The Spot-Forward Relationship in the Atlantic Salmon Market

by

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Abstract

This study examines the Fish Pool salmon futures contract with respect to how well the market performs in terms of the futures price being an unbiased estimator of the spot price and whether the market provide a price discovery function. Using data for 2006-2014 and with futures prices with maturities up to 6 months we find that spot and lagged futures prices are cointegrated and that the futures price provides an unbiased estimate of the spot price. We also find that, with the exception of the front month, that the causality is one-directional. The spot prices lead futures prices between 1 to 6 months maturity. Hence, while the spot and lagged futures prices are unbiased estimates, we do not find support for the hypothesis that futures prices provides a price discovery function. Rather, it seems that innovations in the spot price influence futures prices. This finding is not uncommon in new and immature futures contracts markets. Hence, the salmon futures market is still immature and has not yet reached the stage where futures prices are able to predict future spot prices.

Key words: Atlantic salmon, futures prices, price discovery

JEL codes: G13, G14, Q22

Introduction

Farmed salmon production has been rapidly growing for three decades, and production passed 2.5 million tonnes in 2013 and is expected to continue to grow (Kobayashi et al, 2015). As production increased, the industry has attracted a number of suppliers providing a varied set of services, contributing to productivity growth and competitiveness (Asche, 2008). Among these are Fish Pool, who established a futures exchange in 2007. For most large quantity food commodities, futures markets are an important risk management tool as producers and buyers can hedge price risk, and the futures market provides price discovery as the futures price provide an unbiased estimator of future spot prices. However, most new futures markets do not succeed for a number of reasons (Brorsen and Fofana, 2001), and the trade in the contract is terminated after a relatively short time. The limited attempts at establishing futures contracts for seafood are examples of this. The shrimp futures contracts at Minneapolis Grain Exchange as the futures price did not provide an unbiased estimate for the spot price (Martínez-Garmendia and Anderson, 2001), liquidity was limited and it provided a poor tool at hedging (Martínez-Garmendia and Anderson, 1999).

In this paper we will investigate whether the Fish Pool salmon contract is an unbiased estimator of the spot price and whether the market provides price discovery, and as such whether this market indeed follows the basic characteristics of a well working futures market. That the futures contract price is an unbiased estimator of the spot price is a required feature if the market is to succeed, as only then can the futures contract be used as a risk hedging tool (Brorsen and Fofana, 2001). We do not investigate other criterions for a successful futures market as outlined by Brorsen and Fofana (2001) formally as they require other approaches, but will provide a discussion of the criterions in relation to the salmon futures contract.

The growth in farmed salmon production is primarily due to a substantial productivity growth that has reduced real production cost to less than a third of the level in the early 1980s. Most of the literature has focused on the production stage (Asche, Tveteras and Roll, 2009; Vassdal and Holst, 2011; Roll, 2013; Asche, Guttormsen and Nielsen, 2013). However, it has long been recognized that a substantial part of this productivity growth are provided by input suppliers (Tveteras and Heshmati, 2002), and Sandvold and Tveteras (2014) provide a recent example of in the case of smolt providers. There is also substantial productivity growth associated with downstream activities, and this has led to vertical integration (Kvaløy and Tveteras, 2008; Olsson and Criddle, 2008; Asche et al, 2013), use of contracts (Larsen and Asche, 2011) and focus on other aspects of the transaction mechanisms such as invoicing currency (Straume, 2014). Futures contracts provide an additional tool to hedge risk and reduce transaction costs. The salmon price is volatile and contributes substantially to a salmon farmer's risk (Sikveland and Oglend, 2008; Sollibake, 2012; Oglend, 2013), although there are other seafood prices that are more volatile (Dahl and Oglend, 2014; Asche, Dahl and Steen, 2015), and price forecasting is difficult (Gu and Anderson, 1995; Guttormsen, 1999).[1] The hedging opportunity provided by a futures contract can accordingly smooth revenue flows and reduce risk management costs. This can be particularly important since price is the main factor in explaining variation in profitability in (Norwegian) salmon farming (Asche and Sikveland, 2015).

Our methodological approach follows the standard in the literature investigating if futures prices are unbiased estimates of the spot price and whether the market provide a price discovery function. It is well known that salmon prices are nonstationary, and the first step is then to test for cointegration. Most relationships do not pass this test for the shrimp futures in Martínez-Garmendia and Anderson (2001). If spot and futures prices are cointegrated we go on to test if the futures price is an unbiased estimator of the spot price and whether there is causality in either direction. We use a sample consisting of salmon spot and futures prices with maturities between one month forward and six months. We use monthly observations covering the time period 2006-2014.

[1] Inelastic supply (Andersen, Roll and Tveteras, 2008; Aasheim et al, 2011) and demand that is becomming less elastic (Asche, 1996; Xie and Myrland, 2011; Dey, Rabbani and Singh, 2014) do of course contribute to increased price volatility, as do supply shocks (Asche, Oglend and Xhang, 2015) and demand shocks (Sha et al, 2015; Asche et al, 2015). A particular feature of aquaculture species is that also supply shocks from wild fisheries can influence price volatility (Anderson, 1985; Anderson et al, 2015; Jensen et al, 2014).

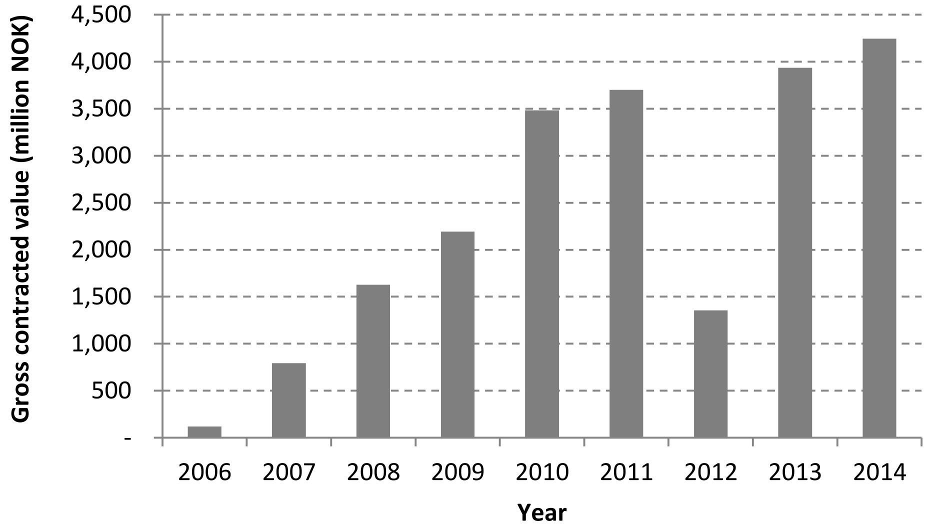
We find that spot and lagged futures prices are cointegrated up to maturities of 6 months. We also find that, with the exception of the front month, that the causality is one-directional. The spot prices lead forward prices between 1 to 6 months to maturity. Hence, while the spot and lagged futures prices are unbiased estimates, we do not find support for the hypothesis that futures prices are predictors of the future spot price for maturities longer than 2 months. Rather, it seems that innovations in the spot price ripple out into the futures prices. This is contrary to findings in most other futures markets, where the opposite tends to be the case, but is not uncommon in new and immature markets.

The remainder of the paper is as follows. The next section reviews the literature, followed by descriptions of the data and methodology. The next section presents and discusses the results and the final section concludes.

Data and the Fish Pool exchange

There have been several attempts to introduce price hedging for salmon. The Swiss company Direct Hedge commenced the trade in a forward contract in 1999. Fish Pool introduced futures contracts in 2006, and it has been well received as traded value increase. Figure 1 shows the development in the gross contracted value since 2006.

Figure 1. Gross contract value



Note: The values are total gross contract value (in million Norwegian kroner) for each year of trading. Source: Fish Pool.

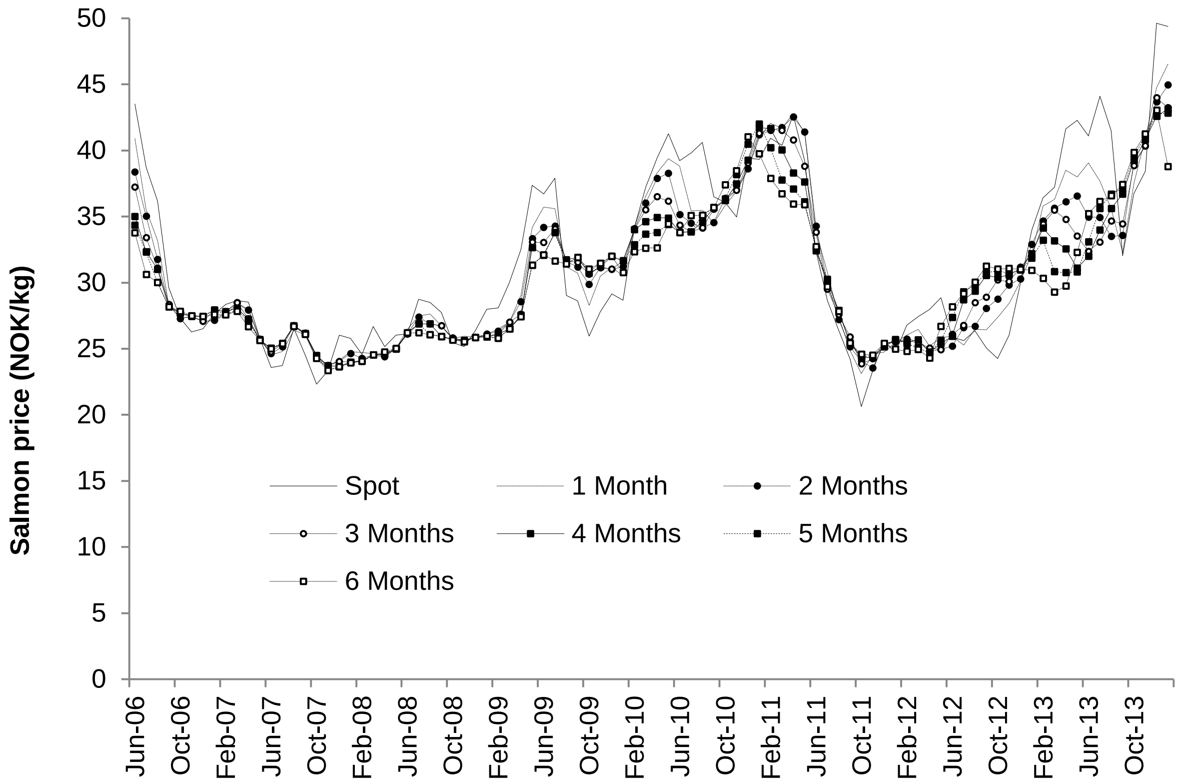
A challenge with a forward contract is that it is customized in the sense that the quantity varies between contracts and therefore the contract must match two specific traders with opposite positions. A futures contract is, on the other hand, a standardized contract with given maturity dates where one does not need to know who holds the opposite position. This also makes trading with the contracts much easier and the market's transaction price provides an estimate of future spot prices.

The Fish Pool contract size is one metric ton and the contract is a financial contract as there is no physical delivery. Rather, at the maturity date the owner of the contract gets paid an amount based on the spot price. This is given by the Fish Pool price index, FPI™ (www.fishpool.eu). The index is based on prices for different sizes of salmon and at different levels in the supply chains, utilizing the fact that different salmon markets are well integrated with a high degree of price transmission (Asche et al., 2014) to provide a broad base for the index. This construct also avoids the grading issue, as the price is always the average price and one does not have to take delivery of a grade one does not want as were the case for shrimps.[2]

Our empirical analysis use spot and futures price for fresh Atlantic salmon for the period June 2006 to June 2014, totalling 8 years and 96 monthly observations. Weekly observations of spot and forward prices for monthly maturities up to 6 months are collected from the Fish Pool exchange (www.fishpool.eu). As our spot price we use the weekly Fish Pool Index, FPI™ (www.fishpool.eu). We convert the weekly spot price to a monthly price by averaging 4 or 5 weekly FPIs in accordance with Fish Pool's product specification for futures contracts. For instance, if the January 2011 futures contract consists of the weeks 1 through 5, we average the FPIs in weeks 1 through 5 to calculate the January 2011 Spot price. The historical development of the monthly averaged spot price and the futures prices are shown in Figure 2. Although futures contracts exist also beyond six months maturity, these are excluded since their trading is thin and liquidity is low.

[2] Salmon prices are size dependent (Asche and Guttormsen, 2001).

Figure 2. Spot and Forward Atlantic salmon prices



Note: The spot price is the monthly average of the Fish Pool spot price index. The forward prices are monthly averages of daily observations of forward prices for maturities between 1 and 6 months. Prices are denoted in Norwegian kroner per kilo (NOK/kg). Source: Fish Pool.

The futures contracts are traded from date of listing until the second Friday after the delivery period. The trading of the contracts into the delivery period has the consequence that the prices in this period incorporate observations of the realized spot price in the same period. In order to avoid the problems with this, we only use the futures prices observations before the commencement of the delivery period. That is, we define the maturity date of the futures contracts as the last business day before the start of the delivery period.

Table 1 indicates that the spot price is on average slightly higher than the futures prices, indicative that the forward curve in the Atlantic salmon market is generally in backwardation. Also, there is positive skewness, which is an indication of the presence of upward price spikes. Moreover, the standard deviation is declining with time to maturity which is consistent with the Samuelson effect (Samuelson, 1965), describing a falling term structure of volatility.

Table 1. Descriptive statistics (log prices)

Maturity	Average	St.Dev.	Min	25 percentile	Median	75 percentile	Max
Spot	3.429	0.208	3.027	3.259	3.355	3.618	3.905
1 Month	3.417	0.186	3.141	3.259	3.345	3.576	3.841
2 Months	3.410	0.176	3.159	3.252	3.456	3.548	3.806
3 Months	3.406	0.168	3.167	3.256	3.374	3.532	3.784
4 Months	3.402	0.163	3.164	3.254	3.410	3.523	3.764
5 Months	3.399	0.161	3.153	3.252	3.406	3.517	3.757
6 Months	3.393	0.157	3.151	3.255	3.392	3.486	3.762

Note: The prices are monthly averages of the natural logarithm of spot and forward prices of maturities between 1 and 6 months. The spot prices are based on monthly averages of weekly spot observations. The forward prices are based on monthly averages of daily observations.

To test the time series properties of the data series the augmented Dickey-Fuller test (ADF) were carried out on log-prices in levels and first differences. The test is conducted both in the version with only a constant term and with a constant term and trend. Test results are reported in Table 2 below. The ADF tests provide clear evidence that log-prices are first-order integrated. The price series will therefore be treated as first-difference stationary.

Table 2. Unit root tests

	Log price in levels		Log price 1st differences	
	Without trend	With trend	Without trend	With trend
Spot	0.634	-2.607	-4.383*	-4.394*
1 Month	0.717	-2.482	-4.158*	-4.173*
2 Months	0.600	-2.353	-4.071*	-4.078*
3 Months	0.774	-1.962	-3.866*	-3.886*
4 Months	0.640	-2.617	-3.927*	-3.933*
5 Months	0.807	-2.310	-4.034*	-4.047*
6 Months	0.786	-2.020	-3.986*	-4.030*

Note: The ADF tests reports the test statistics for the null hypothesis of a unit-root. The tests including a trend accounts for the alternative hypothesis that the series is trend-stationary (ADF-test). Number of lags to include in the ADF testing procedure is determined by the Akaike Information Criteria.

* indicates significant at a 5% level

Theory and method

The shrimp futures at Minneapolis Grain Exchange is not the only poorly performing futures contract. Brorsen and Fofana (2001) indicate that nine out of ten new future contracts for food commodities fail. They indicate that the most important factor for the success of a futures market is an active spot market. This is a condition that the salmon market seems to fulfill and is more likely to fulfill in the future as production continue to grow. However, an increased use of contracts and more vertical integration works in the opposite direction. Other conditions are (Brorsen and Fofana, 2001): The own-hedge contract should be more effective in reducing risk than existing cross-hedge contracts. This is clearly the case as obvious cross-hedge alternatives for salmon do not exist.[3] Prices must be sufficiently variable to create a hedging need. With the substantial volatility reported for salmon prices (Dahl and Oglend, 2014), this seem to hold. The commodities traded must be homogenous and/or have a well-defined grading system. This was a key component in why the shrimp futures failed (Martínez-Garmendia and Anderson, 2001), and is a potential issue for salmon as there is size dependent pricing (Asche and Guttormsen, 2001). Finally, the cash market must be large enough to attract a large number of potential participants into the futures markets as either hedgers or speculators, to give the contract enough liquidity. As shown in

[3] This is because there is no market integration between salmon and any commodity for which there exist a futures contract. The only analysis of cross-hedges related to seafood we are aware of is Vukina and Anderson (1993), who show that fishmeal prices can be hedged with soyabean meal futures contracts.

Figure 1, the Fishpool exchange is improving on this point.

Most empirical studies of futures markets focus on the hedging properties and the price discovery of the contract. The theory indicates that futures and spot prices should reflect the same aggregated value of the underlying asset (Wright and Williams, 1989). Hence, the future price should be an unbiased predictor of the spot price.

With respect to price discovery, it is often argued that the futures prices respond more quickly to new information than spot prices due to lower transaction costs and flexibility of short selling. Spot purchases require more initial outlay and take longer to implement. If so, spot prices will react with a lag since spot transactions cannot be executed as quickly (Garbade and Silber, 1983; Silvapulle and Moosa, 1999). However, exogenous market shocks can lead spot prices to influence future prices, leading causality in both directions (Moosa, 1996).[4] The empirical literature finds that the future market indeed provides price discovery in many markets, while it is not uncommon to observe bidirectional causality.

There are also some cases where spot prices contain information about futures prices, but not vice versa (Quan, 1992; Moosa, 1996). This feature is particularly associated with immature markets as there are many types of market participants in the spot

[4] Salmon aquaculture is exposed to several types of production shocks that can lead to unexpected changes in produced quantity such as biophysical factors (Asche, Oglend and Zhang, 2015; Torrissen et al, 2011) and diseases (Torrissen et al, 2013).

market that do not participate in the futures market. In this setting, there does not appear to be enough informed buyers of the future contract for the future price to respond to news beyond what is reflected by the spot price.

Let p_t^sbe the expected spot price of the commodity at time *t*, and p_{t-n}^f be the current price for future delivery, e.g. a forward or futures price with maturity *t-n*. The basic relationship to be investigated is then:

$$\ln p_t^s = a + b \ln p_{t-n}^f + u_t, \qquad (1)$$

The intercept α allows the price levels to differ. This will typically be the case when there is a convenience yield. The slope parameter b specifies the relationship between prices. If b=0 no relationship exists between prices, while if b=1 the prices are proportional. If this is the case, the market will be unbiased and the future contract will provide a good hedge. It is also common to test the joint restriction $a = 0$ and $b = 1$. However, this does not hold for most commodities due to the convenience yield.

Equation (1) describes the case when prices are adjusted immediately. Normally, however, frictions will exist. Hence, a dynamic model is adopted through the introduction of lagged prices. This is also necessary to test hypothesis with respect to price discovery. In a vector autoregessive system containing the spot price and the futures price, both prices are assumed to be endogenous, and causation can run in both directions. If one price explains the other but not vice versa, one price will be exogenous in this system. Hence, if the futures price is to lead the spot price, the futures price must be exogenous.

As shown above, our price series are non-stationary. Hence, cointegration tests are the appropriate tool to use. Johansen's multivariate technique (Johansen, 1988, 1991; Johansen and Juselius, 1990) is now the standard test, and allows us to make inferences about the parameters of the equilibrium relationship between two or more time series as well as hypothesis with respect to the dynamics in the system, which is necessary to make inference with respect to price discovery. The Johansen test is based on a vector autoregressive error correction model (VECM). With the vector $\boldsymbol{P_t}$ containing the N prices we are interested in, the system can be written as:

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + e_t \tag{2}$$

The Π matrix contains the parameters in the long-term context when Π does not have full rank. Π;- $\Pi=\alpha\beta'$ can then be factorized, where α and β are $(N \times r)$ matrices, and β contains the cointegration vectors and α the adjustment parameters.

In our case, there will be two prices series in the $\boldsymbol{P_t}$ vector. If the prices are cointegrated, the cointegration rank will be 1 and α and β will be 2x1 vectors. Assuming only one lag or that the short-term dynamics is excluded, the system being estimated will be given as:

$$\begin{bmatrix} \Delta \ln p_t^s \\ \Delta \ln p_{t-n}^f \end{bmatrix} = \begin{bmatrix} A_1 \\ A_2 \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \begin{bmatrix} 1 & \beta \end{bmatrix} \begin{bmatrix} \ln p_{t-1}^s \\ \ln p_{t-n-1}^f \end{bmatrix} \quad (3)$$

A test of the restriction β' = (1,-1)' will then provide a test of whether the forward price is unbiased estimate of the future spot price, and in conjunction with the constant term one can also test the restriction $a = 0$ and $b = 1$. The vector $\boldsymbol{\alpha}$ provides information on the long-run dynamics in the system, and in particular allows one to test for (weak) exogeneity in the system. When both elements in the $\boldsymbol{\alpha}$ vector are different from zero, causality will run in both directions. If one of the elements is zero, the associated price will be exogenous and will then determine the other price in the system. If α_1=0, the spot price is exogenous and leads the future price, while if α_2=0, the future price is exogenous and leads the spot price.

Empirical results

Results from the cointegration tests are provided in Table 3. The hypothesis of no cointegration vectors can be rejected for all maturities, while the hypothesis that there is only a single cointegration vector cannot be rejected. Spot and 1-6 month future prices (lagged) thereby have a long-term relationship.

The fourth column in Table 3 shows that the unrestricted estimate for b is between 0.967 and 1.027, or fairly close to 1. A test of whether this is significantly different from 1 is reported in the fifth column of Table 3. This hypothesis cannot be rejected, and we are unable to reject the hypothesis that the forward price is an unbiased estimate of the future spot price. Furthermore, we also test the joint restriction $a = 0$ and $b = 1$. Also here we cannot reject the null hypothesis for any of the relationships between the spot and the 6 maturities of the forward prices (Table 3, column 6). Hence, there appears to be no convenience yield in this market. This is not too surprising given that the contract is settled financially and not by physical delivery.

Table 3. Cointegration tests

	H0:rank=r	Trace test[a]	β	H_0: $\beta = 1$[b]	H_0: $\alpha = 0$ *and* $\beta = 1$[b]	Exogeneity[b,c]
Spot	r = = 0	23.20*	0.967	0.136 (0.712)	0.649 (0.723)	3.090 (0.079)
1 Month	r < = 1	5.3				5.276 (0.022)*
Spot	r = = 0	41.25*	1.074	0.662 (0.416)	1.554 (0.460)	0.192 (0.661)
2 Months	r < = 1	4.30				27.977 (<0.001)*
Spot	r = = 0	35.58 *	1.088	0.569 (0.450)	1.649 (0.438)	2.538 (0.111)
3 Months	r < = 1	2.42				27.089 (<0.001)*
Spot	r = = 0	28.07*	1.043	0.051 (0.822)	0.929 (0.628)	0.783 (0.376)
4 Months	r < = 1	2.89				17.956 (<0.001)*
Spot	r = = 0	33.35 *	1.123	0.672 (0.412)	3.204 (0.202)	2.476 (0.116)
5 Months	r < = 1	3.18				22.029 (<0.001)*
Spot	r = = 0	29.00*	1.027	0.021 (0.884)	2.749 (0.253)	3.046 (0.081)
6 Months	r < = 1	3.79				14.388 (<0.001)*

[a] Critical value from Johansen and Juselius (1990). * indicates significant at a 5% level.
[b] p values in brackets.
[c] First row in each cell uses the restriction a_2=0 while the second row uses the restriction a_1=0.

The final column in the Table 3 reports the exogeneity tests that contain information with respect to price discovery. These shows that we cannot reject the null hypothesis that spot prices are exogenous in the systems for forward price maturities up to 6 months at the 5% level. At the 10% significance level we can reject the null hypothesis for maturities of one and six months. On the other hand, we can clearly reject the hypothesis that forward prices are exogenous for all the maturities. The overall impression is that the spot price is exogenous. Hence, the Fishpool market is not performing any price discovery role.

Conclusions

It is well known that the seafood market is heterogeneous (Tveteras et al., 2012). This makes it difficult to establish functions that require substantial scale. One such function is a futures contract that in large and well-functioning commodity markets provides and important tool for risk management (hedging) and of price discovery. With increased aquaculture production there has been interest in futures contracts for two of the most valuable species – shrimp and salmon. The only seafood futures contracts that has been analysed in the academic literature is the shrimp contracts at the Minneapolis Grain Exchange (Martínez-Garmendia and Anderson, 1999: 2001). These contracts failed basic tests for a well-functioning futures market, and it is then not too surprising that the contract has been terminated.

In this paper studies the spot-forward relationship in in the Fish Pool market for salmon futures. In particular, we examine whether the future price provides an unbiased estimate of the spot price and price leadership along the forward curve. The literature, both theoretical and empirical, suggests that futures should lead spot prices if the futures market is to have a price discovery function. However, in some instances this might not be the case, especially in immature markets. Furthermore, recent research indicates that the convenience yield in salmon forwards is related to production variables, suggesting that elements from the supply side are important for the pricing of forward contracts. Consequently, this implies a role for the spot market in price discovery.

Using spot and forward price data we examine the lead-lag relation in the salmon market. We find that spot and lagged futures prices are cointegrated up to maturities of 6 months. Furthermore, we also find that the causality is one-directional, from spot to futures prices. Hence, our result of spot prices leading futures prices contradicts many empirical studies on the spot-forward relationship in commodity markets. A reason could be that salmon futures markets are still immature, and have not yet reached the stage where forward prices are able to predict future spot prices.

Brorsen and Fofana (2001) specifies a number of criterions required for a successful futures market. Given that the Fishpool future price provides an unbiased estimator of the spot price, the most important criterion is fulfilled as the future contract will then provide a good price hedge, a criterion that was not fulfilled for the shrimp futures. It is harder or impossible to test the other criterions for a single market, as it for instance is hard to assess whether liquidity is sufficient. However, the Fishpool futures contract seem to fulfil or move in the right direction for the other criterions. Hence, while the futures market has some signs of an immature futures market, particularly in that it does not provide price discovery, it seems to move in the right direction. The Fishpool futures contract therefore seems to have a good chance for becoming a standard risk handling tool in the salmon market in years to come.

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