production technology, prices will move proportional to each other over time. This is also the only general condition under which the elasticity of price transmission is equal to one, so that retail price signals are perfectly transmitted to primary product producers and vice versa. This allows a test of whether derived demand elasticities contain information about consumer elasticities using only prices. An empirical analysis is carried out for the Norwegian cod sector. Since prices are found to be nonstationary, cointegration tests are used to test for price proportionality.

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1. Introduction

A problem in applied demand analysis is often that data are not available at the level for which we would like to conduct our analysis. In particular, production data, wholesale data, export data and import data is often readily available, while retail data are not. An important issue is then what information the available data can give us about consumer demand. The literature on derived demand indicates that in general, it is rather unlikely that consumer demand elasticities and derived demand elasticities can coincide (Hicks, 1957; Gardner, 1975; Wohlgenant, 1989). This is to a large extent founded on the substitution possibilities intermediaries have between different input factors. For instance, an intermediary for an agricultural product is thought to be able to respond to changes in farm prices by changing the market effort. Hence, the product purchased by the consumer is a composite of the agricultural good and the marketing effort by the intermediaries.

For many agricultural and seafood products, the primary product makes up a substantial part of the cost of the final product. Moreover, even when the marketing cost is substantial, it is often not unreasonable to argue that these costs are regarded as fixed by the intermediaries. If this is the case, one might argue that markup pricing is the norm for the intermediaries, where the markup is the portion of the price that the seller adds to variable cost in order to cover overheads and yield a net profit. This is important, since if the intermediaries use markup pricing, the demand elasticities for the consumers and intermediaries will coincide, and hence, one can use lower level data to gain information about consumer demand. Furthermore, one can test whether this is appropriate using only price data, instead of modelling a system with demand and supply equations. Since price data is more available than quantity data, in particular at the retail level, this is important in applied work.

Recently, most price series have been shown to be nonstationary.[1] This implies that ordinary statistical tools in general cannot be used when analysing relationships between price series. In particular, normal inference theory breaks down. However, cointegration analysis provides appropriate tools for this kind of data. This will be used in this study to investigate the relationship between the ex. vessel price for cod in Norway, and the prices for the three main uses, domestic fresh consumption, exported dried salted cod, and exported frozen fillets. We will show that a test similar to tests of the Law of One Price can be used to determine whether the ex. vessel price can be used when estimating demand at the higher levels.[2]

This paper will be organised as follows. A brief discussion about derived demand is given in Section 2. A background on the industry is given in Section 3 and a discussion of the data is provided in Section 4. The cointegration tests are presented in Section 5, before the empirical analysis is reported in Section 6. In Section 7, a discussion of the demand for cod is provided and some concluding remarks are given in Section 8.

2. Derived demand

We will in the following use the approach of Hicks (1957) and Gardner (1975) to derived demand, and assume that the intermediaries technology is characterised by constant returns to scale. While we lose some generality as shown by Wohlgenant (1989), this greatly simplify the analysis. Moreover, for intermediaries between a primary producer and the consumer, constant returns to scale is often not an unreasonable assumption.

[1] Examples related to seafood include Gordon, Salvanes and Atkins (1993), Bose and McIlgrom (1996), Gordon and Hannesson (1996), Asche, Salvanes and Steen (1997), Asche and Sebulonsen (1998), Asche, Bremnes and Wessells (1999), Jaffry, Pascoe and Robinson (1999).

[2] Using a similar approach, cointegration tests have been used when investing market integration in a number of studies. Examples related to seafood include Gordon, Salvanes and Atkins (1993), Bose and McIlgrom (1996), Gordon and Hannesson (1996), Asche, Salvanes and Steen (1997), Asche and Sebulonsen (1998), Asche, Bremnes and Wessells (1999).

In the case where the intermediaries' production technology uses two inputs, a primary product *a* and marketing *b*, and is characterised by constant returns to scale, the relationship between the derived demand own-price elasticity for input *a*, E_a, and the consumer demand own-price elasticity η, may be expressed as (Hicks, 1957, p. 244; Gardner, 1975);

$$E_a = \frac{\eta\sigma + e_b(S_a\eta - S_b\sigma)}{e_b + S_a\sigma - S_b\eta} \tag{1}$$

where σ is the elasticity of substitution between the two inputs, e_b is the supply elasticity for input *b*, and S_a and S_b are the cost shares for inputs *a* and *b* respectively. The derived demand elasticity will be less elastic than the consumer demand elasticity if $\sigma < |\eta|$, it will be more elastic if $\sigma > |\eta|$ and it will be equal to the consumer demand elasticity if $\sigma = |\eta|$. In general, these relationships will not be stable since elasticities are functions of prices and quantities. Hence, even if the condition $\sigma = |\eta|$ holds at one point, one will not expect it to hold for other price and quantity realisations. Equation (1) implies that the intermediary will respond to price changes at farm or retail level partly by changing the demand for the primary product, and partly by adjusting marketing effort. The changes in marketing effort will distort the signal from the retail level to the farm lever and vice versa, and is therefore the reason why the derived demand elasticity does not coincide with the retail demand elasticity.

Since it is the interaction between the primary product and marketing factor that cause the difference in the two elasticities, one response in the literature has been to assume that the relationship between the retail and derived demand elasticities are linear (George and King, 1971). The relationship is then given as

$$E_a = \eta E_T\,. \tag{2}$$

where E_T is the elasticity of price transmission. The elasticity of price transmission is the elasticity of the consumer price with respect to the input factor price.[3] This assumption makes the relationship between the retail demand and derived demand elasticities proportional, but in general they will not be equal. This will only happen when the price transmission is perfect, i.e. when the elasticity of price transmission is equal to 1. Moreover, Gardner (1975) shows that this expression is correct only when the intermediaries' production technology is characterised by fixed factor proportions (i.e., the elasticity of substitution is zero). Equation (1) will then reduce to;

$$E_a = \frac{e_b S_a \eta}{e_b - S_b \eta}. \tag{3}$$

Note that in this case the derived demand elasticity in general will be less elastic than the consumer demand elasticity as $0 = \sigma < |\eta|$. This implies that the elasticity of price transmission is less then one, so that shocks in primary prices are only partly reflected in consumer prices.[4]

An interesting question is whether the derived demand elasticity will equal the consumer demand elasticity under any other conditions than $\sigma = |\eta|$. The answer is yes, if the intermediaries' production technology may be represented with only one variable input. If S_a is equal to one and S_b equal to zero, it is easily seen that equation (1) reduce to

$$E_a = \eta. \tag{4}$$

Since equation (2) and (3) are special cases of equation (1), this is true also for these equations, implying that the elacticity of price transmission will be 1 only under two conditions; when $\sigma = |\eta|$, or when the production technology can be regarded as having only one input. Of

[3] Although the elasticity of price transmission does not have to be constant, it is in general assumed to be constant and is often estimated as a single parameter (see e.g. Kinnucan and Forker, 1987).
[4] This is consistent with the common observation that price volatility tends to be less at the retail level relative to the producer level.

these two condition only the last one will in general hold for all price levels.

The condition that an intermediary has a production technology with only one variable input may seem restrictive, since it implies that all marketing inputs are treated as fixed costs. For many retailers, wholesalers and light processing activities, a production technology with only one variable input factor might still be a reasonable description of their short-run production technology. A supermarket, for instance, is operating in a given building with a fairly fixed amount of shelf space, and also has a fairly fixed labour force. A notable change in any of these variables will lead to a significant change in the supermarket's sales strategy. Moreover, while the cost of the goods sold are clearly the largest cost component, no single good are likely to be so important that it might change the sales strategy. A pricing strategy based on some markup rule to cover all fixed costs is therefore not unreasonable.[5] However, if this is the case, all marketing costs will be fixed costs.

While a short-run technology with only one variable input factor in each production process does not seem unrealistic for many retailers or wholesalers, other factors such as labour and capital cannot be treated as fixed in the long run. It may therefore be of interest to see how the relationship between the consumer demand and the derived demand elasticities changes with different relationships between two cost shares. This is graphed in Figure 1 for four different values of the elasticity of substitution, $\sigma = 0$, $\sigma = 0.5$, $\sigma = 1$ and $\sigma = 5$. The consumer demand

[5] We are here also assuming that there are no substitution between outputs, or that the intermediary's production technologies are nonjoint so that there exist a separate production function for each output. This assumption is implicitly made in virtually all analyses of the relationship between retail and derived demand elasticities as only one good are considered. It also seems like a reasonable assumption, since one would not expect e.g. supermarkets to make large adjustments which goods are on the shelves based on changes in the relative prices of the goods.

own-price elasticity η is set equal to minus one, and the supply elasticity for input *b*, e_b, is set equal to one.

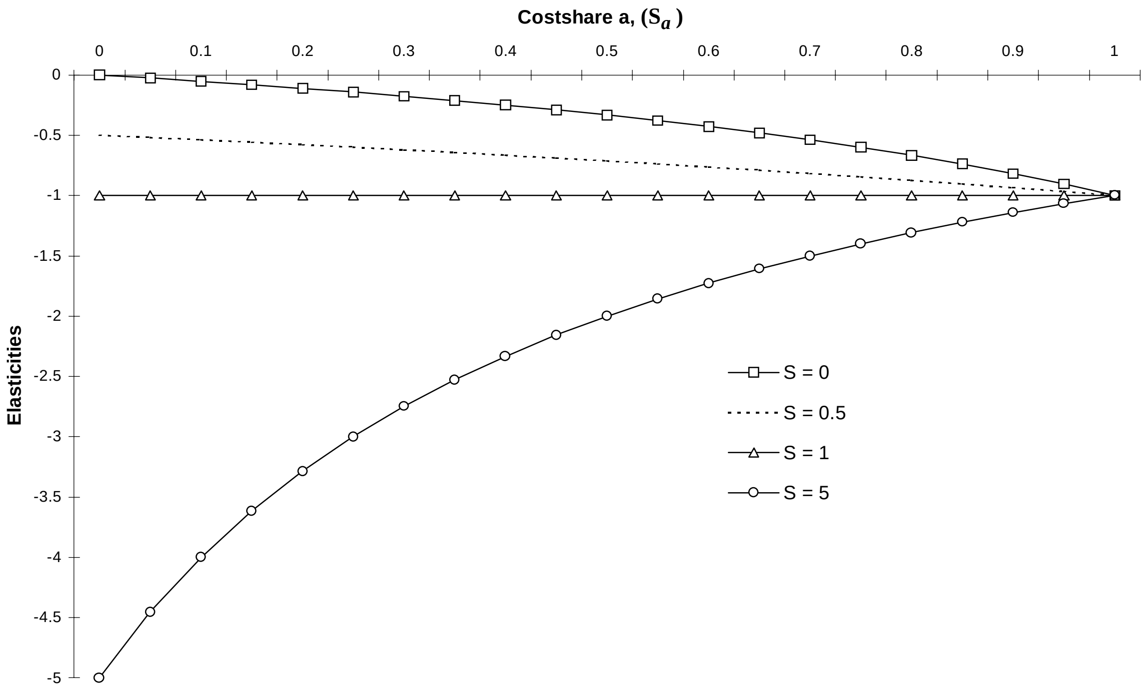

Figure 1. The relationship between consumer and derived demand elasticities, S = σ.

The relationships in the figure are relatively insensitive to the supply elasticity for input *b*, and also to η if the relationship between η and σ is kept constant. In all cases, the derived demand elasticity approaches the elasticity of substitution when the cost share of input *a* approaches zero, and in all cases the derived demand elasticity approaches the consumer demand elasticity when the cost share of input *a* increases towards unity. The elasticities are equal when the cost share of input *a* is one.

That the derived demand elasticity will equal the consumer demand elasticity when one might regard the intermediaries' production technology as containing only one variable input factor is useful in empirical work. For the elasticities to be identical, the prices must be proportional, implying an elasticity of price transmission of 1.[6] This give us the opportunity to test this hypothesis using only price data, which are often much easier available than quantity data, particularly at the retail level. The test performed is similar to tests for the Law of One Price, but with data at different levels in the marketing chain rather then from different markets.

3. The Industry

The Norwegian fishing fleet is a heterogeneous mix of vessels, encompassing both large trawlers with processing machinery for production on board as well as small one-man inshore vessels. For most vessels cod is the main species, with saithe as a clear number two species. Of a total of 13,944 registered fishing vessels in 1996, only 1,254 had an over all length of more than 13 meter. Of this group, about 360 had an overall length more than 28 meters. There are 102 vessels larger than 51 meters. In terms of numbers, smaller vessels dominate. However, their economic importance is far less than the number of fishing vessels should indicate. In 1996 only 2,860 vessels are defined as full year operated fishing vessels. The majority of vessels smaller than 13 metres are therefore operated only seasonally, and have a small contribution to both total catch and value adding. Vessels above 28 meters catch 100 % of the quantity of capelin, 83 % of the quantity of mackerel, 72% of herring, 48% of cod and about 70% of shrimps and other crustaceans. In total about 70 % of the Norwegian catches are caught by the largest 360 vessels in the fishing fleet. The same vessels employ about 6,600 persons having fishing as their dominant income, whereas the rest of the fleet gives employment to about 9,000 fishermen.

[6] This can most easily be seen in a double log demand function, where the estimated parameters is elasticities. If one changes the base of one of the prices, the only effect this has in the model is that the constant term changes. The elasticity is the same.

The first hand sale of fish is by law controlled by six sales organisations. Formally each sales organisation has a monopoly for the sale of fish to producers/exporters. Each prevail in specific geographic areas, or has a focus on broader definition on species, like pelagic or demersal species. Historically, the sales organisations were created to protect the fishermen from buyers exercising undue market power. The sales organisations are given exclusive rights on the first hand sale of most fish species through the Raw Fish Act of 1951. Various pricing regimes are employed, spanning from rigid minimum prices to auctions. Given that these sales organisations have monopoly over first hand sales of fish in their districts, tension arises between them and the processing industry. The buyers tend to claim that the sales organisations are exploiting their market power, particularly by stipulating a minimum price that in effect are concentrating all the profit to the fishermen. Virtually all cod are traded under a regime where a minimum price is set by the Norwegian Raw Fish Organisation, the northern sales organisation, which handles more than 80% of Norwegian landings of cod (Bendiksen and Dreyer, 1991). However, most transactions are at prices above the minimum price. Moreover, the fact that there is a global market for whitefish where about 90% of Norwegian landings are sold, makes it unlikely that these sales organisations can exercise market power.

Processing and conservation of fish and fish products involves various refinements like salting, drying, smoking, preserving, filleting, freezing and so forth. In 1995, the number of employees in the fish processing industry was 12,540 spread on 493 establishments. However, the 25 biggest with respect to revenues, constituted approximately 80 percent of total export value. Of the landings, freezing (fillets, round and minced) constitutes about 36 % and salting/dried salting 52%. The rest is almost equally distributed among fresh and dried (stockfish). For all product forms, the fish is the major input factor, as it makes up between 50 and 80 percent of total cost (Bendiksen and Dreyer, 1991; Toft and Bjørndal, 1997).

About 90 percent of the Norwegian fish and fish products are exported. In 1996, measured in value, dried salted cod and frozen fillets of cod are after farmed salmon and frozen mackerel the most important single components of this export. Portugal and Brazil are the two dominant markets for dried salted cod. Great Britain, Denmark and the USA are the most important markets for the Norwegian export of frozen cod fillets. Only ten percent of the catch is consumed on the domestic market, which is never the less the fifth largest market.

4. Data

Our data set contain monthly data for the period January 1982 to December 1995. The data for ex vessel prices that are made use of in this analysis, are average prices for cod and saithe (gutted without head) obtained from statistics prepared by the Directorate of Fisheries. Statistics Norway collects the data on prices for the domestic market. Monthly price indexes are calculated for use in compilation of the national consumer price index. Statistics Norway also provide the Norwegian consumer price index that are used in the demand analysis. The export prices for dried salted cod and frozen fillets are obtained from the Norwegian Exports Statistics. The price series are graphed in Figure 2.

Figure 2. Monthly cod prices, January 1982 – December 1995

Before we can determine which method to use when investigating the relationship between the price series, we must investigate the time series properties of the price series. In common with the normal practice, we conduct our empirical analysis on the natural logarithms of the variables. When we are investigating the price relationships, we are using nominal prices. However, for the demand analysis, no money illusion is imposed by deflating the prices with the consumer price index. The time series properties of the prices are investigated with Augmented Dickey-Fuller tests (Dickey and Fuller, 1979; 1981), where the number of lags are chosen so that the error term in the tests are not serially correlated.[7] In Table 1, the results of these tests for individual prices are reported both for the prices in levels and in first differences.

[7] As Dickey-Fuller tests have a nonstandard distribution under the null, ordinary critical values cannot be used. We use critical values computed with MacKinnon's (1991). The critical value is independent of the numbers of lags chosen. The criterion for choosing lag length used in this paper is the highest significant lag from the autocorrelation function or the partial autocorrelation function.

The null hypothesis is that each data series is nonstationary. For all prices in levels, we cannot reject the null hypothesis of nonstationarity. However, for all prices in first differences, we can strongly reject the null hypothesis of nonstationarity. These conclusions are independent of the number of lags chosen. Hence, we must conclude that all the prices are integrated of order one. Cointegration tests will therefore be the appropriate tool for further analysis of these price series.

Table 1. Unit root tests

Variable	Test statistic, levels	Test statistic, first differences
Ex vessel price	-2.116	-6.537*
Domestic price	-2.151	-4.029*
Price of frozen fillets	-1.661	-8.227*
Price of dried salted cod	-1.834	-4.909*
Quantity, cod	-0.749	-6.358*
Real cod price	-2.113	-4.998*
Real saithe price	-2.399	-3.832*
Real income	-0.705	-7.381*

* indicates significant at a 5% level. Critical value at a 5% level is -2.879 (MacKinnon, 1991)

5. Cointegration tests

When data series are nonstationary, normal inference theory breaks down. A data series is said to be nonstationary when its mean and variance are not constant.[8] The idea of cointegration is that even if two or more variables are nonstationary in their levels, but integrated of the same order, linear combinations may exist (so-called cointegration vectors) which is stationary

[8] For a more precise notion of the nonstationarity, nonstationary data series are often labeled depending on how many times they have to be differenced to yield a stationary data series. A data series that has to be differenced once to become stationary is said to be integrated of order one, denoted $I(1)$. Most economic data series seem to be integrated of order one.

(Engle and Granger, 1987). Only if nonstationary data series are found to be cointegrated, the data series exhibit a stable long-run relationship. Two different tests for cointegration are commonly used in the literature. They are the Engle and Granger test (Engle and Granger, 1987) and the Johansen test (Johansen, 1988; 1991). We will here use the latter, as this is the most powerful test (Gonzalo, 1994) and allows parametric tests on the long-run parameters.

The Johansen test is based on a vector autoregressive (VAR) system. A vector, $\boldsymbol{x}_t$, containing the N variables to be tested for cointegration are assumed to be generated by an unrestricted kth order vector autoregression in the levels of the variables;

$$\mathbf{x}_t = \Pi_1 \mathbf{x}_{t-1} + \ldots + \Pi_k \mathbf{x}_{t-k} + \Phi D_t + \mu + e_t \tag{6}$$

where each of the Π_i is a $(N \times N)$ matrix of parameters, μ a constant term and $\varepsilon_t \sim niid(0,\Omega)$. The VAR system of equations in (6) written in error correction form (ECM) is;

$$\Delta \mathbf{x}_t = \sum_{i=1}^{k-1} \Gamma_i \Delta \mathbf{x}_{t-i} + \Pi_K \mathbf{x}_{t-k} + \mu + e_t \tag{7}$$

with $\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i$, $i = 1, \ldots, k-1$ and $\Pi_K = -I + \Pi_1 + \ldots + \Pi_k$. Hence, Π_K is the long-run 'level solution' to (6). If $\boldsymbol{x}_t$ is a vector of $I(1)$ variables, the left-hand side and the first (k-1) elements of (7) are $I(0)$, and the last element of (7) is a linear combination of $I(1)$ variables. Given the assumption on the error term, this last element must also be $I(0)$; $\Pi_K x_{t-k} \sim I(0)$. Hence, either $\boldsymbol{x}_t$ contains a number of cointegration vectors, or Π_K must be a matrix of zeros. The rank of Π_K, r, determines how many linear combinations of $\boldsymbol{x}_t$ are stationary. If $r = N$, the variables in levels are stationary; if $r = 0$ so that $\Pi_K = 0$, none of the linear combinations are stationary. When $0 < r < N$, there exist r cointegration vectors - or r stationary linear combinations of $\boldsymbol{x}_t$. In this case one can factorise Π_K; $-\Pi_K = \alpha\beta'$, where both α and β are $(N \times r)$ matrices, and β contains the cointegration vectors (the error correcting mechanism in the system) and α the adjustment parameters. Two asymptotically equivalent tests exist in this framework, the trace test and the maximum eigenvalue test.

The Johansen procedure allows hypothesis testing on the coefficients α and β, using likelihood ratio tests (Johansen and Juselius, 1990). In our case, it is restrictions on the parameters in the cointegration vectors β which is of most interest. More specifically, in our case there are two price series in the $\boldsymbol{x}_t$ vector. Provided that the price series cointegrate, the rank of $\Pi = \alpha\beta'$ is equal to 1 and α and β are (2×1) vectors. A test of whether the prices are proportional is then a test of whether $\beta'=(1,-1)'$. However, also tests on the α vector are of interest. If a row in α contains only zeros (or in our case one element since α is a column vector), the price in question will be weakly exogenous. In this case, this price will determine the other price. A further discussion of these tests in a market delineation context, where they have very similar interpretations, can be found in Asche, Bremnes and Wessells (1999).

6. Empirical results

We will here test for price proportionality between the ex vessel price for cod in Norway, and the three major end markets for cod - the domestic market for fresh cod and the export markets for frozen fillets of cod and dried salted cod. Since the price series where found to be nonstationary, but integrated of the same order, cointegration analysis is the appropriate tool. The results from the cointegration tests and the tests for price proportionality are reported in Table 2.

Table 2. Cointegration tests and tests for Price Proportionality

Variables	H_0: Rank = r	Max test	Trace test	Proportionality[a]
Ex vessel and	r = 0	19.93*	26.35*	0.021
domestic price	r ≤ 1	6.43	6.43	(0.884)
Ex vessel and	r = 0	31.36*	35.72	7.274*
Frozen fillets	r ≤ 1	4.36	4.36	(0.007)
Ex vessel and	r = 0	23.08*	27.64*	0.079
Dried salted cod	r ≤ 1	4.55	4.55	(0.778)

* indicates significant at a 5% significance level.
[a] *p*-values in the parenthesis

The ex vessel price is cointegrated with all the end market prices. Hence, there is a causal relationship between the ex vessel price and the different market prices. The null hypothesis of price proportionality cannot be rejected between ex vessel prices and domestic fresh cod and ex vessel prices and dried salted cod. However, we must reject this hypothesis between ex vessel prices and frozen fillets. Hence, ex vessel prices is sufficient to obtain information about demand elasticities in the final market for fresh cod and dried salted cod, but not for frozen fillets of cod. That frozen fillets is the product where we do not find price proportionality is not too surprising, since this is the product form where the intermediaries (processors) have the greatest opportunity to respond to price changes, as they can change the kind of fillets and therefore the end product they are producing. Moreover, this is also the sector where the cost share for raw fish is the lowest (Toft and Bjørndal, 1997).

Given that the minimum ex vessel prices are set by the fishermen's sales organisation, it is also of interest to investigate whether impulses between ex vessel prices and the other prices go in both directions. This can be tested by testing whether any of the prices are weakly exogenous (Johansen and Juselius, 1990). If no prices are weakly exogenous, the causation will go in both directions so that shocks in one market will be transferred to the other and vice versa. If a price is weakly exogenous, shocks in this price will be transferred to the other price, but not the other way around. Hence, this price will in our context then determine the other price.

The results from the weak exogeneity tests are reported in Table 3. We can see that the price for domestic fresh cod is completely determined by the ex vessel price, since the ex vessel price is weakly exogenous in this relationship. This result holds also when price proportionality and weak exogeneity is imposed simultaneously, as a $\chi^2(2)$ test gives a test statistic of 0.306 with a *p*-value of 0.858. At a 2.5% significance level, although not at a 5% significance level we cannot reject the null hypothesis that the price of dried salted cod is weakly exogenous for the ex vessel price. When price proportionality and weak exogeneity is imposed simultaneously in this relationship, the test statistic is 6.1863 with a *p*-value of 0.0454. Hence, there are some evidence that the price of dried salted cod is weakly exogenous for the ex vessel price. In the relationship between frozen fillets and ex vessel prices, the causality goes in both directions. Hence, the export prices seem to be important in determining ex vessel prices, while the domestic market does not influence the ex vessel price at all. Moreover, while the price of frozen fillets are also influenced by shocks to the ex vessel price, this do not seem to be the case for dried salted cod to any extent. The price of dried salted cod is therefore determined outside of this system, and accordingly it has strong influence on the other prices.

Table 3. Tests for weak exogeneity

Price not tested	Potentially exogenous price	Test statistic[a]
Ex vessel	Domestic	0.148 (0.700)
Domestic	Ex vessel	13.485 (0.001)**
Ex vessel	Dried Salted Cod	4.764 (0.029)*
Dried Salted Cod	Ex vessel	11.895 (0.001)**
Ex vessel	Frozen fillets	8.383 (0.003)**
Frozen fillets	Ex vessel	9.730 (0.002)**

* indicates significant at a 5% significance level and ** indicates significant at a 1% significance level
[a] *p*-values in the parenthesis

7. Demand analysis

Given the results above, it may be of interest to investigate the demand elasticity for cod. There are no studies that investigating demand for Norwegian cod, and few studies that investigate the demand for cod in Europe at all.[9] This is somewhat surprising given the importance of cod for fishermen all over northern Europe. We will therefore estimate a demand function for Norwegian cod at the ex. vessel level.[10] Saithe is the most important whitefish species after cod in Norway, and we therefore use the saithe price as substitute price.

When estimating demand for fish it is always an issue whether one should specify an ordinary (quantity dependent) or inverse (price dependent) demand equation. If the landings are supplied to a local fresh market it is certainly most reasonable to specify an inverse demand relationship as in Jaffry, Pascoe and Robinson (1999). However, if the product can be stored and one is not restricted to a local market, an ordinary demand relationship is more appropriate

[9] Burton (1992) estimates demand for fresh whitefish in the UK using houshold data, reporting a own-price elasticity of –0.95.
[10] This is parallell to the price to the farmer in agriculture.

(Asche, Salvanes and Steen, 1997). In our context, the last description seems to describe the market structure rather closely, and we will therefore estimate an ordinary demand relationship.[11]

Given that the data series in levels are nonstationary, an Error Correction Model (ECM) seems to be a good economic framework. We started out with a high number of lags, and then reduced the model as much as possible. The final model contains only one lag. Let q denote the quantity of cod, pc the price of cod, ps the price of saithe and inc income, and Δ as the difference operator. With seasonal dummies surpressed and standard errors in parenthesis, the estimated demand equation is then

$$\begin{aligned}\Delta \ln q_t = & \underset{(0.088)}{-0.101} \underset{(0.298)}{-0.956}\Delta \ln pc_t + \underset{(0.208)}{0.408}\Delta \ln ps_t + \underset{(0.081)}{1.179}\Delta \ln inc_t \\ & \underset{(0.068)}{-0.432} (\ln q_{t-1} \underset{(2.390)}{+5.758} + \underset{(0.345)}{1.173}\ln pc_{t-1} \underset{(0.315)}{-0.159}\ln ps_{t-1} \underset{(0.255)}{-1.624}\ln inc_t)\end{aligned} \tag{8}$$

The estimated equation has an R^2 of 0.837. With p-values in parenthesis the following misspecification test was produced: LM-test agains autocorrelation up to the 12th order, $F(12,139)$, 1.191 (0.295); normality, $\chi^2(2)$, 2.265 (0.322), Heteroskedasticity $F(69,81)$ 1.125 (0.302), Ramsey RESET, $F(1,150)$ 2.523 (0.114). The model seems to be well specified statistically, as none of these tests provide any evidence against the model. The adjustment parameter can be used to test for cointegration (Kremers, Ericsson and Dolado, 1992). A parameter of –0.432 with a standard error of 0.068 gives a t statistic of 6.290. As this rejects

[11] This discussion also suggest that simultaneity may be an issue. However, as noted by Stock (1987), with nonstationary data and cointegrtion relationships, this is not the case.

the null hypothesis at all conventional levels, we conclude that the variables are cointegrated. Hence, the estimated demand equation is indeed a long-run relationship.

The demand elasticity for cod at the ex vessel level is –1.173. Given the results from the price analysis, this is then also the elasticity for fresh cod in Norway and for dried salted cod, but not for frozen fillets. Although one cannot really compare Burton’s (1992) estimate of the household demand elasticity for fresh whitefish in the UK at –0.95 with our result, it is of some comfort that they are of a similar magnitude.

8. Concluding remarks

Based on standard microeconomic theory, we have in this paper shown that when there are only one variable factor in the intermediaries’ optimisation problem, the consumer demand and the derived demand elasticities will be identical. This is also the only general condition that gives an elasticity of price transmission of 1. Since this implies that the primary producers' prices and the consumer prices will be proportional, one can test whether the consumer demand and derived demand elasticities coincide using data only on prices.

An empirical analysis is provided for the Norwegian cod sector. We found a proportional relationship between the ex vessel price and the price in the domestic fresh market, and between the ex vessel price and the export price of dried salted cod. However, the relationship was not proportional between the ex vessel price and the export price of frozen fillets. Hence, derived demand elasticities will only provide information about final demand for the two first product forms. We also investigated the direction of the causal relationships between the prices. We found that the export price for dried salted cod was important in determining the ex vessel price, as there was some evidence that the price for dried salted cod was weakly exogenous for the ex vessel price. However, also the price of frozen fillets matter for the ex vessel price, but here the causal relationship is in both directions. The price on the domestic market for fresh cod is determined by the ex vessel prices, as this is weakly exogenous for the domestic price.

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