Structural Breaks in the European and US Market for Salmon

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Abstract This study investigates a possible structural break in the relationship between the price of Norwegian salmon exported to the EU and prices of Chilean salmon exported to the US. A structural break is expected in the spring/summer 1997 because restrictions on price and quantum on Norwegian salmon was introduced at this time. A test for cointegration suggests that there is a long term relationship between prices of salmon in the EU and US before and after the break. A Chow test reveals that that there is a distinct structural break in May 1997. The study can and will be improved in subsequent studies by using better tests for cointegration.

Keywords: salmon, cointegration, structural break

1 INTRODUCTION

In 1996-97 the Commission of the European Union started an investigation on dumping of Norwegian salmon in the European market. The investigation was initiated when Scottish Salmon Growers Association filed a complaint to the Commission in June 1996. As a consequence of this, the Norwegian government and the Norwegian salmon farming industry introduced quotas on fish meal to prevent the Commission from imposing tariffs on exported salmon. The government also agreed to implement a minimum price and export quotas on Norwegian salmon. This study investigates whether this has led to changes in the long-term relationship between the European and the US market for salmon products.

2 METHODOLOGY

Two or more timeseries are defined as cointegrated if a linear combination of these has a stationary error term. Let Y be a $T \times 1$ vector and X a $T \times k$ matrix. X may contain a unit column. Further, let β be a $1 \times k$ vector of coefficients and u a $T \times 1$ vector of residuals. Then the variables are said to be cointegrated if the residuals u of the linear combination

$$Y = \beta X' + u \qquad (1)$$

are stationary. The residuals are stationary if we have

$$u_t = \rho u_{t-1} + \varepsilon_t \qquad \rho < 1 \qquad (2)$$

Where ε_t is *iin*. If $\rho < 1$ the variance and autocovariance of u_t converges to a constant, var(u)=1/(1−ρ^2). A constant variance implies that there exists a long-run relationship between the variables since the average absolute deviation does not change. If $\rho = 1$ the variance will increase over time, $\text{var}(u) = t$, and there is not a long-run relationship between the series (Maddala 1998).

3 TEST PROCEDURE

There are many different ways to test for stationarity in the residuals, or alternatively, to test (1) directly for cointegration. The one most used is the Augmented Dickey-Fuller test (ADF-test). This test has been much criticized for the lack of power, the ability of the test to distinguish the null and the alternative hypothesis. Also the test has been criticized for size distortion, which may result in ambiguity of the significance level (Maddala 1998).

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However, here the ADF test will be applied as the only measure of cointegration, as other test has not yet been applied to these data. The problem with lack of power is mainly a problem when one cannot reject the null hypothesis of a unit root, though. One advantage of the ADF procedure is the simplicity of the test, making it easy to do recursive testing.

The ADF t-test has a standard t-statistic, but with a different distribution than in the normal case. The critical values are calculated by MacKinnons response surface estimates (Maddala 1998). The lag length of the test is chosen as the highest significant lag detected by a either autocorrelation matrix or a partial autocorrelation test.

The Chow-test is applied to test for structural break in the cointegration relationship (Intriligator 1996, p.97). In addition the QUSUM[2] and QUSUMSQ[3] plots are used to evaluate possible breakpoints.

4 RECURSIVE ESTIMATION

First a backward and forward ADF test is performed. The backward statistic at time τ is estimated by first estimating regression equation (1) by OLS for the observations from τ to T. Then an ADF test is run on the resulting estimated residuals. This procedure is carried out for all $\tau \in \{1, T\}$. A plot of the resulting test statistics against the corresponding τ's gives an indication of for which interval ending in the terminal period the timeseries is stationary, if any. A forward ADF is performed in much the same way, except that the residuals to run ADF on are estimates from observations in the period 1 to τ.

Second a recursive Chow-test is performed, which measure the gain in terms of reduced variance by dividing the sample in two. At each time in the sample period, the sample is divided into two sub-samples at the date τ. The residuals from the two sub-samples, estimated by OLS as in (1), are then used to calculate the Chow-test statistic. This procedure is carried out for all $\tau \in \{1, T\}$

Third, to check if the structural break is due to changes in the intercept or the trend term of the ADF regression, a recursive t-test and F-test on dummies of these variables is performed. The ADF regression equations at time τ is thus changed to:

$$\Delta u_t = \mu + \gamma t + \delta u_{t-1} + \sum_{i=2}^{l} \delta_i u_{t-i} + d + \varepsilon_t \qquad (3)$$

$$d = 0 \quad \text{if} \quad \tau < t$$

where the dummy observations prior to τ is $d = t$ when the test is for the trend term and $d = 1$ when the test is for the constant term.

5 THE DATA

Monthly data from the US on quantum and value of imported salmon from Chile to the US is used as the dependent variables. This data is available from National Marine Fisheries Service. The independent variables are quanta and values of imported salmon to the EU from Norway, extracted from Norwegian export statistics. The sample period was 1995-2000[4] and counts 63 cases. The US prices were converted to NOK. The data was

Table 1: Some main statistics on the regressions *1% : d_L=1,41 d_U=1,4

	Structural break May-97	R^2	Durbin-Watson statistic*	ADF test-statistic	ADF-Test critical value (10%)	Result
Fresh filet	After the break:	0.88	0.76	-5.06	-3.79	Cointegrated
	Before the break:	0.83	1.52	-4.03	-3.80	Cointegrated
Fresh	After the break:	0.31	0.52	-2.68	-3.71	Not cointegrated
	Before the break:	-0.03	0.68	-2.84	-3.76	Not cointegrated
Frozen	After the break:	0.13	1.61	-3.94	-3.72	Cointegrated
	Before the break:	-0.35	1.98	-1.53	-3.89	Not cointegrated
Frozen filet	After the break:	0.45	1.27	-3.97	-3.72	Cointegrated
	Before the break:	-0.48	2.13	-5.36	-3.78	Cointegrated
smoked	After the break:	0.23	1.69	-1.21	-3.79	Not cointegrated
	Before the break:	-0.14	0.77	-2.19	-3.77	Not cointegrated

7 5% : d_L=1,57 d_U=1,63

[2] Sum of current at previous error terms at each instance in time

[3] Sum of current at previous squared error terms at each instance in time

transformed using the natural logarithm.

The samples had five products in common; fresh filet, fresh, frozen filet, frozen and smoked.

6 RESULTS

For each product the Norwegian data was regressed on the corresponding US data and a constant term[5]. Table 1 shows some main statistics for the regressions. The ADF test is performed on residuals before and after the assumed date of the structural break, May 1997. The figures in the table indicate that the most correlated series are the fresh filet series, with a R^2 of .8-.9 before and after the break. This is also the only fresh product exempted from the US import tariff on Norwegian salmon. The residuals of fresh and frozen filet appear to be stationary before and after the break. Also, frozen salmon seem to be cointegrated after the break. It seems like the main reasons for failure to reject the null hypothesis of unit root in the other regressions is high unexplained variance in the data and not close to zero coefficients.

The fresh and frozen filet samples are both cointegrated before and after the break and display the highest explained variance ratio (R^2). These regressions are therefor selected for further analysis.

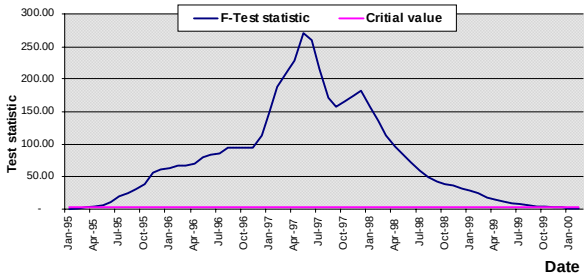

Chart 1: Recursive Chow-test for fresh filet

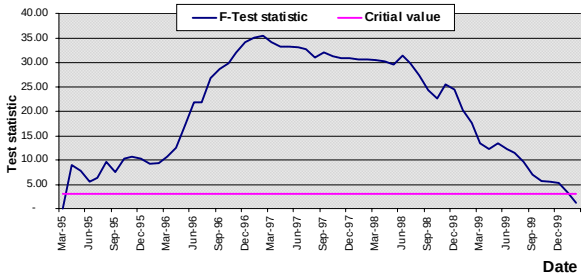

Chart 2: Recursive Chow-test for frozen filet

Both tests in Chart 1 and

Chart **2** indicate a structural break in the period 1996-97. However the break in the fresh filet regression is much more defined then in the frozen filet case, which may be due to less unexplained variance in this regression. A suspicion confirmed by a visual inspection of the plotted data in Chart 3 and Chart 4:

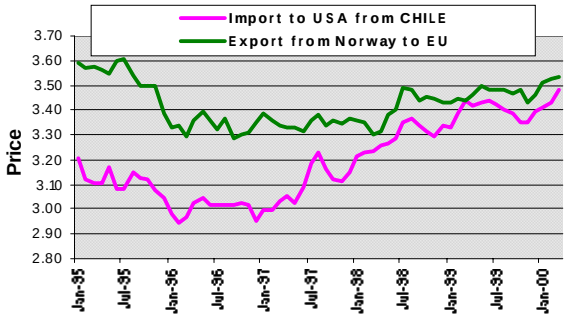

Chart 3: Plot of fresh filet of salmon

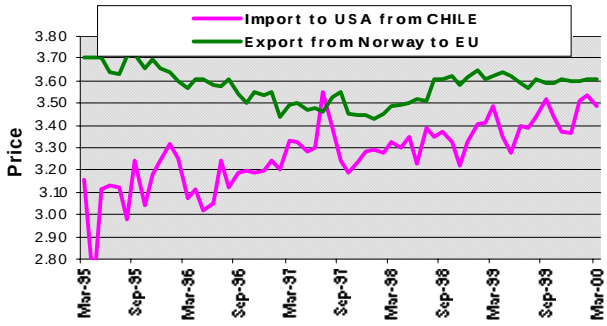

Chart 4: Plot of frozen filet of salmon

Because of the ambiguous breakpoint in the frozen filet series, we proceed with the fresh filet sample only. A backward and forward ADF test will reveal for which periods the series are cointegreated and for which they are not. Chart 5 and Chart 6 show that the series are cointegreated at the breakpoint, which is expected since the break implies that the cointegrating vector β in (1) has changed. The backward ADF-statistic is significant at a 1% level and the forward at a 10% level at this point.

[4] That is January 1995 to March 2000.
[5] The Norwegian data was lagged one month behind the US data in order to improve the test results.

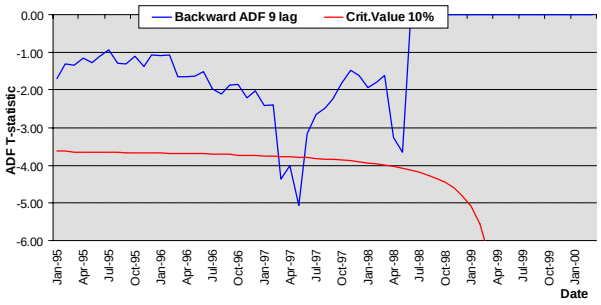

Chart 5: Backward recursive ADF t-tests on fresh filet

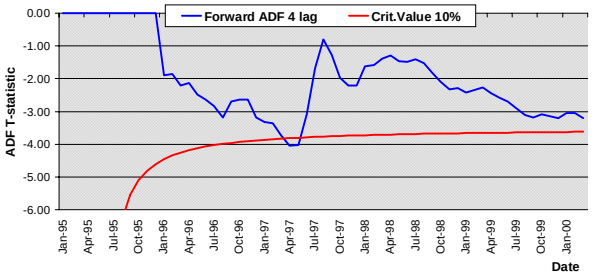

Chart 6: Forward recursive ADF t-tests on fresh filet

In Chart 7 the constant term and trend term of the ADF-regressions shows a drop in these terms, indicating that the break is partly due to changes in these coefficients:

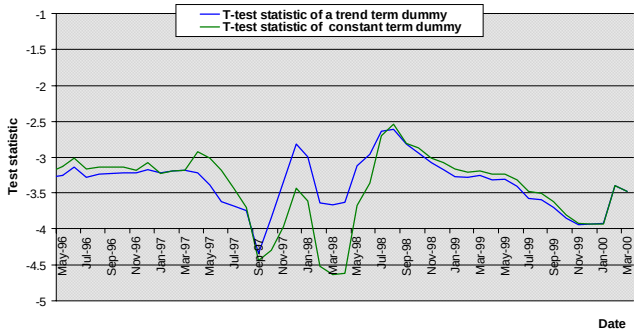

Chart 7: Drop in constant and trend term dummy after the breakpoint

7 CONCLUSION

There seems to be a definite break in the relationship between prices of fresh filet of salmon in the US and the EU in the spring 1997. It is not completely certain though that the break occurs because of the actions taken by the Norwegian government and the industry itself since the plot of the variables in Chart 3 indicates that there has been a change in the trend of the US fresh filet price as well. It is however reasonable to believe that the actions taken did stabilize the Norwegian salmon price at the minimum price set by the EU. The actions are therefor likely to have prevented the price from dropping further after mid 1997. A visual inspection of the prices in Chart 3 suggest that if the prices had dropped further, the breakpoint should have been in early 1996 since that was the time when the price of Chilean fresh filet of salmon started to increase. Since the detected break was at the same time as the introduction of minimum prices and quotas on export and fish meal, it seems likely that one to some extent can attribute the structural break to these actions.

In this study a ADF test on cointegration is used. This test has been criticized for lack of power and size distortion. Better tests are available and will be applied in subsequent studies on this topic.

8 REFERENCES

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Intriligator, M.D., Bodkin, R.G and Hsiao, C.: "Econometric Models, Techniques and Applications", Prentice-Hall 1996.