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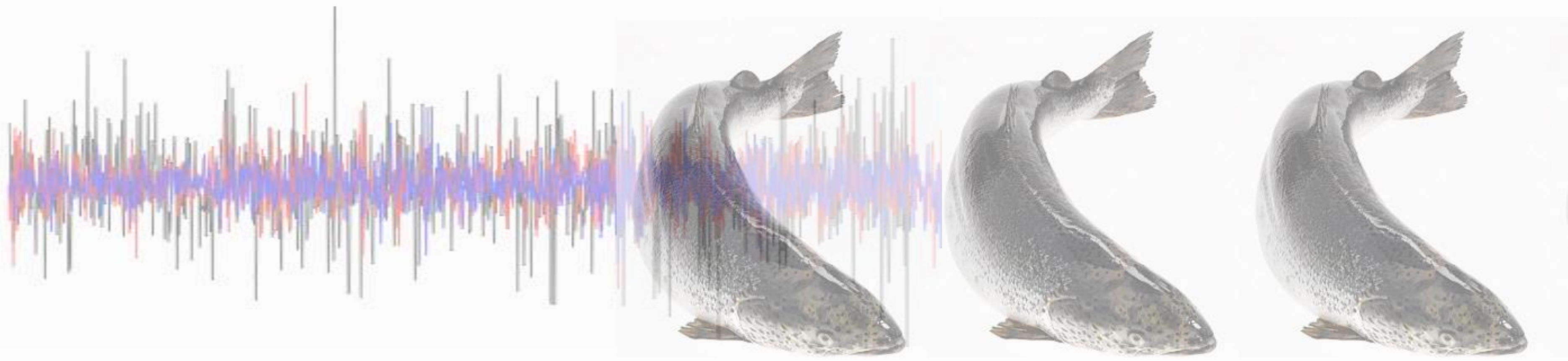

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Price Formation in the Salmon Futures Market

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Abstract

The study examines the relationship between salmon spot market prices and up to 12 month maturity futures contract prices. Mixed results are found but in majority of the cases; cointegration relationship is established and unbiasedness hypothesis is found to hold, revealing the presence of risk neutrality and market efficiency. Also, futures contracts tend to lead the spot market. The shorter the futures contract, the higher the volatility and hence the higher would be the risk premium. The evidence points towards a maturing exchange market capable of serving as a price risk management tool.

Introduction

Futures market have been used in the agricultural sector for decades as a price risk management. Extension into the seafood industry has been a challenge. For example;

- Frozen shrimp futures in 1960s was discontinued due to low trading volumes on the Chicago Mercantile Ex.
- Another on the Minneapolis Grain Ex. discontinued due to lack of interest (Engle & Quagrainie, 2008).
- That of Japan could not achieve global reach.

Comparatively, grains and frozen shrimp are effectively storable/non-perishable commodities. On the contrary, fresh salmon is a non-storable renewable resource (Ewald, 2013) and perishable. However, the salmon futures exchange has existed for a decade.

Questions raised in this study are:

1. **Is the salmon futures market a suitable risk management tool?**
2. **What is the term structure of volatilities of the futures contract?**

The study partly extends Asche et al (2016) and contributes to the limited body of literature on the functioning of futures market in the seafood industry.

Theory and Empirical Methods

The pricing of futures contracts revolves around two frameworks: the theory of *storage* and *risk premium*. As opposed to Asche et al (2016), we employ the later. Empirical formulation of research question 1 is:

$$s_t = a + \beta f_{t-1} + u_t \qquad eq.1$$

where s_t is current log spot prices, f_{t-1} is log futures prices one period to maturity, a and β are unknown parameters.

The unbiasedness hypothesis requires the restriction of risk neutrality ($a = 0$) and efficiency ($\beta = 1$) and u_t to be white noise. Eq.1 is estimated using Johansen (1988) ML approach to avoid spurious results.

The term structure of futures volatility is analyzed based on the:

- Samuelson (1965) hypothesis/Maturity Effect: *that futures price volatility decreases as the futures contract approaches its expiration date (TTM).*
- Bessembinder et al (1995,1996): *maturity effect holds in markets that exhibit negative covariance between the spot price changes (ΔS_{it}) and changes in net carry cost (Δc_{it}).*

The following empirical models were estimated:

$$r_t = \mu + \vartheta r_{t-1} + \varepsilon_t,\ \varepsilon_t | \boldsymbol{\Omega}_{t-1} \sim i.i.d(0, \sigma_t^2) \qquad eq.2a$$

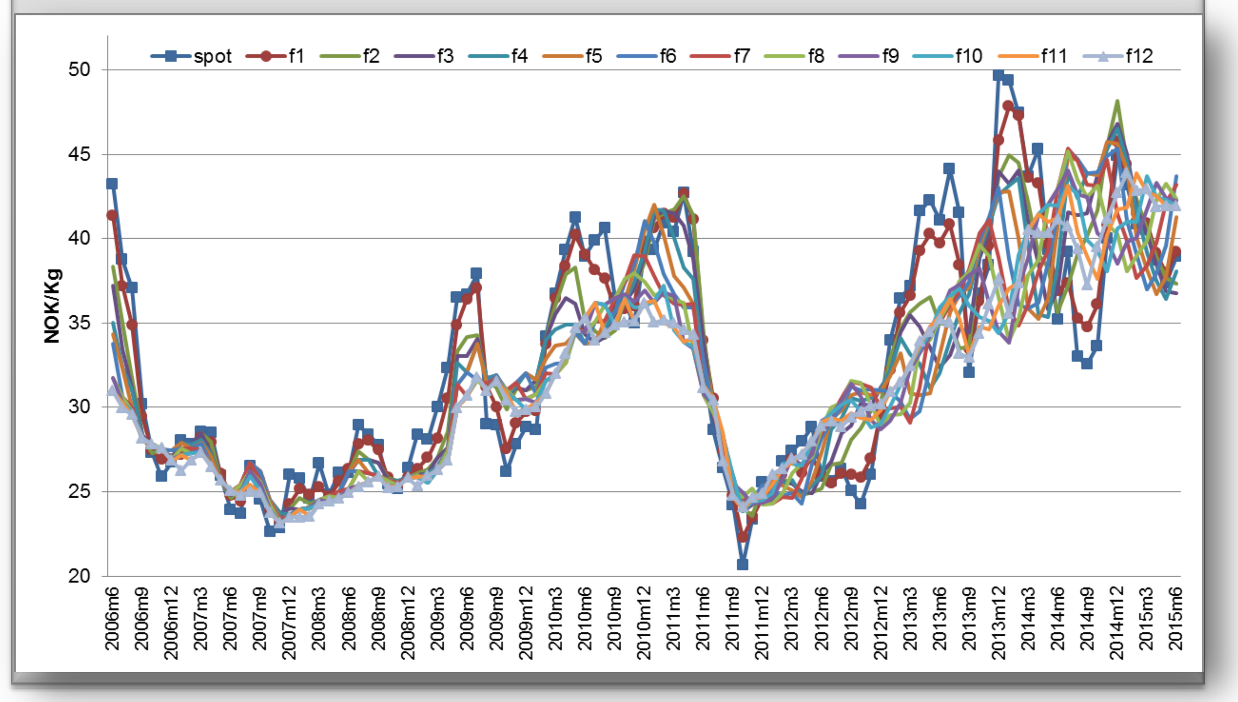
$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \delta TTM_t + e_t \qquad eq.2b$$

$$\Delta c_{it} = \gamma_0 + \gamma_1 \Delta S_{it} + \epsilon_{it} \qquad eq.3$$

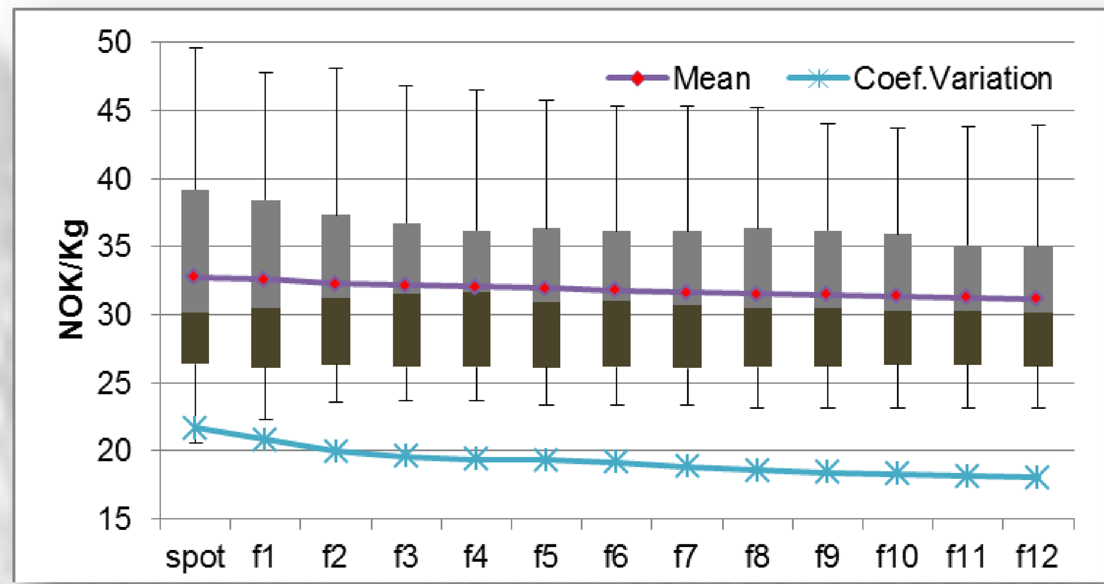
where r_t is the futures contract log return for time t, ε_t is the error term with mean zero and conditional variance σ_t^2, c_t is net carry cost: $c_t = (\ln(F_t) - \ln(S_t))/TTM_t$. TTM_t is the time left to maturity at time t. The hypothesis holds if δ and γ_1 are strictly negative and significant.

Data

The spot and futures (f#) contract prices were obtained from the Fish Pool website (www.fishpool.eu). The data span from 2005 to 2015 and 1 to 12 month maturity futures contracts were included in the analysis. The evolution of prices is shown in figure 1 below:



The summary statistics is shown in figure 2 below:



As observed, the mean and coefficient of variation decreases with increasing futures contract maturity. Implying that near month contracts are more volatile.

Results

First, all series tested unit root using the ADF test and a series of panel unit root test. Following this, the cointegration test of Johansen ML approach is undertaken. The results are presented in Table 1 below:

Table 1 Bivariate Johansen Test for Cointegration for Spot and Futures Prices

	$r=0$		$r=1$				
	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	β	a	$P(a=0, \beta=1)$
lSpot-lf1(3)	22.72**	18.45**	4.27	4.27	0.97	0.11	0.86
lSpot-lf2(5)	22.72**	18.99**	3.73	3.73	0.98	0.07	0.58
lSpot- lf3(13)	22.03**	20.65***	1.39	1.39	0.84	0.54	0.20
lSpot- lf4(9)	20.76**	17.10**	3.65	3.65	0.89	0.38	0.25
lSpot-lf5(11)	23.49**	20.77***	2.73	2.73	0.82	0.63	0.07
lSpot-lf6(5)	23.97**	18.28**	5.69	5.69	1	0.01	0.33
lSpot-lf8(5)	16.66	13.47	3.19	3.19	0.87	0.47	-
lSpot-lf9(2)	26.88***	24.86***	2.02	2.02	0.98	0.08	0.21
lSpot-lf10(5)	13.67	11.50	2.18	2.18	0.83	0.62	-
lSpot-lf11(5)	11.62	9.37	2.25	2.25	0.86	0.52	-
lSpot-lf12(18)	27.09***	21.82***	5.27	5.27	0.88	0.46	0.01

Lags used for cointegration are shown in parentheses and were selected based on one that gives well specified model. ** and *** indicate that the null hypothesis is rejected at 5% and 10% level respectively.

Table 2 Weak Exogeneity and Granger Causality Test

Contract Length	Dep Variable	Weak Exogeneity		Short-Run Causality Chi-square-statistic
1 month	d(spot)	α_1	-0.03	2.26
	d(f1)	α_2	0.27***	38.79***
2 months	d(spot)	α_1	-0.07	6.54
	d(f2)	α_2	0.23***	23.21***
3 months	d(spot)	α_1	-0.77***	20.50*
	d(f3)	α_2	0.11	28.21***
4 months	d(spot)	α_1	-0.47***	21.57**
	d(f4)	α_2	0.10	18.65**
5 months	d(spot)	α_1	-0.62***	17.04
	d(f5)	α_2	0.02	43.44***
6 months	d(spot)	α_1	-0.14	3.86
	d(f6)	α_2	0.14***	27.55***
8 months	d(spot)	α_1	-	-
	d(f8)	α_2	-	-
9 months	d(spot)	α_1	-0.30***	0.29
	d(f9)	α_2	0.04	3.58
10 months	d(spot)	α_1	-	-
	d(f10)	α_2	-	-
11 months	d(spot)	α_1	-	-
	d(f11)	α_2	-	-
12 months	d(spot)	α_1	-1.18**	18.59
	d(f12)	α_2	0.14	19.91

*, **, *** significant at the 10%, 5% and 1% levels respectively

- Spot and futures contract prices move together (cointegrated) for 8/12 contracts for maturity periods (in months) – 1, 2, 3, 4, 5, 6, 9 and 12 (see Table 1).
- Unbiasedness (a=0 β=1) holds in 7/8 cointegrated pairs at the 5% significance level (all excl. the 12-month futures contract) – last column in Table 1.
- Weak exogeneity (Table 2) – futures contracts for 3,4,5,9 and 12 months maturity lead the spot markets (5/8 cointegrated pairs).

Tables 3 and 4 present the term structure of volatility (Samuelson hypothesis) respectively from the GARCH model and the Bessembinder et al theory/model.

Table 3 AR(1)-GARCH (1,1) model for Samuelson hypothesis

Conditional Mean	Model 1	Model 2	Model 3	Model 4
μ	0.004***	0.003***	0.003***	0.003***
ϑ	0.309***	0.293***	0.290***	0.289***
ω	0.0003**	-5.296***	-5.307***	-5.924***
Conditional Variance				
α	0.311***	0.305***	0.229***	0.216***
β	0.630***	-0.059***	-0.056***	-0.039
δ		***-0.082****	***-0.080****	***-0.077****
$(Spotreturn)^2$				27.50***
$F(Seasonality = 0)$			97.22***	64.11***
N	3103	3103	3103	3103
DoF	2.60	2.592	2.798	2.913

*** Significant at 1% level. DoF indicates the degree of freedom of the test and N is the sample size. Residual errors follow a Student t-distribution. Inferences are based on the Huber-White standard errors.

Table 4 The Negative Covariance Model

Parameters	Monthly Level		Weekly Level	
	Δc_t	Δc_t	Δc_t	Δc_t
γ_0	0.000	-0.003***	0.000	0.001**
γ_1	**-0.003*****	**-0.002*****	**-0.004*****	**-0.004*****
F(Season=0)		6.18***		1.490
ρ	-0.089	-0.105	-0.180	-0.181
R²	0.391	0.4014	0.336	0.337
DW-Stat	1.997	2.000	2.096	2.097

***, ** significant at 1% and 5% levels respectively. Note: changes in net carry cost and spot prices are stationary.

- The parameters: δ and γ_1 are statistically significant and negative.
- Volatility increases with time to maturity
- Not surprising since Atlantic salmon exhibit short term seasonal cycles as agricultural products.

Conclusion

- The salmon futures market shows a maturing market and is capable of being used as a price risk management tool.
- Long running contracts are less volatile and hence the cost of insurance paid in the form of risk premium will be less in such contracts.

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