

## EX-VESSEL PRICE LINKAGES IN THE NEW ENGLAND FISHING INDUSTRY

DALE SQUIRES<sup>1</sup>

### ABSTRACT

This study examines the direction of ex-vessel price linkages between the three New England ports of Boston, New Bedford, and Gloucester. Within-sample, bivariate tests of Granger causality are applied for monthly data from 1965 through 1981. It is found that cod and haddock prices are formed in New Bedford, that pollock prices are simultaneously formed between Boston and Gloucester, and that a spurious relationship exists for flounder prices between the three ports. The hypothesis is advanced that this spurious relationship may be due to flounder price leadership from outside the region, most probably the New York Fulton Fish Market.

The direction of price linkages between various market and production centers in an industry is important to studies of marketing and prices. Although these spatial and hierarchical relationships are generally well understood in domestic agriculture, they have received little or no attention in natural resource utilization and in the domestic commercial fishing industry in particular. This study therefore examines the spatial characteristics of round ex-vessel price linkages of the most important species in the New England fishing industry from 1965 through 1981.

Three ports—New Bedford, Boston, and Gloucester—dominate the New England fishing industry, as both home ports or production centers and as marketing centers. By both volume and value of landings, New Bedford is the most important port, followed by Gloucester and then Boston. The most important species of groundfish in New England are cod; haddock; yellowtail, winter, and other flounders; ocean perch or red fish; and pollock. Sea scallops and lobsters also provide a significant contribution to the industry in both value and volume of landings. This study accordingly focuses upon the ports of Boston, New Bedford, and Gloucester, and the species of cod, haddock, yellowtail and winter flounders, and pollock. Additional attention is given to ocean perch and sea scallops, though rigorous conclusions are not possible.

In New Bedford and Boston, fishermen sell their catches to the highest bidder in an open auction. The New Bedford auction begins at 8:00 a.m. and ends at 8:22 a.m. The Boston market begins at 7:00 a.m.,

and invariably overlaps with the New Bedford market. There is significant communication between the two markets during the auctions. The volume and total value of fish harvested is substantially greater in New Bedford than in Boston. Bidders purchase an entire vessel's landings in New Bedford, while in contrast, purchasers offer individual bids for each species in Boston. In most of the ports other than Point Judith in Rhode Island (where an important fishermen's cooperative exists), the catch is sold directly to fish processors or by prior arrangements between individual vessels and purchasers. Further, it is generally believed that Gloucester prices for most fresh groundfish species are set in Boston, and differ only by a transportation cost.

Fishermen of all ports are free to land their harvests at any port offering the highest prices, which, however, must be balanced against steaming time. Few vessels land exclusively at a single port, since the distances between the three are not great. A definite limit exists to port switching due to the prevalence of market transactions costs. Wilson (1980) indicated that personal and financial relationships tend to bind particular fishermen and fish buyers. In contrast to many other natural resource and primary production industries, a futures market does not exist for fresh fish.<sup>2</sup>

Different ports and markets have developed singular reputations. These specializations are based in large part upon proximity to resource stocks. New Bedford has developed a reputation as a flounder and sea scallop port, while Boston has become known as a cod, haddock, and, to a lesser extent,

<sup>1</sup>Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

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<sup>2</sup>Trading on futures markets involves buying and selling standardized contracts for the future delivery of a specific grade of a commodity at a specific location(s).

pollock port. Although Gloucester fishermen direct much of their effort towards cod, haddock, and flounders (generally joint products), Gloucester has developed a reputation as a port for both pollock and ocean perch.

Conventional wisdom in the New England ground-fishery market holds that New England round (fish as harvested) ex-vessel prices of fresh flounders are formed in the New Bedford auction market, while fresh cod, haddock, and pollock round ex-vessel prices are set in the Boston auction. These widely held beliefs serve as the null hypotheses to be tested in this study of the ex-vessel groundfish price linkages in New Bedford, Gloucester, and Boston.

Knowledge of ex-vessel price linkages has a number of applications. Efforts at improving market efficiency would find this information useful. The broadcasting of daily ex-vessel fish prices by the National Marine Fisheries Service can properly focus upon the most crucial markets. Infrastructural or institutional improvements can be more judiciously targeted, an important consideration in a time of tight public and private budgets. Price forecasts to improve industry functioning can concentrate upon those prices formed in markets which demonstrate price leadership. Fishermen may want to land their harvests in the market in which ex-vessel prices are first formed, should fishermen want to affect the pricing process, be less dependent upon the landings of others, or capture advantageous prices. Similar considerations apply to buyers. Knowledge of the price formation process allows government price policies to target the appropriate markets. Finally, price linkage information is crucial to studies of marketing margins, length of price transmission, and asymmetric pricing.

### THE DATA

The data are taken from the vessel weighout files of the National Marine Fisheries Service. After every trip of a commercial fishing vessel of any gear type, port agents in each port obtain the value and volume of landings for each species harvested. The entire collection of this information constitutes the weighout file. The output vector from the weighout file is then linearly aggregated over vessels and trips to form monthly round ex-vessel prices for each port. The resulting nominal prices are subsequently deflated by the consumer price index for food. As Sims (1974) and Feige and Pierce (1980) noted, the use of seasonally adjusted data may confound lag distributions and causality relationships. Consequently, the data are left in their unseasonalized

state. However, to account for seasonal differences, quarterly dummy variables are employed. The time domain of the data set extends from 1965 through 1981.

### METHOD OF ANALYSIS

Granger (1977) provided a definition of causality among a set of variables that is based upon predictability as well as the fact that the effect of a change in an exogeneous variable upon an endogeneous variable requires time. A variable  $X$  causes another variable  $Y$ , with respect to a given universe or information set that includes  $X$  and  $Y$ , if present  $Y$  can be better predicted by using past values of  $X$  than not doing so, all other information in the past of the universe being used in either case. Causality from  $Y$  and  $X$  is defined in the same manner. Feedback occurs if  $X$  causes  $Y$  and  $Y$  causes  $X$ . A causal relationship between  $X$  and  $Y$  does not exist if causality does not run from  $X$  to  $Y$  or from  $Y$  to  $X$ , and feedback does not occur.

Causality tests may be classified into two fundamental types at their most basic level, within-sample and out-of-sample tests. The within-sample test is widely applied and is the first one developed. This test is developed over the full-time domain of the data set, and essentially relies upon a measure of fit. The definition of causality in the out-of-sample test requires evidence of improved forecasts. This approach is implemented by identifying and estimating different models using the first part of the sample and then comparing their respective forecasting abilities on the latter part of the sample. This study utilizes the within-sample test, the one most commonly applied, since the properties of the out-of-sample test have yet to be systematically examined.

Two basic approaches have been advanced by which to apply empirically the within-sample bivariate Granger criterion to time series. The first approach is represented by the test proposed by Pierce (1977) based upon Haugh (1976). The procedure first estimates whitening filters for each time series, then subsequently estimates the cross-correlation function for the first step's residuals.<sup>3</sup> However, Sims (1977) and Geweke (1981) indicated that this approach may be limited.<sup>4</sup> A second basic

<sup>3</sup>Whitening filters remove serial correlation from a time series. Each time series used in a test of causality will be a white noise process, and any relationships will be based on actual, systematic relationships between the two time series, instead of a spurious relationship caused by the common serial correlation.

<sup>4</sup>Pre-filtering each time series with separate autoregressive integrated moving average (ARIMA) filters biases the test toward

approach relying directly upon distributed lag relationships between dependent and independent variables has led to three widely used tests: those suggested by Sims (1977), the direct Granger test forwarded by Sargent (1976), and the Modified Sims test advanced by Geweke et al. (1983).

The small-sample properties of the Sims (1972), direct Granger, and Modified Sims tests have recently been examined within Monte-Carlo frameworks by Guilkey and Salemi (1982) and Geweke et al. (1983). Although the two studies differ somewhat in their specifications, both found that the Sims test was outperformed by the other two. Since the Sims test is more time-consuming and expensive to employ and requires more decisions about parameterizations, both studies unequivocally recommend against its use.

The two studies reach slightly different conclusions on the efficacy of the direct Granger and Modified Sims test. These contradictory results can be attributed to differences in research design. Geweke et al. (1983) concluded that the two tests essentially perform equally well. In contrast, Guilkey and Salemi (1982) determined that the direct Granger test consistently outperforms the Modified Sims procedures by small amounts. Since the direct Granger test is computationally the least expensive of the three and results in the fewest degrees of freedom lost from formation of leads and lags, Guilkey and Salemi recommend its use over the Modified Sims and Sims procedures. Nonetheless, they do note that the Granger procedure's advantage over the other two diminishes with increases in sample size.

Several additional findings of Guilkey and Salemi (1982) are also worth reporting. They observed that for sample size <200, the shorter versions of all three tests are superior to the longer versions.<sup>5</sup> They further noted that in their Monte-Carlo study the direct Granger and Modified Sims procedures accurately recover the coefficients of the relevant population projections of the statistical model used to generate experimental time series in small samples. Consequently, it may be unlikely to observe "large" coefficient estimates arising spuriously. Finally, test performance is extremely sensitive to sample size, strength of causation, and length of test parameterization employed.

The direct Granger test as applied in this study

failing to reject the null hypothesis of independence of the two series more often than the specified level of significance suggests. Because of this limitation, the second basic approach is applied.

<sup>5</sup>Longer versions of these tests include additional lead and lag variables.

is based upon ordinary least squares regression of the current observation of the time series of round ex-vessel prices from one port upon its own past observations and the past observations of the other port's round ex-vessel prices for species  $k$ :

$$P2_k(t) = a_k + \sum_{i=2}^4 b_{ki} D_i + cLT + \sum_{j=1}^J d_{kj} P2_k \times (t - j) + \sum_{j=1}^J f_{kj} P1_k(t - j) + e_{kt} \quad (1)$$

Here,  $LT$  refers to a linear time trend,  $D_i$  is the zero-one variable for quarter  $i$ ,  $P1_k(t)$  is the round ex-vessel price of species  $k$  in month  $t$  in port 1,  $J$  is the number of periods lagged, and  $e_{kt}$  is a vector of stochastic, white noise residuals. The presence of lagged dependent variables in Equation (1) is counted on to remove serial correlation from the estimated residuals.<sup>6</sup>

The test of the null hypothesis that  $P1_k$  does not cause  $P2_k$  is a test that  $f_{kj} = 0$ ,  $j = 1, 2, \dots, J$ . Guilkey and Salemi (1982) indicated that the  $F$ -test statistic is calculated by estimating Equation (1) in both constrained ( $f_{kj} = 0$ ,  $j = 1, 2, \dots, J$ ) and unconstrained forms, and may be written as<sup>7</sup>

$$F = \frac{(SSE_c - SSE_u)J}{SSE_u/(T - (2J + 2))} \quad (2)$$

where  $SSE_u$  and  $SSE_c$  are the residual sum of squares from the unconstrained and constrained regressions, respectively, and  $T$  represents the number of monthly observations on round ex-vessel prices. Under the null hypothesis,  $F$  is an  $F$ -test statistic with  $J$  and  $T - (2J + 2)$  degrees of freedom. This procedure is then repeated reversing the roles of  $P1_k$  and  $P2_k$  to test the null hypothesis that  $P1_k$  does not cause  $P2_k$ .

The direct Granger test requires selection of a lag length,  $J$ , large enough to purge serial correlation from estimated residuals. Several factors require consideration before specifying the lag length. Chilled fresh fish is a commodity that rapidly deteriorates in quality. Consequently, definite limits exist to the length of time which inventories of

<sup>6</sup>Serial correlation exists when the error terms from different observations in a time series are correlated. Serial correlation tends to give unbiased but inefficient estimators, and a biased sampling variance, which then affects the results from significant tests such as the  $F$ - or  $t$ -tests.

<sup>7</sup>A constrained  $F$ -test includes one or more restrictions, such as one or more coefficients constrained to zero. An unconstrained  $F$ -test does not include these restrictions.

chilled fresh fish can be held. Since most groundfish harvested in New England waters are not processed into frozen fish products, long-term storage of New England groundfish is unlikely, and fresh fish prices are likely to adjust more quickly than those of most other food commodities. In addition, previous exploratory analysis with adaptive filtering methods on the weighout file suggests that two sets of round ex-vessel prices for any species  $k$  are particularly important, the previous month's price and the price within one month on either side of the previous year. In order to account for these characteristics and to provide both short and long versions of the test, lags of 8 and 14 mo were specified. These lag lengths are sufficiently long to encompass price lags with monthly data. The diagnostic  $Q$  test of Box and Pierce (1970) is used to detect serious serial correlation.

### EMPIRICAL RESULTS

The empirical results from the direct Granger causality tests lead to somewhat unexpected conclusions for most species. The null hypothesis that monthly round ex-vessel prices of cod and haddock in all three ports are first formed in the Boston auction market is rejected in almost all instances. The findings in Table 1 instead suggest that the cod and haddock prices established in the New Bedford auction lead the prices formed in the Boston market. Several factors may account for this. The New Bedford auction's volume of landings is substantially higher than that of Boston. In addition, the two market times ordinarily overlap, and frequent com-

munication occurs between economic agents during the auctions. Further, the proximity of New Bedford to Boston allows fresh fish to be easily trucked to Boston from New Bedford. The markets are thus physically linked, before the auctions by fishermen and after the auctions by fish buyers. One element of conventional wisdom may perhaps be substantiated, however. Although the  $Q$ -test statistic indicates severe serial correlation (and thereby possibly refuting the  $F$ -test statistic), the empirical results indicate that Boston cod prices do lead Gloucester cod prices at the ex-vessel level for the shorter lag length parameterization.

Rejection of the null hypothesis that Boston prices lead New Bedford and probably Gloucester cod and haddock round ex-vessel prices and the finding that New Bedford prices lead Boston prices suggest a second null hypothesis for consideration. This second hypothesis states that Gloucester cod and haddock prices are directly led by New Bedford prices. In addition, the possibilities that Boston prices lead Gloucester prices and that New Bedford prices lead Boston prices suggest an additional, indirect price linkage between Gloucester and New Bedford via Boston.

The results for this second null hypothesis are also given in Table 1. Since this is an unplanned comparison, a Scheffe interval is used.<sup>8</sup> Strictly followed,

<sup>8</sup>An unplanned comparison occurs when in the course of examining results a hypothesis is tested which was not specified prior to the experiment. The initial region is altered by the additional information, so that the level of significance has changed. A Scheffe interval allows for a more cautious test by providing a larger critical value than that given by a  $t$  or  $F$  table. This pre-test bias is accounted for by a conservative test. The  $F$ -test statistic now

TABLE 1.—Direct Granger causality tests for monthly fresh round ex-vessel cod and haddock prices.

Cod				Haddock			
Direction <sup>1</sup>	Lags <sup>2</sup>	$F$ -test <sup>3</sup>	$Q$ -test <sup>4</sup>	Direction <sup>1</sup>	Lags <sup>2</sup>	$F$ -test <sup>3</sup>	$Q$ -test <sup>4</sup>
B ----->G	8	2.37*	35.67*	B ----->G	8	1.69	9.60
B ----->G	14	1.17	2.61	B ----->G	14	1.09	4.49
G ----->B	8	1.59	10.98	G ----->B	8	1.07	10.98
G ----->B	14	1.02	12.35	G ----->B	14	1.29	15.07
B ----->NB	8	1.67	13.52	B ----->NB	8	0.08	12.54
B ----->NB	14	0.74	21.85*	B ----->NB	14	0.09	7.06
NB ----->B	8	2.52*	8.82	NB ----->B	8	3.15*	8.62
NB ----->B	14	1.89*	16.27	NB ----->B	14	1.76*	8.74
G ----->NB	8	1.78	16.46	G ----->NB	8	0.56	11.71
G ----->NB	14	0.91	28.42	G ----->NB	14	1.36	15.09
NB ----->G	8	<sup>5</sup> 2.96	7.84	NB ----->G	8	<sup>5</sup> 2.90	11.76
NB ----->G	14	1.40	6.86	NB ----->G	14	1.65	8.37

<sup>1</sup>Variable abbreviations are B (Boston), G (Gloucester), NB (New Bedford).

<sup>2</sup>J indicates J months lagged.

<sup>3</sup>Null hypothesis that past values of the causal variable do not significantly affect current values of the dependent variable. An asterisk indicates rejection of the null hypothesis at the 5% level.

<sup>4</sup>Null hypothesis that regression residuals are white noise. An asterisk indicates rejection of the null hypothesis at the 5% level.

<sup>5</sup> $F$ -test statistic is significant at the 5% level, but not significant at the 5% level when a Scheffe interval is used.

the results indicate that the cod and haddock price linkage does not run from New Bedford to Gloucester. If a Scheffe interval is not used, then the New Bedford cod and haddock prices do lead those of Gloucester. Therefore, with this caveat, New Bedford auction market monthly round ex-vessel cod and haddock prices lead the prices of Gloucester and Boston, and Boston prices may lead those of Gloucester. In any case, it appears that the New Bedford auction market dominates the formation of round ex-vessel prices for cod and haddock.

The empirical results for yellowtail and winter flounder of Table 2 also contradict the null hypothesis that monthly fresh round ex-vessel prices for both species are formed first in New Bedford. Instead, the findings indicate that pricing feedback exists between both New Bedford and Gloucester and between New Bedford and Boston. These conclusions must be tempered by the significant Q-test statistics for several relationships.

These conclusions lead to a second null hypothesis

between the prices of New Bedford and Gloucester, New Bedford and Boston, and possibly between Gloucester and Boston rests with a spurious relationship. Although New Bedford is the most important flounder port by landings in New England, New York City is even more important on the eastern seaboard by volume of consumption. New York City's Fulton Fish Market is primarily a wholesale market without substantial landings. Much of the New England flounder harvested is sent to Fulton on consignment without an ex-vessel price being established in New England. The Fulton Fish Market also begins much earlier in the morning than New Bedford's auction market. Thus the apparent feedback among the ex-vessel yellowtail and winter flounder prices in the New England ports is probably due to their following of the wholesale prices set in the Fulton Fish Market.

Table 3 presents the results for pollock. As with the other species, consistent results are obtained for different lag lengths. Again, the null hypothesis dic-

TABLE 2.—Direct Granger causality tests for monthly fresh round ex-vessel yellowtail and winter flounder prices.

Yellowtail flounder				Winter flounder			
Direction <sup>1</sup>	Lags <sup>2</sup>	F-test <sup>3</sup>	Q-test <sup>4</sup>	Direction <sup>1</sup>	Lags <sup>2</sup>	F-test <sup>3</sup>	Q-test <sup>4</sup>
NB ----->G	8	2.05*	20.19	NB ----->G	8	7.52*	5.68
NB ----->G	14	2.27*	19.42	NB ----->G	14	8.71*	1.78
G ----->NB	8	1.96*	23.56*	G ----->NB	8	2.88*	16.98
G ----->NB	14	2.48*	26.78*	G ----->NB	14	2.97*	22.19*
NB ----->B	8	2.02*	10.56	NB ----->B	8	11.87*	18.45
NB ----->B	14	1.76*	9.89	NB ----->B	14	7.66*	7.92
B ----->NB	8	0.75	17.63	B ----->NB	8	23.57*	9.94
B ----->NB	14	2.83	21.83*	B ----->NB	14	5.25*	3.99
G ----->B	8	2.27 <sup>5</sup>	9.41	G ----->B	8	3.87 <sup>5</sup>	12.43
G ----->B	14	2.50 <sup>5</sup>	12.74	G ----->B	14	4.37 <sup>5</sup>	4.70
B ----->G	8	1.48	16.86	B ----->G	8	4.15 <sup>5</sup>	18.16
B ----->G	14	1.27	18.82	B ----->G	14	3.56 <sup>5</sup>	17.34

<sup>1</sup>Variable abbreviations are B (Boston), G (Gloucester), NB (New Bedford).

<sup>2</sup>J indicates J months lagged.

<sup>3</sup>Null hypothesis that past values of the causal variable do not significantly affect current values of the dependent variable. An asterisk indicates rejection of the null hypothesis at the 5% level.

<sup>4</sup>Null hypothesis that regression residuals are white noise. An asterisk indicates rejection of the null hypothesis at the 5% level.

<sup>5</sup>F-test statistic is significant at the 5% level, but not significant at the 5% level when a Scheffe interval is used.

to be tested on the yellowtail and winter flounder price linkages between Gloucester and Boston. Since this test is also an unplanned comparison, a Scheffe interval is required. Again, the strict test results indicate that neither port's prices lead the other, nor that feedback exists.

The most probable explanation for the feedback

becomes significant only if it exceeds in magnitude  $((a-1)F_b)^{1/2}$ , where F is the b · 100% critical value for F (a-1, N-a) and N is the number of observations. See Snedecor and Cochran (1976, p. 271) for more details.

TABLE 3.—Direct Granger causality tests for monthly fresh round ex-vessel pollock prices.

Direction <sup>1</sup>	Lags <sup>2</sup>	F-test <sup>3</sup>	Q-test <sup>4</sup>
B ----->G	8	4.34*	12.54
B ----->G	14	4.99*	10.15
G ----->B	8	5.28*	18.27
G ----->B	14	4.77*	22.96*

<sup>1</sup>Variable abbreviations are B (Boston), G (Gloucester), NB (New Bedford).

<sup>2</sup>J indicates J months lagged.

<sup>3</sup>Null hypothesis is that past values of the causal variable do not significantly affect current values of the dependent variable. An asterisk indicates rejection of the null hypothesis at the 5% level.

<sup>4</sup>Null hypothesis that regression residuals are white noise. An asterisk indicates rejection of the null hypothesis at the 5% level.

tated by widely held industrial perceptions is rejected. The results indicate that feedback exists between the monthly fresh round ex-vessel prices of pollock in both Gloucester and Boston. Both ports dominate pollock landings and are close to one another.

A complete time series of prices for sea scallops exists only for New Bedford. Since New Bedford greatly dominates this fishery by both volume and value of landings, it may be safely concluded that monthly round ex-vessel sea scallop prices are formed in New Bedford. Finally, Gloucester is the only one of these ports to possess a complete time series of prices and landings of ocean perch or red fish. Since Gloucester dominates this fishery, monthly fresh round ex-vessel ocean perch prices appear to be formed in this port, at least among these three.

### CONCLUDING COMMENTS

The within-sample bivariate direct Granger causality tests of monthly round ex-vessel price linkages for the three most important New England ports (Boston, New Bedford, and Gloucester) and the most important groundfish species lead to unexpected results. Conventional wisdom considers the round ex-vessel cod and haddock prices formed in the Boston auction market to lead the comparable prices of the other New England ports. However, the empirical results indicate that New Bedford's prices lead those of the other ports, although in certain cases Boston's cod prices may lead those of Gloucester as well.

The common industry perception also holds that the yellowtail and winter flounder round ex-vessel prices are first formed in New Bedford and lead those of Boston and Gloucester. Instead, the empirical findings suggest that feedback and simultaneous price formation occur among all three ports for both species. Since flounder landings in Boston and Gloucester are negligible in comparison to those of New Bedford, a spurious relationship due to the leading wholesale prices formed in the even earlier and more flounder-important Fulton Fish Market of New York City is suggested. Feedback is likely for fresh round pollock ex-vessel price formation in Boston and Gloucester. Finally, it is suggested that the New Bedford auction market dominates fresh ex-vessel sea scallop price formation and that Gloucester dominates among these three ports for ocean perch. New Bedford thus generally dominates ex-vessel price formation among the major New

England ports for the most important species harvested.

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