MISREPORTED LANDINGS OF NORTH SEA COD: ESTIMATION OF THE TRUE LEVEL OF AGGREGATE LANDINGS 1983-2003

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ABSTRACT

It is widely believed that there have been significant levels of cod landed from the North Sea over and above permitted quota levels in recent years as the TAC and quota system of the Common Fisheries Policy has squeezed the fishing opportunities of EU fleets in an attempt to conserve the fish stock. The extent is described diplomatically as "Unallocated" in ICES Working Group Reports which suggest that the amount has exceeded 10% of official landings at times but at other times, when the fish have been particularly scarce, ghost fish have been reported in order to preserve track record. This data-fouling weakens scientific and economic modelling of the fisheries. However, a way of calculating the amount of misreporting is to observe the behaviour of the fish markets. Studies conducted on the fisheries around the North Sea have indicated that cod prices respond to the quantity landed despite being part of a large international market. After testing for market integration and the direction of causality in the demand system, this project models the market for North Sea cod as an international unit and uses dummy variables on both the intercept and gradient of the demand curve to separate the impact of misreported landings from the residuals. The product is a revised series of aggregate landings of North Sea cod.

Keywords: Fishery Economics, Inverse Demand Functions

Introduction

It is widely believed that there have been significant levels of cod landed from the North Sea over and above permitted quota levels in recent years as the TAC and quota system of the Common Fisheries Policy has squeezed the fishing opportunities of EU fleets in an attempt to conserve the stock. The item described diplomatically as "Unallocated" in ICES Working Group Report reviews of landings suggests that the figure has exceeded 10% of official landings at times but at other times, when the fish have been particularly scarce, ghost fish have been reported, perhaps in order to preserve track record.

This data-fouling weakens scientific and economic modelling of the fisheries and its extent has only been visible through the noise in Virtual Population Analysis (VPA) and other methods of study.

A way of noting the amount of misreporting is to observe the behaviour of the fish markets. Many studies conducted on the fisheries around the North Sea (Ioannidis and Whitmarsh 1987, Jorgensen *et* al 1991 and Nielsen 1999 are examples) have indicated that cod prices respond to the quantity landed despite being part of a large international market.

However successfully concealed from the authorities, unreported landings join the remainder of the fish available for purchase and if the quantity of landings of fresh cod affects the price obtained in the market then illegal landings will affect the price too. The price could be expected to be lower than the reported level of sales would justify. This will be true even if the illegal landings fetch a price discounted because of their dubious origin since they will lessen the demand for the legal lots on the auction market.

Anecdotal evidence suggests that much of the over-quota fish appears to have gone through the auction markets where that part of a vessel's catch which is quota and that part which is over-quota cannot be separated. Buyers purchase only a box of fish. It is not necessarily clear to them whether a vessel has landed more fish than it was entitled to. Nor would that be clear from the vessel logbook which would merely record quantities within the quota. Only comparison of the logbook and the auctioneer's sales note would show a discrepancy. Where the fish is landed directly to a processor the paper chase is more complex still. Hence the hypothesis of this paper is that by examining the market for North Sea cod and observing price movements the true level of landings will be revealed.

Market Integration and Boundaries

Guillotreau *et al* (1998) concluded that the markets are integrated for roundfish in Belgium, Denmark, France, Germany and United Kingdom. Assuming this to be the case enables the aggregated function to be estimated.

Data

Most cod from the North Sea is landed into Belgium, Denmark, France, Germany, the Netherlands and the United Kingdom and those countries formed the basic group studied as an aggregate. The prices attained at auction were collected for each country.

Data on landings were collected as were those on landings of cod into the six countries from other fisheries, imports of cod in all forms, and of imports of Alaska Pollock which has emerged as a major white fish substitute in the last thirty years for less valuable forms of cod product. The largest of the national markets for North Sea cod is in the United Kingdom where haddock has also become a significant substitute. Data on haddock landings into the six countries were also collected. All the data were annual and the periods for which they were available are set out in Table 1 below.

In order to create a mean price variable for the period 1976 to 2003, the values were adjusted to a level based on their relationship to a common mean over the period 1996 to 2002, summed and divided by the number of contributing series at each observation. They were adjusted for inflation using the British retail price index for all items. It was felt acceptable to use the British index given the importance of the United Kingdom in this market and as the British price series was the only complete contributor over the whole period. All the variables were then put into logarithmic form.

In addition, two dummy variables were created. The first, to replicate the shift in the intercept, took the value 1 when misreporting was thought to have been taking place. The second designed to show a change to the gradient of the inverse demand function was constructed by multiplying the first dummy variable by the reported level of landings of cod. Hence both dummy variables were in operation at the same time since a single event with two possible outcomes for the position of the inverse demand function is being modelled. The precise period when the dummies were in operation was tested with a certain amount of trial and error during estimation.

Table 1: Time Periods covered by the Data

Variable	Country	First Observation	Last Observation	Number of Observations
Price	Belgium	1996	2003	8
	Denmark	1980	2003	24
	Germany	1995	2003	9
	France	1973	2002	30
	Netherlands	1990	2003	14
	United Kingdom	1975	2003	29
Landings of Cod from the North Sea	All	1973	2003	31
Landings of Cod from other fisheries	All	1973	2003	31
Landings of Haddock	All	1973	2003	31
Imports of Cod	All	1976	2003	28
Imports of Alaska Pollock	All	1976	2003	28

Causation

Because fishing enterprises cannot control their output on a day-to-day basis it was assumed that causation travels from output to price. This follows long-established practice dating in Europe from Ioannidis and Whitmarsh (1987).

Results

The first attempt to model the market and to provide estimates of the level of mis-reporting followed Rodgers (1996, 1998). Broadly this was to estimate an inverse demand function with a partial correction for first-order autocorrelation and with dummies among the explanatory variables which allowed for alteration of both the intercept and the gradient of the function during periods when misreporting was believed to be taking place. However, despite an apparently reasonable estimate of the function, the results of the simulations using the function with dummies extinguished which were intended to calculate the level of misreporting were unconvincing.

When static simulations were run (using observed values of the lagged dependent variable) there were signs of explosive oscillation within the model. When dynamic simulations run (using estimated values of the lagged dependent variable) the results were more exaggerated but stable. However, the estimate of the last observation, when there had been a sharp fall in reported landings as a result of cuts in the Total Allowable Catch, was noticeably higher. This suggests that the price in the model was not reacting as the price in the real world had done to the change in landings.

The implication is that the dynamic in the model was incorrectly specified. This could have been the result of a mis-specification of the function and especially of the lag structure or it could be the consequence of poor estimates of the coefficients of the function but from the tests it was not immediately obvious what the source of the problem was and various attempts to change the specification failed to eradicate the obvious error in the estimate of the last observation.

It was decided to try a different approach. The Kalman method was used to regress the price of cod on landings of North Sea cod, landings of cod from elsewhere, landings of haddock, imports of cod, and imports of alaska pollock. All the variables were in logs. In the specification finally accepted as best, landings of cod from elsewhere was omitted as an explanatory variable having shown to be wrong-signed and insignificant. This was somewhat unexpected as it suggests that buyers do not look to other auction markets for a substitute. Perhaps this would require developing a trade route that would be unreliable or ephemeral whereas it is easier to expand existing imports lines.

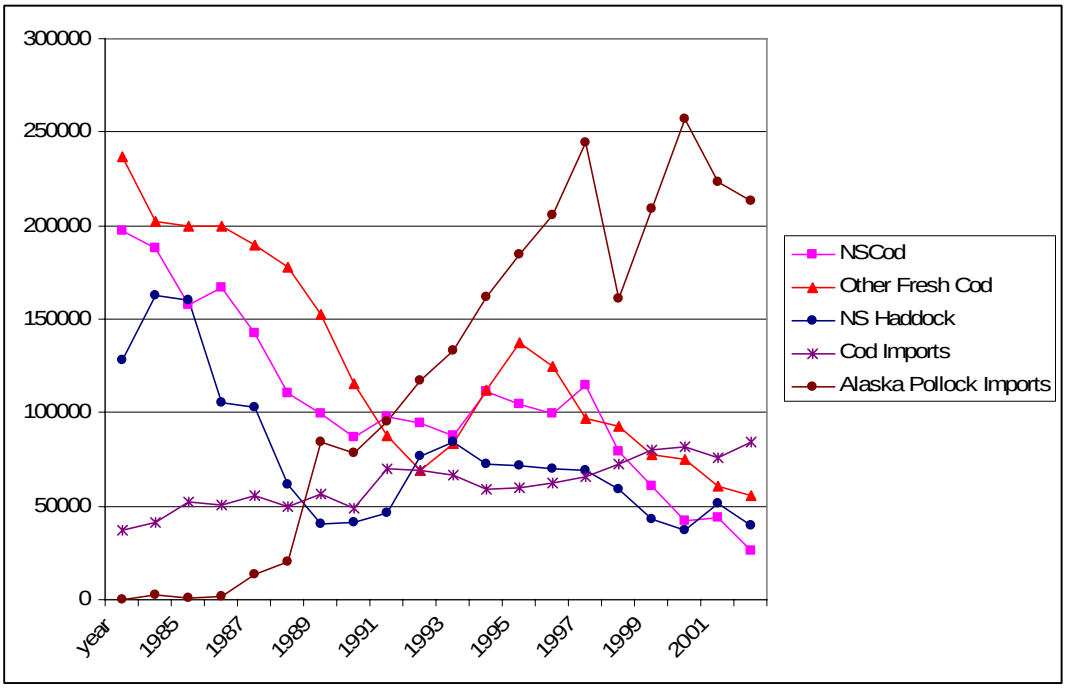
Figure 1: Kalman Estimates of the Coefficients of the Inverse Demand Function for North Sea Cod

Variable	Estimated Coefficient	t-Statistic	P-Value
Constant	36.700		
Landings of North Sea Cod	-1.426	-16.88	0.000
Landings of North Sea Haddock	-0.297	-3.97	0.000
Imports of Cod	-1.349	-17.46	0.000
Imports of Alaska Pollock	-0.099	-1.67	0.095
Adjusted R-Squared	0.859		
Observations for Prior Estimation	6		
Observations for Estimation	21		

The influence of imports of cod was found to be lagged one year. The function explains 85% of the variability in the log of the price and the fitted values have a root mean squared percentage error of 5.48%. The explanatory variables were significant at the 1% level except for the log of imports of alaska pollock which was only significant at the 10% level. Imports of this important substitute for lower value cod products have grown from nothing to over 200,000 tonnes during the estimation period and it was felt necessary to continue to include the variable in the function. When excluded 3% of the explanatory power of the function was lost. In the same period

landings of cod from the North Sea have fallen from around 200,000 tonnes to 25,000 tonnes and from elsewhere landed into the six countries from 200,000 to 55,000, while imports of cod have risen from 26,000 tonnes to 84,000 tonnes. The total of these varies between approximately 400,000 and 500,000 tonnes. Figure X shows the progress of the explanatory variables.

Figure 2: Landings of North Sea Cod and Substitutes into North Sea Countries 1983 to 2004



It appears that the processing industry does not immediately switch inputs but waits until it is able or perhaps compelled to change but this rigidity was rather unexpected. This suggests that the independent variables may not be orthogonal, challenging one of the assumptions fundamental to econometric estimation.

The Kalman method proceeds by estimating the coefficients of the function in the first observations with one degree of freedom and then repeating the calculations with the addition of each successive time period.

In each time period, the dependent variable, price, will include an element governed by official landings and the other explanatory variables and a second element caused by the misreported landings, as well as the residual. This second element will cause the estimated value of the constant term to shift, downwards for over-quota landings and upwards for ghost landings.

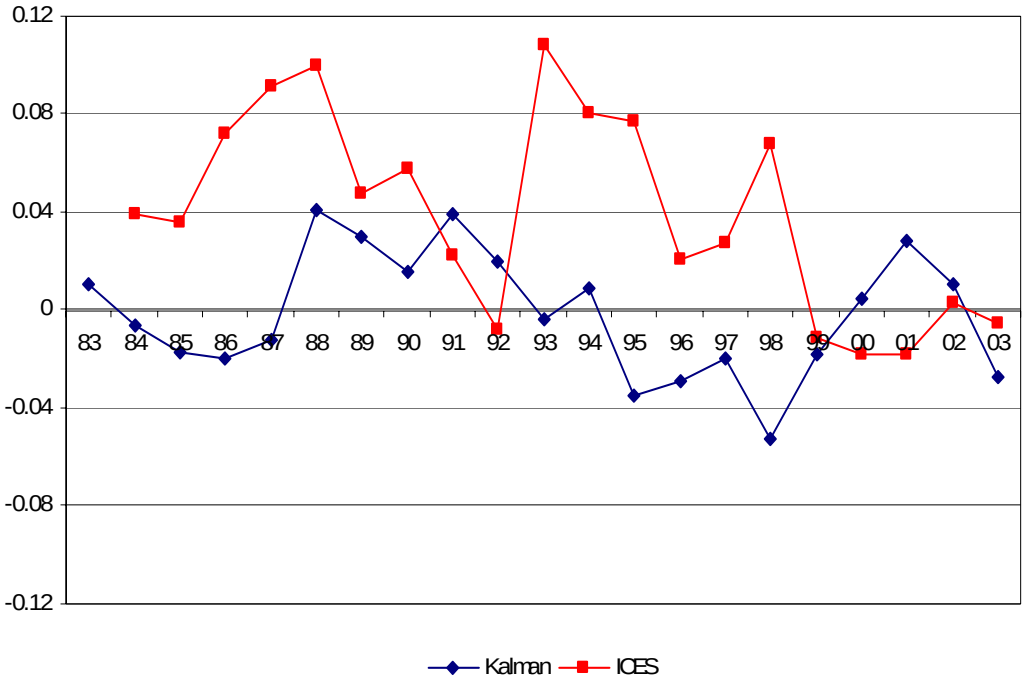
To calculate this second element, the successive estimates of the constant term were retrieved and regressed as the dependent variable on the two dummy variables. Both explanatory dummies proved significant. The estimates of the constant term again retrieved.

Figure 3: Kalman Estimates of the Coefficients of the Constant Term Function

Variable	Estimated Coefficient	t-Statistic	P-Value
Constant	37.280		
Intercept Dummy	-3.134	-16.88	0.000
Gradient Dummy	0.255	-3.97	0.000
Adjusted R-Squared	0.953		
Observations for Estimation	27		

Two simulations were then run to calculate the quantity of landings, first of the originally-estimated equation (assuming the residuals were all zero) and secondly of the function but with the Kalman estimates of the constant term with the dummies in place. These produce an estimate of what the model says the official landings were and of what the actual landings were, comparing like with like and giving a percentage difference. Figure X shows the differences in graphic form and compares them to the estimates made by scientists on the ICES North Sea Working Group (ICES 2005).

Figure 4: Percentage Difference of Estimated Landings from Reported Landings



Discussion

This project set out to model the market for North Sea cod as an integrated unit and to use variables which respond to changes in both the intercept and gradient of the demand curve to separate the impact of misreported landings from the residuals. The method previously developed [4] proved insufficient for the aggregated model. Refinements using the latest understanding of the influence of the unit root hypothesis [5], and market integration [3] on econometric estimates of demand and inverse demand functions have been unnecessary beyond showing the presence of at least a partially integrated market and that the six countries covered are within that market, but it has again been shown that it is possible to calculate the extent of misreported landings and to correct official figures by examining the movement of the price in the market.

It would be possible, if the will existed, to use econometric methods more widely to examine the figures published by individual countries for each species.

There are several standard problems which may continue to present difficulties. The first is accurate specification of the inverse demand function needed to enable official landings figures to be revised. It is the task of research to tease out this relationship which will vary for each species and country (or group of countries). The research reported in this paper has suffered from an inadequacy of price data. The basic time series of data for own-quantities and cross-quantities of landings and imports are available from published sources. The price variable has had to be concocted using six series, none of which shared the same time period. In the European Union countries this problem should be gradually eradicated as the data is now collected in conformity with the Data Collection Regulations (EU 2000).

The failure to identify significant explanatory power in the quantity of landings from elsewhere has been a disappointment as intuitively they appear to be a near perfect substitute. It can be rationalised by buyer behaviour, but this is not entirely convincing and leaves a question as to whether some degree of multicollinearity or perhaps autocorrelation has affected the estimates of the coefficient.

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