Wholesale and retail price integration in the live reef food fish trade

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ABSTRACT

Keywords: cointegration, live reef food fish, Hong Kong market

This paper explores price integration between wholesale and retail prices of live reef food fish, a high-value export fishery supplied by nearly 20 countries in the Asia-Pacific region with demand centred in Hong Kong. Cointegration analysis is used to test for relationships between wholesale and retail prices in demand countries for live reef fish species in aggregate and then by species. Results indicate that wholesale and retail prices of live reef fish species are cointegrated and form part of the same market. An analysis of price integration between wholesale supply and wholesale demand prices is undertaken using a high value reef fish exported to Hong Kong from Australia.

1. Introduction

The live reef food fish trade, where are fish caught on coral reefs and sold live through restaurants or up-market supermarkets, is a low-volume high-value trade. Fish are supplied by up to 20 countries in Asia-Pacific and demand is centred in Hong Kong and southern mainland China (Sadovy et al. 2003). Sadovy and Vincent (2002) estimate that at least 60 percent of the international trade is exported to Hong Kong where as much as 50 percent is re-exported to mainland China[1]. Declared imports into Hong Kong are approximately 15-20,000 tonnes annually, valued at approximately US$350 million (Sadovy et al. 2003)[2].

Supplies of live reef food fish (LRFF) to Hong Kong, with the exception of those in Australia, come predominantly from artisanal and subsistence fisheries. These fisheries are characterised by their low gear technology, geographic remoteness of fishing grounds, long distances between these grounds and export hubs and markets, large numbers of landing sites and undeveloped storage and transport infrastructure. For these reasons the market chain for the LRFF trade is both extended and complex with product passing though many levels of trade between the fisher and the restaurant. Furthermore, high transport costs associated with maintaining and exporting a live product has led to traders in supply countries forming vertical relationships with those in Hong Kong in order to export their product. This has tended to the belief that transmission of price information between agents at the supply end of the market chain is restricted and that market power is concentrated among Hong Kong traders, who garner most of the gains from trade.

In practice, gains may be unevenly distributed among agents for a variety of reasons including the disproportionate marketing costs and risks borne by agents at specific

[1] Trade agreements between Hong Kong and mainland China have meant that tariffs are lower on live reef fish entering China through Hong Kong than entering China directly.
[2] The reliability of these estimates is hindered by the underreporting of imports because there is no requirement for Hong Kong-licensed live-fish transport vessels to declare imports by sea. Declared sea imports have been estimated to be underreported by nearly half (McGilvray and Chan, 2001)

points along the market chain. This is particularly so in the LRFF trade where poor handling and husbandry techniques in supply countries have historically increased risk of mortality and fish health (e.g. ciguatera) assumed by Hong Kong importers and wholesalers (Sadovy and Vincent, 2002). Australia is unique in that the application of improved husbandry and transport technology has lowered mortality risk significantly (P. Chan, personal comment).

Even in integrated markets, if the traders marketing costs are disproportionate to costs and risks they bear, they may be able to exert market power. As steps in testing for market cointegration under these conditions, we test firstly for integration at the wholesale and retail level of the Hong Kong market. Subsequently, we test for integration between one export market, Australia, and Hong Kong.

If the market for LRFF in Hong Kong is well integrated and competitive the wholesale prices of LRFF (defined as the price paid to the wholesale importer by restaurants) should follow a similar pattern to the retail prices (defined as the price paid to the restaurant by consumers), with the difference being marketing and transport costs. Similarly, the Australian beach price for LRFF (defined as the price paid by domestic buyers/exporters to fishers in Australia) should follow a similar pattern to wholesale prices in Hong Kong. Short-run deviations in price trends are possible, but market forces should operate to restore a synchronous movement in prices, representing a cointegrated system. Jaffry et al. (2000) argues that cointegration between price series implies the existence of a long-run equilibrium to which the proportional relationship between prices of species remains the same. Lack of cointegration between wholesale and retail prices may provide evidence of market power in the marketing chain. Markets that are not cointegrated may convey inaccurate price information, distorting marketing decisions and contributing to inefficient product movements. Cointegration analysis has predominantly been used to examine spatial integration of markets (e.g. Goodwin and Shroeder 1991 and Ling 2003).

More recently, cointegration analysis has been used to examine the interactions between different commodities to test market interdependencies, and hence market delineations (Jaffry et al. 2000, Gordon et al. 1993, Gordon and Hannesson 1996, Bose and McIlgorm 1996 and Asche et al. 2004). A market can be defined as "the area within which the price of a commodity tends to uniformity, allowance being made for transportation costs" (Stigler 1969, p85). Hence, a stable long-run relationship between prices implies those goods to be in the same market. Simple regression or correlation analysis can be used where data is stationary (a random walk around some constant value over time, as opposed to a general trend upwards or downwards over time), but specific cointegration tests is required for non-stationary data.

In this paper, two aspects of price integration in the live reef food fish trade are tested. First, spatial integration of wholesale and retail prices within Hong Kong markets are examined, both in terms of an aggregate live reef food fish price, and for nine of the most highly traded species individually. Second, spatial integration of Australian beach price and Hong Kong wholesale price are examined for the main export species, Leopard coral trout, to test for integration further up the marketing chain. Third, market delineation between these species is tested, first between wholesale prices and then between retail prices. If interdependencies are found to exist, cointegrated species are likely to form part of the same market and their prices are likely to move together in the long-run and increased production of one species is likely to affect the price of the other species. The paper proceeds firstly with an outline of the methodology (Section 2), followed by a presentation of the results and discussion (Section 3), and concludes with a summary and discussion on policy implications (Section 4).

2. Methodology: cointegration analysis

Cointegration analysis involves establishing statistically sound long-run relationships between time-series data. This implies that the prices of two interrelated prices of the same commodity should not diverge from one another to any great extent in the long-run (Granger 1986). Cointegration analysis starts with an investigation of the stationarity properties of each time-series. To do this, a standard Augmented Dickey-Fuller (ADF) test of the following form is applied to each of the price variables:

$$\Delta P_{it} = \beta_0 + \beta T + \rho P_{i,t-1} + \sum_{j=1}^{k} \alpha_j \Delta P_{i,t-j} + e_t \qquad (1)$$

where Δ is the difference operator, P_{it} is the price of species, *i*, at time, *t*, and *T* is a time trend (Dickey and Fuller 1979). The trend term captures the possibility of deterministic growth in time series over time. The null hypothesis is that the series is non-stationary [i.e. ~$I(1)$][3] against the alternative hypothesis of stationarity [i.e. ~$I(0)$]. The number of lagged difference ($\Delta P_{i,t\text{-j}}$) terms are specified in order to eliminate any serial correlation in the e_t values. The null hypothesis is tested based on the "t-statistic" value of ρ in Equation (1) If the estimated value of ρ is negative and significantly different from zero, the null hypothesis will be rejected. The analyses are undertaken using the natural log of real prices. Critical values are linearly interpolated from Fuller (1976) and the *p*-values are MacKinnon approximates published in MacKinnon (1994).

Cointegration with stationary data

It is common in studies of market integration for the logarithm of prices to be used, and the following equation assumes this transformation. The simplest specification to test for market integration of two stationary prices, say p_t^1 and p_t^2, is:

$$p_t^1 = a + bp_t^2 + e_t \qquad (2)$$

A null hypothesis that $b = 0$ is a test that no substitution possibilities exist. A null hypothesis that $b = 1$ is a test for constant relative prices. The constant term, *a*, is the logarithm of a proportionality coefficient, and is zero if the prices are identical, except for arbitrary deviations caused by the error term. A non-zero constant term is generally interpreted as product quality differences or transportation costs, which are

[3] The critical assumption in the Johansen approach is that each time series is integrated of order one; $I(1)$

assumed to be static. Where the assumption of static transportation costs is too strict, tests will show lesser market integration than actually exists (Goodwin et al. 1990).

It has been argued that adjustment costs associated with supply and demand shocks could be significant and may take time to manifest (Asche et al. 2004). Subsequent models have been introduced with variable specifications to distinguish between short and long-run effects to account for this. Slade (1986) accounts for this dynamic adjustment to market integration by running the regression to test for causality between prices p^1 and p^2:

$$p_t^1 = a + \sum_{j=1}^{m} b_j p_{t-j}^1 + \sum_{i=0}^{n} c_i p_{t-i}^2 + e_t . \tag{3}$$

The lag structure on prices is chosen so that e_t is white noise. There is a relationship that p_t^2 causes p_t^1 if the joint test that all c_i parameters are zero is rejected[4]. In econometric terms, this is a test for Granger noncausality (Granger 1969). If causality is not observed, the markets are independent. Evidence of price leadership is inferred if one price causes the other with no evidence of causality in the opposite direction and may be termed weakly exogenous.

Cointegration analysis with non-stationary data

Normal statistical inference is not valid for linear regressions on non-stationary data as there will be non-linear long-run relationships. However, if the data series in question have common stochastic trends, the linear combinations of the two non-stationary data series can be stationary, and therefore said to be cointegrated (Engle and Granger 1987). There are two common approaches to testing for cointegration of non-stationary data: the Engle and Granger (1987) test and the Johansen test (1988, 1991). The Engle and Granger test suffers problems such as arbitrary selection of dependent variables (as with stationary data) and failure to identify the number of cointegrating vectors for multivariate cases. The Johansen test, avoids these problems by modelling the price relationships in a vector autoregression (VAR) format.

Given a vector, P_t , containing variables of interest (in this case the two prices), the Johansen test is carried out using the following VAR representation:

$$P_t = \sum_{i=1}^{k} \Pi_i P_{t-i} + \Pi_k P_{t-k} + \mu + e_t , \tag{4}$$

where each Π_i is a *NxN* matrix of parameters and μ is a constant term. The system of equations can be written in error correction form as:

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i P_{t-i} + \Gamma_K P_{t-k} + \mu + e_t , \tag{5}$$

[4] This test for causality is based on the contention that p^2 causes p^1 if predictions of p^1 based on lagged values of both p^1 and p^2 are better than predictions of p^1 based on its past history alone.

where $\Gamma_i = -\mathrm{I} + \Pi_1 + ... + \Pi_i$ and i = 1, …, k-1. Here Γ_K is the long-run solution to equation (4). If ΔP_t is a vector of I(1) stationary variables, then the left hand side and the first k - 1 variables on the right hand side of equation (4) are stationary I(0) and the error term, e_t, is, by assumption, stationary. Hence, either Γ_K must be a matrix of zeros or P_t contains a number of cointegration vectors. The rank of Γ_K, defined by r, determines how many linear combinations of P_t are stationary. If $r > 0$, then the variables are stationary in levels; if $r = 0$, there exists no linear combinations that are stationary; and if 0 > r < N there are r stationary linear combinations of P_t.

The Johansen approach tests for the number of cointegrating ranks, not cointegration directly. In the Johansen framework, there are two asymptotically equivalent tests for cointegration, a trace test and the maximum eigenvalue test. The calculated statistics for the trace test and maximum eigenvalue test are used to test the null hypothesis that there exists no cointegrating vector (r = 0) (the alternative hypotheses for the trace and maximum eigenvalue tests being r > 0 and r = 1, respectively) and that there exists less than or equal to one cointegrating vector (r ≤ 1) (the alternative hypotheses for the trace and maximum eigenvalue tests are r > 1 and r = 2, respectively)[5]. The Johansen framework can be applied to stationary and non-stationary data.

Data sources

Hong Kong prices for live reef fish from November 1999 to July 2003 were obtained from surveys carried out by the International Marinelife Alliance (IMA). Average monthly retail prices were drawn from 726 restaurants in 18 districts around Hong Kong with 150 restaurants randomly selected each month. Wholesale prices were collected twice weekly from markets in Kwun Tong and Aberdeen and monthly from wholesalers/distributors in Quarry Bay and Wanchai and averaged over the month. The application of these econometric techniques to test for integration between export (supply) and Hong Kong markets is hindered by a paucity of usable time-series data from supply countries with the exception of Australia. Data on beach prices paid in Australia for Leopard coral trout were obtained from domestic fish buyers. All prices are real prices and are presented in constant November 1999 Hong Kong dollars.

3. Empirical results

Empirical results are presented in four parts. First, spatial integration of aggregated wholesale and retail live reef fish prices are examined (Section 3.1). Second, spatial integration of wholesale and retail prices for the eight or the nine major live reef species individually are investigated (Section 3.2). Third, spatial integration between export and import markets for a single species is analysed (Section 3.3). Fourth, market delineation across species is tested, first using wholesale prices and second using retail prices (Section 3.4).

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[5] According to Johansen and Juselius (1990), the trace test tends to accept cointegration too often. Acceptance of cointegration will be in accordance with the maximum eigenvalue test

3.1 Examining spatial integration of aggregated wholesale and retail prices

Aggregate price trends are shown in Figure 1. Visually, it is difficult to determine whether the two prices move together. The data suggests that marketing costs for retail traders are approximately HK$140/kg (75% of wholesale price).

Figure 1: Wholesale prices and retail prices aggregated across eight key restaurant species marketed within the live reef food fish trade in Hong Kong

The results of the ADF tests are reported in Table 1 with and without a trend, for wholesale and retail prices aggregated across all nine live reef fish species. For each price series, we reject the null hypothesis of non-stationarity. Hence, each series are stationary. Therefore, dynamic regression analysis and Johansen Tests can both be used to investigate cointegration in these prices. In the following results, Johansen Tests are used to investigate cointegration, with dynamic regression analysis employed to identify the most significant cointegrating vector.

Table 1: ADF test results for aggregated and logged wholesale (WP) and retail prices (RP) of nine key species marketed within the live reef food fish trade in Hong Kong

Variable	No trend		Trend	
	Aggregated WP	Aggregated RP	Aggregated WP	Aggregated RP
test-statistic (ρ)	-4.719***	-5.306***	-4.729***	-5.817***
p-value	0.0001	0.0000	0.0006	0.0000
Stationary	Yes	Yes	Yes	Yes

*** indicates significance at the 1% level.
Number of observations = 44.

Results of bivariate Johansen cointegration tests for aggregated wholesale and retail prices are presented in Table 2. The null hypothesis of no cointegrating vector ($r = 0$) is rejected as is the null hypothesis of less than or equal to one cointegrating vector ($r \leq 1$). This indicates that the wholesale and retail prices are cointegrated, with two cointegrating vectors. This is evidence that wholesale and retail live reef fish prices form part of a system of live reef fish prices that may vary independently in the short-run, but in the long run, the will vary simultaneously as part of a single market.

Table 2: Bivariate Johansen tests for cointegration for aggregated and logged wholesale and retail prices of nine key species marketed within the live reef food fish trade in Hong Kong (including a trend)

Aggregated Wholesale and Retail Price	Trace test	Max test
$r = 0$	39.2182***	29.6987***
$r \leq 1$	9.5195***	9.5195***

*** indicates significance at the 1% level.
number of observations = 43, number of lags = 2.

Granger causality wald tests are performed to test the causality of prices (Granger 1969). These test the null hypothesis that the causal variable does not cause the variable in question. The null hypothesis that aggregated retail price does not cause aggregated wholesale price cannot be rejected (Tests 1). Hence, the log of the retail prices do not have a causal effect on the log of the wholesale prices. Conversely, Test 2 suggests that the aggregated wholesale prices and its lags do have a causal relationship to aggregated retail prices. Therefore, it is suggested that wholesale price causes retail price and not vice versa.

Table 3: Granger causality wald test results for aggregated and logged wholesale (WP) and retail prices (RP) of nine key species marketed within the live reef food fish trade in Hong Kong

Test	Variable	Causal variable	χ^2-statistic	*p*-value
1	Aggregated WP	Aggregated RP	1.1165	0.572
2	Aggregated RP	Aggregated WP	12.568	0.002***

*** indicates significance at the 1% level.

On conducting dynamic regression analysis on these prices, it was found that wholesale prices are causing retail prices with a geometric lag (Table 4).

Table 4: Dynamic regression analysis of wholesale and retail prices of aggregated live reef fish, where aggregated and logged retail price is the dependent variable

Variable	Estimated coefficient	t-statistic
Aggregated wholesale price	0.282	4.14***
Aggregated and lagged retail price	0.320	2.86***
Constant	2.476	3.27***
Model *F* statistic:	12.17	
Model *p*-value:	0.0001	
Adj-R^2:	0.3419	
Number of observations:	44	

*** indicates significance at the 1% level, two-tailed test.

3.2 Examining spatial integration of Hong Kong wholesale and retail prices for individual species

This section investigates integration between wholesale and retail prices of individual live reef fish species in the Hong Kong market place. Eight major live reef food fish species imported into Hong Kong for the restaurant trade have been divided into high, medium and low-value species[6]. Figure 2 shows price trends for the two high-value species; High-finned grouper and Humphead wrasse. Prices appear to be relatively stable over the study period, with retail prices fluctuating more that wholesale prices. Marketing costs are approximately HK$295/kg (58 percent of wholesale price) and HK$390/kg (104 percent of wholesale price) for High-finned grouper and Humphead wrasse, respectively. Visually, it is not clear whether prices for either of these species are cointegrated.

Figure 2: Wholesale price and retail prices in Hong Kong for two high-value species; (a) High-finned grouper and (b) Humphead wrasse.

(a) Highfin grouper **(b) Humphead Wrasse**

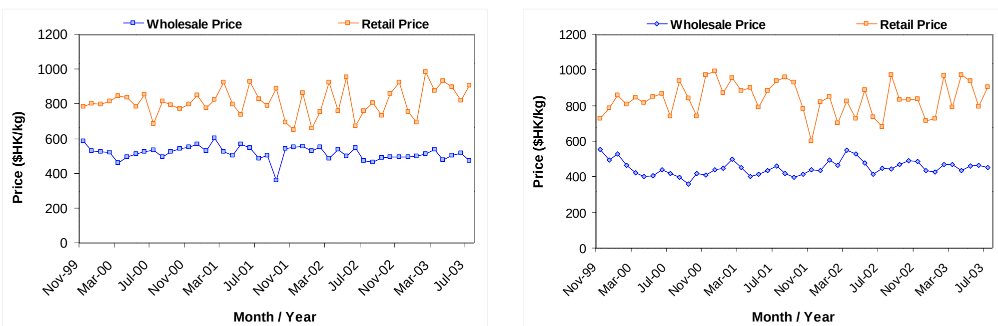

Figure 3 presents price trends for four medium-value species: Leopard coral trout, Spotted coral trout, Tiger grouper and Giant grouper. Price trends, and all subsequent results, for the fifth medium-value species, Flowery grouper, are not included in this section as the findings are very similar to Tiger grouper and do not add to the analysis. The first three species in Figure 3 displayed show slight downward trends for both wholesale and retail prices, while there is a marked downward trend in the retail price of Giant grouper. With the exception of Giant grouper, retail and wholesale prices seem to move simultaneously, although cointegration cannot be inferred without further testing. Marketing costs are on average HK$175/kg for Leopard coral trout (62 percent of wholesale price), HK$195/kg for Spotted coral trout (110 percent of wholesale price), HK$175/kg for Tiger grouper (92 percent of wholesale price), and HK$195/kg for Giant grouper (107 percent of wholesale price).

Figure 4 presents price trends for the two low-value species: Green grouper and Mangrove snapper. The downward trend in prices is especially marked in wholesale and retail prices of Green grouper. Marketing costs are on average HK$95/kg (104 percent of retail price) for Green grouper and HK$78/kg for Mangrove snapper (148

[6] Results for Flowery grouper are not presented here as this medium-value species is a close substitute for Tiger grouper

percent of wholesale price). Visually, it is not clear whether prices for either of these species are cointegrated.

Figure 3: Wholesale prices and retail prices in Hong Kong for four medium-value species; (a) Leopard coral trout, (b) Spotted coral trout, (c) Tiger grouper and (d) Giant grouper.

(a) Leopard coral trout

(b) Spotted coral trout

(c) Tiger grouper

(d) Giant grouper

Figure 4: Wholesale prices and retail prices in Hong Kong for two low-value species; (a) Green grouper and (b) Mangrove snapper.

(a) Green grouper

(b) Mangrove Snapper

The results of the ADF test are reported in Table 5 with and without a trend. For results without a trend, we can reject the null hypothesis of non-stationarity (at the 5% level) for all series with the exception of retail prices of tiger grouper and wholesale and retail prices for both the Giant grouper and Green grouper. For results with a trend, we can reject the null hypothesis of non-stationarity for all price series. Subsequent Johansen cointegration tests are performed with a trend variable.

Table 5: ADF test results for logged wholesale (WP) and retail prices (RP) for each of eight key species marketed within the live reef food fish trade in Hong Kong

		No trend		Trend	
Variable	# obs	t-stat (ρ)	p-value	t-stat (ρ)	p-value
		High-value species			
Highfin grouper WP	44	-5.830	0.0000***	-6.030	0.0000***
Highfin grouper RP	44	-6.722	0.0000***	-6.822	0.0000***
Humphead wrasse WP	44	-3.744	0.0035***	-3.978	0.0095***
Humphead wrasse RP	44	-6.215	0.0000***	-6.148	0.0000***
		Medium-value species			
Leopard CT WP	44	-4.279	0.0005***	-4.365	0.0025***
Leopard CT RP	44	-4.652	0.0001***	-5.204	0.0001***
Spotted CT WP	44	-4.614	0.0001***	-4.731	0.0006***
Spotted CT RP	44	-3.645	0.0050***	-5.486	0.0000***
Tiger grouper WP	44	-5.755	0.0000***	-5.685	0.0000***
Tiger grouper RP	44	-2.754	0.0652	-4.445	0.0019***
Giant grouper WP	32	-2.668	0.0798	-3.750	0.0193**
Giant grouper RP	32	-2.860	0.0503	-5.086	0.0001***
		Low-value species			
Green grouper WP	44	-2.761	0.0640	-4.797	0.0005***
Green grouper RP	44	-1.610	0.4777	-4.887	0.0003***
Mangrove Snapper WP	44	-3.135	0.0241**	-5.803	0.0000***
Mangrove Snapper RP	44	-5.582	0.0000***	-5.555	0.0000***

*** indicates significance at the 1% level, two-tailed test.
** indicates significance at the 5% level.
number of lags = 2.

The results of the pair-wise Johansen cointegration tests for wholesale and retail prices for each species are presented in Table 6. We reject the null hypothesis of no co-integrating vectors (r = 0) for all species except Green grouper, where the trace test indicates that there is at least one cointegrating vector, but the maximum eigenvalue test does not. We reject the null hypothesis of less than or equal to one cointegrating vectors ($r \leq 1$) for all species for both tests. While there is evidence that wholesale and retail prices for all species are cointegrated with two co-integrating vector (confirming our earlier stationarity tests), this evidence suggests cointegration is weaker for the low value species. These results support the notion that, in general, wholesale and retail prices vary simultaneously for each species as part of a single market.

Table 6: Bivariate Johansen tests for cointegration for logged wholesale (WP) and retail price (RP) for each of eight key species marketed within the live reef food fish trade in Hong Kong.

Variable		# obs ($n-1$)	Trace test	Max test
High-value species				
Highfin grouper (WP/RP)				
	$r = 0$	43	43.7849***	25.8741***
	$r \leq 1$		17.9109***	17.9109***
Humphead wrasse (WP/RP)				
	$r = 0$	43	35.4115***	23.9093***
	$r \leq 1$		11.5022***	11.5022***
Medium-value species				
Leopard coral trout (WP/RP)				
	$r = 0$	43	48.7659***	32.8230***
	$r \leq 1$		15.9429***	15.9429***
Spotted coral trout (WP/RP)				
	$r = 0$	43	37.114***	19.440**
	$r \leq 1$		17.674***	17.674***
Tiger grouper (WP/RP)				
	$r = 0$	43	31.293***	23.883***
	$r \leq 1$		7.410***	7.410***
Giant grouper (WP/RP)				
	$r = 0$	31	30.471***	18.996**
	$r \leq 1$		11.475***	11.475***
Low-value species				
Green grouper (WP/RP)				
	$r = 0$	43	19.756**	12.022
	$r \leq 1$		7.735***	7.735***
Mangrove snapper (WP/RP)				
	$r = 0$	43	23.378**	17.632**
	$r \leq 1$		5.747**	5.747**

*** indicates significance at the 1% level.
** indicates significance at the 5% level.
number of lags = 2.

Granger causality wald test results are presented in Table 7. A clear trend is not provided by these results. There is strong evidence that wholesale prices cause retail prices for the Leopard coral trout, Spotted coral trout and the Mangrove snapper. There is weak evidence that retail prices cause wholesale prices for Green grouper. No obvious causality is indicated for any of the other species.

Table 7: Granger causality wald test results for logged wholesale (WP) and retail prices (RP) for each of eight key species marketed within the live reef food fish trade in Hong Kong.

Test	Variable	Causal variable	χ^2-statistic	*p*-value
		High-value species		
1	Highfin grouper RP	Highfin grouper WP	3.4835	0.175
2	Highfin grouper WP	Highfin grouper RP	0.80795	0.668
3	Humphead wrasse RP	Humphead wrasse WP	0.09266	0.955
4	Humphead wrasse WP	Humphead wrasse RP	2.3383	0.311
		Medium-value species		
5	Leopard coral trout RP	Leopard coral trout WP	16.034	0.000***
6	Leopard coral trout WP	Leopard coral trout RP	4.4304	0.109
7	Spotted coral trout RP	Spotted coral trout WP	6.895	0.032**
8	Spotted coral trout WP	Spotted coral trout RP	0.943	0.624
9	Tiger grouper RP	Tiger grouper WP	2.045	0.360
10	Tiger grouper WP	Tiger grouper RP	1.029	0.598
11	Giant grouper RP	Giant grouper WP	0.569	0.752
12	Giant grouper WP	Giant grouper RP	3.722	0.155
		Low-value species		
14	Green grouper RP	Green grouper WP	3.721	0.156
13	Green grouper WP	Green grouper RP	4.943	0.084*
16	Mangrove snapper RP	Mangrove snapper WP	6.223	0.045**
15	Mangrove snapper WP	Mangrove snapper RP	1.162	0.559

*** indicates significance at the 1% level.
** indicates significance at the 5% level.
* indicates significance at the 10% level.

3.3 Examining spatial integration between export and import markets for a single species.

This analysis examines spatial integration between export and import markets using the beach prices of Leopard Coral trout in Australia and its wholesale price equivalent in Hong Kong (Figure 5). Visually, there is a downward trend in the price series which appear to be cointegrated. Marketing costs are on average HK$145/kg (123 percent of the Australian retail price).

An Augmented Dickey Fuller test was undertaken using the natural log of real prices to determine the stationarity of each series. The null hypothesis of non stationarity can be rejected for both beach and wholesale prices, with and without a trend (Table 8). The series for beach and wholesale prices are therefore both stationary and further analysis of cointegration is continued using the Johansen Test.

Figure 5: Australian domestic beach price and Hong Kong wholesale prices for Leopard coral trout

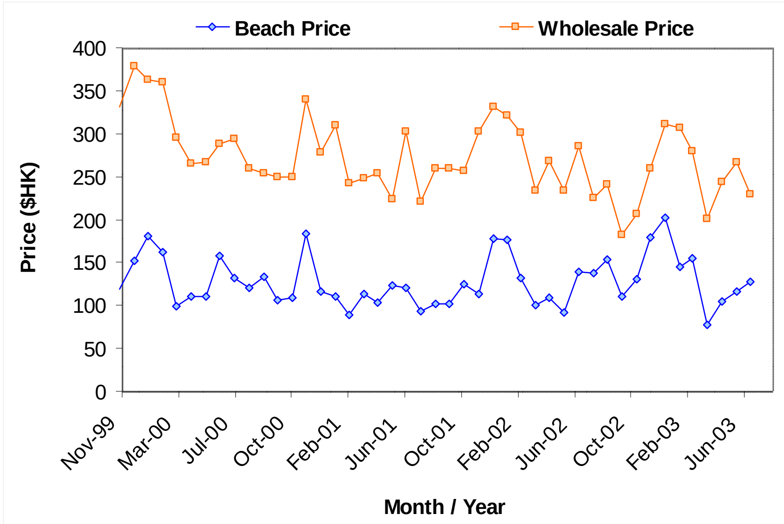

Table 8: ADF test results for the Australian domestic beach price (BP) and Hong Kong wholesale prices (WP) for Leopard coral trout

Variable	No trend		No trend	
	Australian Domestic BP	Hong Kong WP	Australian Domestic BP	Hong Kong WP
test-statistic (ρ)	-4.636	-4.279	-4.581	-4.365
p-value	0.0001***	0.0005***	0.0011***	0.0025***
Stationary	Yes	Yes	Yes	Yes

Number of observations = 44, *** indicates significance at the 1% level.

Results of bivariate Johansen cointegration tests are presented in Table 9. The null hypothesis of no co-integrating vector ($r = 0$) can be rejected for the trace test; but can not be rejected for the maximum eigenvalue test. The null hypothesis of less than or equal to one co-integrating vector ($r \leq 1$) is rejected for both tests. Taking these results into consideration, it is assumed that there is more than one cointegrating vector, indicating cointegration between the two series of beach prices and wholesale prices.

The Granger Wald causality test indicates that there is no causal relationship between Australian domestic beach and the Hong Kong wholesale prices of Leopard coral trout, with no significant results (Table 10).

Table 9: Bivariate Johansen tests for cointegration for the Australian domestic beach price (BP) and Hong Kong wholesale prices (WP) for Leopard coral trout (including a trend)

Australian BP and Hong Kong WP	Trace test	Max test
$r = 0$	24.6701***	15.9151
$r \leq 1$	8.7549***	8.7549***

Number of observations = 43. Number of lags = 2, *** indicates significance at the 1% level.

Table 10: Granger causality wald test results for the Australian domestic beach price (BP) and Hong Kong wholesale prices (WP) for Leopard coral trout

Test	Variable	Causal variable	χ^2 -statistic	*p*-value
1	Australian BP	Hong Kong WP	0.67956	0.712
2	Australian BP	Lagged Hong Kong WP	0.67956	0.712
3	Hong Kong WP	Australian BP	1.4908	0.475
4	Hong Kong WP	Lagged Australian BP	1.4908	0.475

3.4 Examining market delineation between individual species

Market delineation between species is investigated in this section. This market delineation is examined first with wholesale prices and second with retail prices. Results of bivariate Johansen trace tests are provided in Appendix Tables A.1 and A.2. Results suggest that wholesale and retail prices of all species are cointegrated with greater than one cointegrating vectors. These results give evidence that all live reef species are part of one undelineated market.

Multivariate Johansen tests were performed (although specific results are not reported here) providing evidence of cointegration with four cointegrating vectors for wholesale prices of all species, and two cointegrating vectors for retail prices of all species. Dickey et al. (1991) argues that the more cointegrating vectors that exist, the more stable the long-run price relationship. Hence, there is evidence that the relationship between long-run wholesale prices of each species is more stable than long-run retail prices.

4. Discussion and Conclusions

Within the fisheries sector, most cointegration studies have examined seafood chains of large-scale industrial fisheries (references). There have been no such studies carried out for small-scale artisanal fisheries, which predominate in inshore and reef-based fisheries. The ability to examine price and margin relationships for these fisheries is hindered by the paucity of long-term datasets for various intermediaries along the market chain. In this study we use co-integration analysis to test for various pairwise relationships across a range of fish species marketed as part of the LRFF trade in

Hong Kong. We also test for causality in prices to identify instances of 'price-leadership' in either wholesale, retail or export prices.

The results indicated that in aggregate, wholesale and retail prices in Hong Kong for LRFF are cointegrated. These results suggest that overall, market prices move synchronously in the long-term and vary simultaneously as part of a single market. In terms of individual species, we found evidence of co-integration between wholesale and retail prices for all species tested with the possible exception of Green grouper. The Green grouper occupies a unique status within the LRFF trade in that a sizeable quantity of annual imports now come from cultured as well as wild-caught sources. This may explain the more marked downward price trend for Green grouper whereby increased supplies of cultured product have reduced prices for both product forms (Asche et al, 2005).

There are sizeable differences between wholesale and retail prices of LRFF in Hong Kong. The aggregate retail price is 75% higher than aggregate wholesale price while for individual species, retail prices are 58%–110% higher than wholesale prices. This difference is generally greater for lower-value species than for higher-value species, suggesting that retailers may be adding a relative mark-up to cover their marketing costs. Marketing costs for retailers are considerable as they must absorb the high cost of premise rental (Chan, 2001).

Retail prices showed greater variation than did wholesale prices, for all LRFF species. Greater variation in prices is usually evidence of greater uncertainty, which is historically higher on the upstream end of seafood chains due to constraints (e.g. biological, weather) faced by suppliers. The relationship between uncertainty and price leadership is less clear. Gonzales and Guillotreau (2002) observed decreasing price variation along the market chain for processed seafood and increasing variation along the chain for fresh seafood. In both cases however, they found prices to be weakly exogenous upstream (i.e. closer to resource)[7]. Within this study, wholesale prices were found to be weakly exogenous in four of the eight species examined, Leopard coral trout and Spotted coral trout and Green grouper and Mangrove snapper[8]. We focus on this result to explore these issues in the context of characteristics of the LRFF trade.

Greater price variation within the retail sector is a likely result of the perishable nature of the product. Retailers can only hold LRFF for a few days and before risk of mortality increases. This may mean that the market clearing mechanism (marginal revenue = marginal cost) is ignored in the short-run to ensure the product is sold alive. Despite this greater variation in retail prices, wholesalers in the LRFF trade face higher supply uncertainty than do retailers. Moreover, they must contend with the risk of product loss from mortality at various points along the market chain (Sadovy and Vincent, 2002). It may be that retailers are allowing wholesalers to set their prices on the basis of the supply costs, including risk and uncertainty, they face. We have explored this concept further by comparing prices further upstream along the market chain.

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[7] Note that exogeneity does not imply price-setting status for the agent whose price is exogenous; it is more the direction in which price is being transmitted.

[8] Leopard coral trout and Spotted grouper are the most highly traded LRFF species making up more than 85% of all high- and medium-value imports into Hong Kong.

Leopard coral trout occupies a unique niche within the restaurant trade having both a high price (considerably higher than prices for other medium-value species in this study) and a being traded in great volumes (~50% of all species in this study). In comparison to other species in this study, which are often incidental catch as opposed to the main target species, wholesalers are able to maintain greater control over supply. Both Green grouper and Mangrove snapper are supplied from both cultured and wild-caught supply, while Green grouper is the also traded in very large volumes (~38% of all species in this study). Despite these idiosyncrasies, all four species bear the same risks of mortality that characterise the trade in general.

Cointegration tests between beach prices paid by exporters in Australia to local fishers for Leopard coral trout and the wholesale price received by wholesalers in Hong Kong provide evidence of a cointegrated system of prices. Despite an absence of price data for the next step along the chain between Australian exporters and Hong Kong wholesalers, our knowledge of complex vertical business relationships between wholesalers in Hong Kong and exporters in source countries suggests that a similar relationship would exist between these two intermediaries. Any difference in prices would be based on a standard mark-up to cover marketing costs and yield a net profit.

Despite no evidence of price causality between these intermediaries, we suggest that the wholesaler in Hong Kong is the vertical price leader along the whole LRFF market chain. Their financial support of intermediaries in supply countries (Indonesia, the Philippines, Malaysia) allows them to control prices upstream, while the disproportionate costs and risks associated with that stage of the supply chain allows them to set prices for downstream agents as well.

Data permitting, it is hoped to undertake further research to test for cointegration between wholesalers and exporters in other South-east Asian supply countries and wholesalers in Hong Kong to examine the hypothesis that the latter is the intermediary exhibiting most market power along the marketing chain. We hope to be able to test whether prices between intermediaries along the supply chain are proportional and to determine the elasticity of price transmission. Finally, given the increasing importance of cultured product in the LRFF trade, further exploration of the relationship between cultured and wild-caught product would be useful.

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Appendix Table A.1: Bivariate Johansen trace tests for cointegration for logged wholesale prices of each species

	LHfinWP		LHumpWP		LLeopWP		LGiantWP		LTigerWP		LSpotWP		LFlowWP		LGreenWP	
	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1
LHumpWP	36.95*	11.51*														
LLeopWP	33.88*	12.44*	29.22*	10.89*												
LGiantWP	34.41*	13.01*	23.70*	9.94*	20.54*	6.48*										
LTigerWP	32.21*	11.50*	32.87*	9.99*	23.52*	9.09*	25.24*	8.99*								
LSpotWP	40.45*	16.20*	36.32*	12.49*	29.90*	10.76*	25.83*	8.35	32.04*	12.44*						
LFlowWP	34.40*	16.87*	37.29*	12.67*	31.79*	11.74*	24.55*	10.95*	38.30*	13.15*	49.11*	16.85*				
LGreenWP	29.24*	8.64*	20.11*	7.94*	20.38*	8.51*	23.77*	10.20*	20.84*	5.81*	26.50*	8.39*	25.78*	6.06*		
LManWP	26.42*	5.86*	21.52*	6.29*	21.33*	6.09*	23.77*	9.08*	19.75*	6.05*	26.41*	5.68*	28.76*	6.12	22.20*	5.36*

Number of lags = 2. The 5% critical values are 18.17 where Rank = 0 and 3.74 where Rank = 1.
Number of observations = 43, except for tests including Giant grouper where the number of observations = 31.
* indicates significance at the 5% level

Appendix Table A.2: Bivariate Johansen tests for cointegration for logged retail prices of each species

	LHfinRP		LHumpRP		LLeopRP		LGiantRP		LTigerRP		LSpotRP		LFlowRP		LGreenRP	
	Rank = 0	Rank = 1	Rank = 0		Rank = 0		Rank = 0		Rank = 0		Rank = 0	Rank = 1	Rank = 0	Rank = 1	Rank = 0	Rank = 1
LHumpRP	44.59*	20.38*														
LLeopRP	21.06*	18.82*	43.89*	19.91*												
LGiantRP	32.73*	12.78*	32.13*	15.22*	31.18*	10.68*										
LTigerRP	30.21*	12.31*	35.28*	11.30*	29.90*	6.21*	25.54*	7.68*								
LSpotRP	38.70*	15.93	39.76*	16.68*	31.93*	8.89*	27.32*	10.63*	34.11*	14.85*						
LFlowRP	41.05*	13.72*	41.08*	16.12*	37.18*	16.12*	30.03*	11.45*	29.07*	10.25*	40.01*	18.02*				
LGreenRP	33.42*	10.48*	34.76*	9.16*	30.99*	10.32*	25.82*	9.05*	29.48*	13.16*	29.69*	10.92*	26.85*	10.18*		
LManRP	37.29*	13.54*	38.49*	14.78*	36.59*	13.87*	30.72*	12.83*	28.52*	11.76*	35.47*	12.80*	32.58*	13.67*	33.25*	10.42*

Number of lags = 2. The 5% critical values are 18.17 where Rank = 0 and 3.74 where Rank = 1.
Number of observations = 43, except for tests including Giant grouper where the number of observations = 31.
* indicates significance at the 5% level