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Price Setting in Markets for Egyptian Farmed Fish

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Abstract This article investigates the relation between fish supply volumes and sales values in El-Obour wholesale market. The study also examines market cointegration between farmed tilapia and imported wild frozen fish (tilapia, mackerel, Mediterranean horse mackerel, sardine and lizardfish). Regression and Johansen cointegration analysis was used for market data analysis. Market data includes fish sales volume and prices in El-Obour wholesale market in 2012. The results indicate that there is a negative relationship between the volume of farmed tilapia supplied to the market and sales values. Cointegration analysis shows that tilapia grade 1 and 2 prices compete together in market while catfish does not compete with farmed tilapia. Frozen lizardfish and sardines prices are cointegrated with tilapia grades 1 and 2 while tilapia grade 3 competes with lizardfish and Mediterranean horse mackerel, but there was no evidence of market cointegration between catfish and frozen wild fish. The implications are important as increased tilapia supplies to the market leads to declining sales prices. In addition, there is market competition between wild frozen fish and farmed tilapia, however they are not fully integrated. Increasing imports of frozen fish could reduce the selling price of farmed tilapia and negatively influence investment in fish farms.

Keywords Egypt, Fish Market, Tilapia, Market Integration, Price Analysis

1. Introduction

Aquaculture plays an important role as the main source of fish for Egyptian consumers. While 3500 year-old Pharaonic tomb paintings of fish ponds show that fish farming has a long history in Egypt, the rapid rise in aquaculture production has taken place since the early 1980's. Egyptian aquaculture increased from 367,000 t in year 2002 to reach 1,018,000 t in year 2012 [1].

Despite this success, the Egyptian aquaculture industry faces a potential market crisis. The cost of inputs, particularly feeds, has increased rapidly [2], while market prices have remained static or declined in real terms. Almost all aquaculture-produced fish is sold whole in fresh or live form to Egyptian consumers as there is very little value addition or export of farmed fish [3-6].

The main Egyptian wholesale markets for farmed fish are El-Obour (near Cairo) and Kafr el Sheikh in the Nile Delta [6] however there are numerous smaller markets across the country and many smaller retail outlets ranging from formal shops to roadside retailers. El-Obour is the largest and most important fish market in Egypt. It currently has 3 halls for fish, both farmed and wild, with 87 shops working in the fish trade, selling 100 to 150 t of farmed fish per day [6, 7]. It has a daily fish auction selling both farmed and wild fish. Prices set at daily auctions are made publicly available and published on the El-Obour website. They appear to influence market prices across the aquaculture industry and are used by wholesalers during negotiations with fish farmers [6].

Fish farmers usually sell their fish at the pond-side to wholesalers who, for a commission of 3-6% of sales, transport fresh, unprocessed fish to wholesale markets for onward distribution to retailers, or distribute it directly to retailers. In some cases wholesalers have marketing arrangements with fish farmers and may supply credit to them [7, 8]. Larger, higher value, tilapia and mullet tend to be transported to city markets, such as El-Obour, near Cairo, whereas smaller fish are sold in rural or poorer urban areas at lower prices [6]. Reference [8] stated that farmed fish is sold the same day or the day after and attributed that to the nature of fresh fish sales with or without ice.

Several studies have highlighted the relationship between seasonal fluctuations in supply and prices for farmed fish resulting in a relative scarcity of aquaculture-produced fish, and higher prices, in the early part of the year compared to greater abundance and lower prices later in the year [6-9]. However, local market preferences are for whole, fresh, locally-produced fish as long as prices are competitive [7], while imports of low value fish species appeared to have an impact on farmed fish prices [10.11]. Reference [12] and [13] studied fish price elasticity and transmission between wholesaler and retailer, and concluded that changes in wholesale prices were greater for retail price increases than for retail price decreases. Market interactions between farmed fish and the wild fish have been studied in many countries [14-21]. None of previous studies investigated cointegration of farmed fresh fish with wild frozen fish in the main Egyptian wholesale market.

This study aimed to investigate price formation of farmed fish in El-Obour wholesale market between 1st January 2012 and 31st December 2012. Moreover, the study aimed to understand farmed fish price competition with low value wild frozen fish in the same wholesale market. Specifically the objectives of the study were:

- study the relationship between supply volumes and selling prices for farmed fish in wholesale market.
- test market integration between different farmed fish products in the same market.
- test market integration between wild frozen fish and farmed fish in wholesale market.

In the following section, the paper discusses Egyptian aquaculture development with a special focus on the main cultured species.

1.1. Egyptian Aquaculture Development

Almost all aquaculture production in Egypt is carried out in earth ponds which are concentrated in low-lying areas where water from irrigation systems drains into Northern coastal lakes (Burullus, Manzala and Edku) [3, 8]. Most fish farmers stock their ponds with sex-reversed Nile tilapia (*Oreochromis niloticus*) and mullet (wild-caught *Mugil cephalus* and *Liza ramada*) fingerlings once temperatures start to rise in April to May and harvest fish before temperatures drop at the end of the year [8]. Productivity has increased from 3 t/ha in 1991 [22] and 4 t/ha in 1994 [23] to reach average production levels of 8.5 t/ha in 2011 [8]. National aquaculture production increased from 376,000 t in 2002 to reach 1,018,000 t in 2012 (table 1) [1], at an average annual increase of 11% over the same period. Meanwhile, tilapia production grew by an average of 17% during the same time (table1). The proportion of tilapia compared to total production of farmed species increased rapidly from 45% in 2002 to reach 76% by volume in 2012. According to national statistics, Nile tilapia (*Oreochromis niloticus*) is the main cultured species (76% of total production in 2012) followed by mullets (13%), while carps (common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*)) account for 6.6%, African catfish (*Clarias gariepinus*) for 2.3%, and European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) for 2.8% [1]. Fish import data indicate an increasing trend. During 2012, fish imports accounted for 25% of per capita consumption. Low value fish such as sardine, mackerel, and other frozen fish represent around 60% of imported fish by volume to Egypt [24].

2. Methodology Approach

2.1. Data

The primary source for this study was daily fish sales data on sales volumes and selling prices for different fish species in El-Obour wholesale fish market near Cairo over the period 1st January to 31th December 2012 [25]. The number of observations for the study was 349 working days.

Market data was collected for the following farmed species/types: Nile tilapia (*Oreochromis niloticus*); mullets (flathead grey mullet, *Mugil cephalus* and thin-lipped mullet, *Liza ramada*); African catfish (*Clarias gariepinus*); and for the following wild species: mackerel (*Scomber scombrus*); lizardfish (*Saurida spp*.); sardine (*Sardinella spp.*) and Mediterranean horse mackerel (*Trachurus mediterraneus*).

There are specific market size grades of tilapia and mullet; tilapia grade 1 (375-600 g), grade 2 (250-375 g), and grade 3 (100-250 g), and mullet grade 1 (250-400 g) and grade 2 (150-250 g).

2.2. Sales Volume and Prices in El-Obour Wholesale Market

Table 2 shows total quantities of different types of fish supplied to El-Obour Market during 2012, average volume per day (for days when it was available) and average unit values during the year. The highest quantity of fish sold in 2012 was farmed tilapia grade 1 (T1) followed by wild-caught Aswan tilapia (AT), farmed grade 2 tilapia (T2), wild-caught frozen Mediterranean horse mackerel (MHM) and wild-caught frozen mackerel (FM). The total amount of farmed fish supplied to the market was 33,152 t/yr (95.5 t/day), while the total sales volume of wild fish was 25,975 t/yr (89.7 t/day). Different grades of farmed tilapia sales represent the majority (88%) of aquaculture-produced fish sold in the market. Reference [8] found in their value chain analysis of the Egyptian aquaculture, that tilapia represented 89% of total farmed fish production.

Figures 1 and 2 show changes of sale volume and unit value for the main species throughout the year (T1, T2, AT, MHM and FM) expressed as % from the average of the year. The supply of tilapia to El-Obour market shows a seasonal pattern (Figure 1). Supplies of farmed tilapia (T1 and T2) were lowest in March to May and highest in September through to December, reflecting greater availability of the larger farmed fish grades from fish stocked in early 2012. As might be expected, prices for farmed tilapia peaked in April when 20% less than the average was being supplied to the market, and were at their lowest in September and October when supplies increased (Figure 2). Supplies and prices of wild Aswan tilapia (AT) appeared to follow similar patterns, but with less fluctuation in prices, perhaps because of price controls in Aswan [26]. Mediterranean horse mackerel (MHM) is wild caught fish from the Eastern Mediterranean, which is stored before release to the market when farmed tilapia is in short supply. Figure 3 shows change in selling prices to changes in sales volumes for different grades of farmed tilapia and wild Aswan tilapia on a monthly basis.

3. Theory/Calculation

3.1. Regression Analysis

In order of understand price formation and to establish the relationships between fish supply volume and sales price for each fish species/type separately, regression analysis was carried out. A simple regression model used in this analysis to quantify change in sales prices due to change in supply volume assuming all other factors remain the same. Fish price selected as the dependent variable while the independent variable was supply volume. The model can be expressed as follows:

$$\mathrm{Y} = B_0 + B_1 X \quad (1)$$

Where; Y = dependent variable (fish prices US$/Kg); B_0 = constant; B_1 = slope regression coefficient and X = independent variable (fish supply in t/day).

3.2. Testing Market Integration

In order to determine the extent to which each type of fish was competing in a single market there was a need to measure whether there were relationships between price fluctuations for each species over the study duration. The Johansen test for cointegration was used with the main condition for using this test being that the price series shows nonstationary probability [5, 17, 27].

For testing the time series properties of price series data before running the analysis, we tested for the unit roots using the most common approach, the Augmented Dickey-Fuller (ADF) test [29]. Automatic selection of Schwartz information criterion (SIC) was used as the basis for determining the optimal lag length, where the maximum number of lags was ten. In this study, we ran the ADF test with and without a constant, as the prices of most species do not fluctuate around a constant. The Augmented Dickey-Fuller (ADF) tests carried out using the formula as described by [27].

$$\Delta p_{it} = \beta_o + \beta T + \sigma p_{it-1} + \sum_{\gamma=1}^{k} \propto_\gamma \Delta p_{it-\gamma} + \varepsilon_t \quad (2)$$

Where: p_{it} is each individual price, Δ is the difference operator, T is the time trend, k is the lag length and ε_t is refer to error term.

The Johansen cointegration test [29] was used for this analysis as it provides a good solution for testing cointegration by modeling the price relationship in VAR format and it allows testing of the 'Low of One Price' (LOP) [18]. The mathematical model carried out as described in detail by [27].

The Johansen test was carried out using the following VAR representation;

$$P_t = \sum_{i=1}^{k-1} \prod_i p_{t-i} + \prod_k p_{t-k} + \mu + e_t \quad (3)$$

Where: each Π is a *N*×*N*. matrix of parameters, μ is a constant and e_t~*iid* (0, *W*). The system of equations can be written in error correction model as following;

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Gamma_k P_{t-k} + \mu + e_t \quad (4)$$

Where: $\Gamma_i = -1 + \Pi_1 + \ldots + \Pi_i$ and i=1,…, *k*-1. Here $\Gamma_{\mathbf{k}}$ is the long-run "level solution" to equation (3). The rank of Γ_k, is defined by *r*, determines how many liner combinations of P_t are stationary. If *r* =*N*, the variables are stationary in levels; if *r* =0, none of linear combinations are nonstationary. When 0< *r* <N there exist *r* liner stationary combinations of P_t or *r* cointegrating vectors [19].

With cointegrated data series, one can factor Γk, such that Γk = αβ', where α and β are both N × r matrices of rank r. The cointegrating vectors or the long-run relationships in the system are contained in the β matrix. The adjustment parameters on the other hand are identified in the parameters contained in α. Two alternative tests that are used to identify the number of significant cointegrating vectors r, the trace test and the maximum eigenvalue test both of which are discussed in detail in Johansen [30]. The two tests have the null hypothesis that there are at most r cointegration vectors. The alternative hypothesis in the trace test is that there exist more than r cointegration vectors while for the maximum eigenvalue test, the alternative hypothesis is that there are exactly r + 1 cointegration vectors.

For testing the Law of One Price (LOP), restrictions can be placed and tested on the parameters in the β matrix. In the case of a bivariate system where two price series are examined, the rank of $\Pi = \alpha\beta'$ would be equal to 1 and the dimensions of α and β matrices would be 2×1. LOP is tested by imposing the restriction $\beta' = (1, -1)$. Since the matrix β contains long-run parameter in the system the test can be considered a test of the validity of LOP as a long-run concept. The equation used for the LOP test was as follows:

$$p_t^1 = \propto + \sum_{j=1}^{m} b_j\, p_{t-j}^1 + \sum_{i=0}^{n} c_i\, p_{t-i}^2 + e_t \quad (5)$$

The test for long-run LOP tests the restriction $\Sigma b_j + \Sigma c_i = 1$. If the restrictions $c_O = 1$, $c_i = 0$, and $b_j = 0$, $\forall_{ij} > 0$ cannot be rejected, this should be considered as evidence that it is statistically significant.

MS Excel was used for descriptive statistics (sum, means and charts). Regression analysis was performed using IBM SPSS statistical software package, version 19 (SPSS) [31] as described by Field [32]. In order to perform Johansen Cointegration analysis, the econometric software package EViews 5.0 was used [33]. For cointegration tests, fish price data was transformed into logarithms before the analysis.

4. Results

For T1, T2 and T3, there was a significant inverse relationship as the fish price increases when the sales volume decreased which was confirmed by linear regression analysis for each species/grade separately (Table 3). For T1, increasing the supply by 1% would lead to a -0.472% change in sales price. Similarly, a 1% increase in daily supply of T2 would lead to a reduction of selling price of 0.356%. Increasing in T3 daily supply by one percent would lead to a price reduction of only 0.174%.

A similar inverse relationship was established for frozen mackerel where an increase in sales volume of 1% would lead to a 0.193% reduction in selling price. In contrast, regression analysis indicated that increasing sales volumes did not influence significantly on the selling price for mullet, Aswan tilapia and frozen sardines. Meanwhile, increased sales volumes of frozen lizardfish and African catfish did not lead to increased selling prices, in spite of the significant relationship between sales volume and selling price. In the case of Aswan tilapia, the supply route for this fish at the time of study was highly regulated as the price was controlled in Aswan [26]. Also Aswan tilapia reach market frozen, so the wholesaler stores before selling as the market needs and sometimes processes a small percentage into fillets [6].

Table 4 shows the Augmented Dickey-Fuller tests on log nominal prices for each species/type. The numbers of lags for the Schwarz information criteria for each ADF test are shown in parentheses. The large number of lags chosen for the MHM price series is due to their high seasonal variability in the market. The null hypothesis of the test is that the data series is nonstationary. The test results indicate that we cannot reject the null hypothesis of nonstationary at levels for T1, T2, T3, CF, FS, MHM and FL. However, for all tested prices at first differences we can reject the null hypothesis of nonstationarity. As a result of this test, only species which were stationary (mullet, AT and FM) at levels were excluded from the Johansen cointegration test.

For nonstationary price series data used for testing selling price associations in the market and testing for the LOP, cointegration procedures are the correct tools for analysis [17, 19, 27]. Cointegration analyses started with multivariate cointegration test for all nonstationary time series prices reported in Table 5. The result of multivariate cointegration tests are reported in Table 5. The results of both max and trace test indicated one cointegration vector at 1% significant level. In order to investigate the source of this cointgeration, bivariate cointegration analyses were carried out.

The results of applying the Bivariate Johansen cointegration test for measuring wholesale price associations are listed in detail in Table 6. Six, separate, pairwise tests were carried out for different grades of tilapia and catfish. Mullet was excluded from this analysis as its price time series was stationary. When the null hypothesis of no cointegrating vector Rank $(\rho) = 0$ is rejected at the 1% or 5% level, that allows rejection of the hypothesis of zero cointegrating vectors. That applied only with T1 and T2. Also the null hypothesis of less than or equal to one cointegrating vector Rank $(\rho) \leq 1$ could not be rejected at the 5% level except for T1 and T2. The combination of the two sets of results indicates more than one cointegrating vector exists for tilapia grade 1 and tilapia grade 2 pair wise. The results indicate that tilapia 1 and tilapia 2 are not separate and formed long-run relationships during the study period. For the T1 with T3 or T2 with T3 pairs, the value of the calculated statistics for the maximum eigenvalues and trace tests (columns two and three) cannot reject the null hypothesis of zero cointegrating vectors. Therefore market integration did not exist between T3 and either T1 or T2. The analysis shows that catfish and different grades of tilapias fail to reject the null hypnosis of no cointegration vector at rank =0 at 5% significance level. Therefore, market integration was not found between catfish and different grades of tilapias and they are presented separately, and catfish do not take market share from tilapia markets.

As the price of T1 and T2 are cointegrated, we tested whether the LOP holds in this relationship. The test result of the LOP is shown in the last column of table 6. As the result of the LOP was rejected at 5% significant level we conclude that the markets for T1 and T2 are not fully integrated.

Table 7, shows the result of bivariate Johansen cointegrated tests between farmed fish and the most popular wild fish in the market. The test results show that the null hypothesis of zero cointegration at rank = 0 is rejected at 1% level for sardine with T1 and T2. Also the results reveal that farmed T2 & T3 are cointegrated with frozen lizardfish. Similarly the null hypothesis of no cointegration at rank=0 was rejected at a 5% level for Mediterranean horse mackerel (MHM) only with T3. This indicates that market integration was found between wild fish and at least one grade of tilapia in the market and that wild fish supply could influence tilapia prices.

On the other hand the test failed to the reject the null hypothesis at rank=0 at 5% significance level in case of catfish for the three wild fish species (FL, FS and MHM). Therefore, market integration was not found between catfish and wild fish in El-Obour market. So the most popular wild fish species do not compete in the same market with farmed catfish.

For pairwise prices of farmed fish and wild frozen fish which were forming long run relationships, we have also tested whether the LOP holds in each of these relationships. The LOP is tested for each pair of prices and reported in Table 7. The pairwise test were; T1&FS, T2&FS, T2&FL, T3&MHM and T3&FL. The null hypothesis was rejected at 1% significant level for the all the pairs tested. These results indicate that the market for wild frozen fish and tilapia are not fully integrated and their prices did not follow the LOP in relation to tilapia prices in wholesale markets.

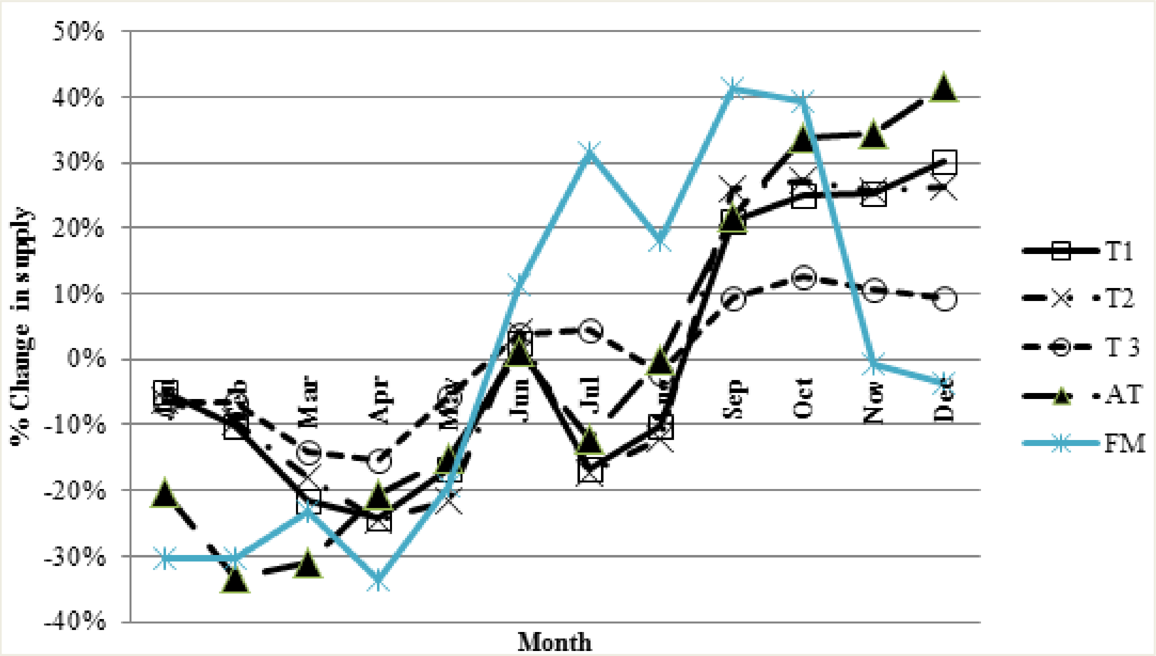

Figure 1. Monthly fluctuations in the supply of the five main fish species to El-Obour wholesale market (% deviation from average annual)

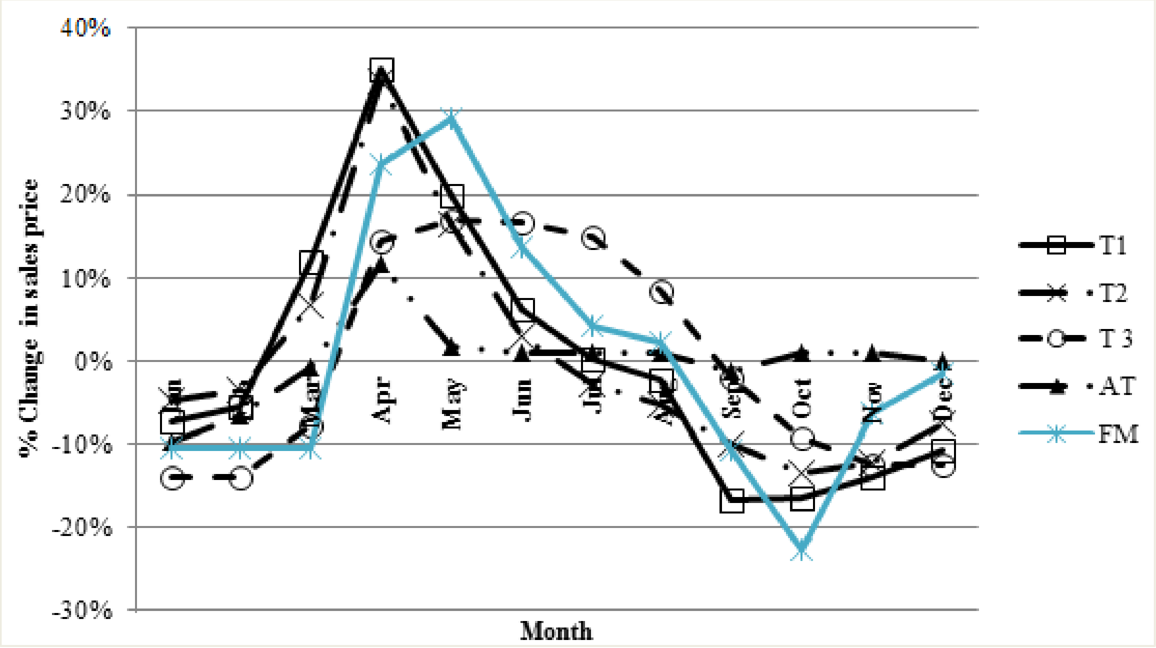

Figure 2. Monthly fluctuations of unit values in wholesale for the five fish species traded in El-Obour wholesale market (% deviation from average annual unit values).

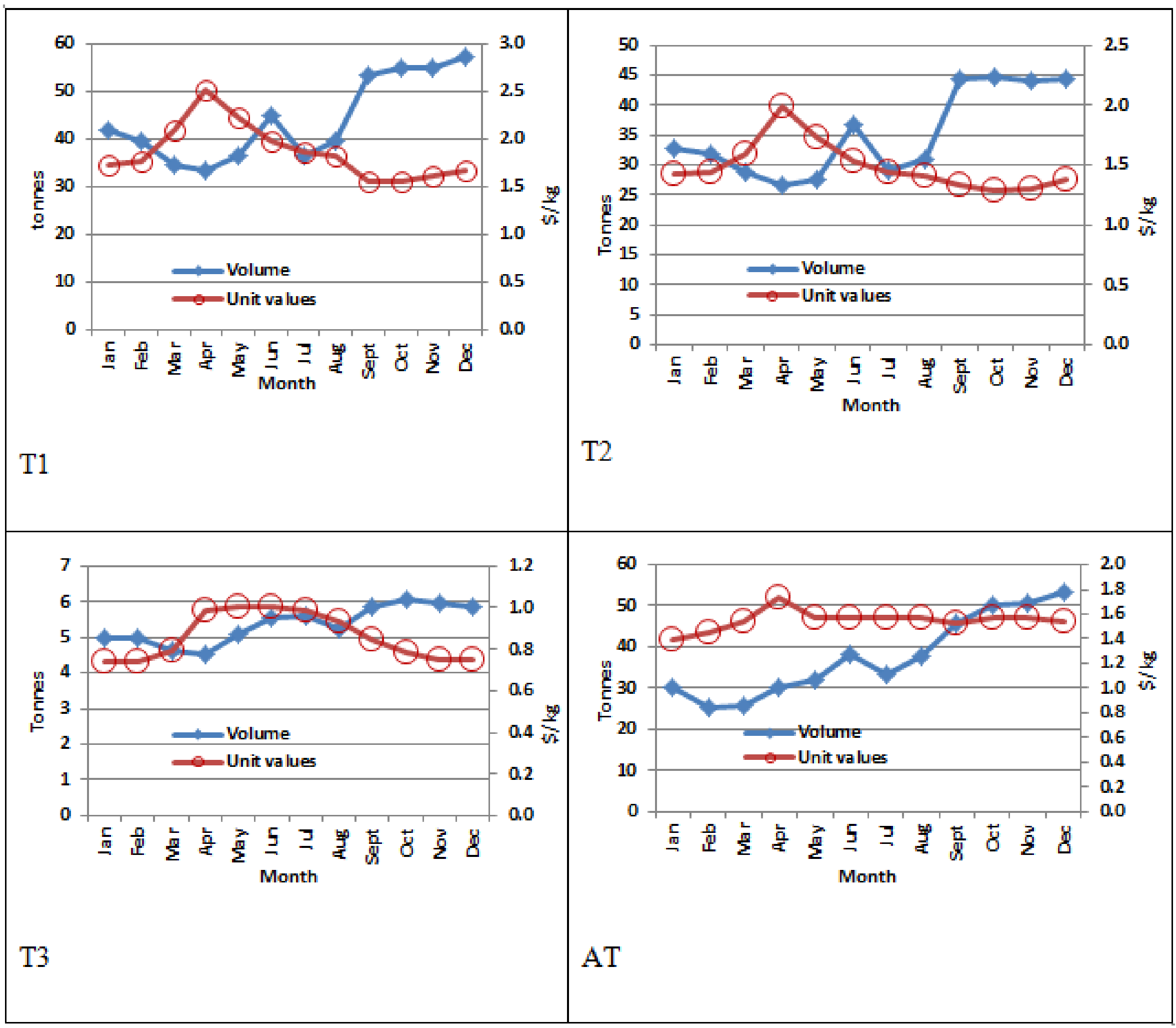

Figure 3. Change in sales prices according to sales volume in El-Obour wholesale market for T 1, T2, T3 and wild Aswan tilapia (AT).

Table 1. Total aquaculture production and fish imports in Egypt (000 t/year) and % annual increases in production, 2002 - 2012.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Aquaculture production in 1000 t	376	445	472	540	595	636	694	705	922	987	1,018
Tilapia production in 1000 t	168	200	199	217	259	266	386	390	557	611	769
Tilapia as % of Aquaculture	45%	45%	42%	40%	44%	42%	56%	55%	60%	62%	76%
Annual increase rate in Tilapia [1]	10%	19%	-1%	9%	19%	3%	45%	1%	43%	10%	26%
Annual increase % of Aquaculture [2]	10%	18%	6%	14%	10%	7%	9%	2%	31%	7%	3%
Fisheries import in 1000 t [3]	154.4	163.0	221.0	219.7	207.6	258.9	136.8	135.5	256.8	182.2	335

Data Source: GAFRD statistics year book
[1]Average increase in tilapia production is 17%
[2]Average increase in aquaculture production is 11%
[3]CAPMAS data shows that mackerel, sardine and other frozen fish comprise 60% of import volume.

Table 2. Quantities of fish supplied to El-Obour wholesale market in t and average unit values ($/kg) during 2012.

Fish Species/grades	Quantity (t/yr)	Average daily supply (t/day)	Unit value $/kg
Farmed Fish			
Tilapia grade 1 (T1)	15,352	43.99	1.88
Tilapia grade 2 (T2)	12,227	35.03	1.49
Tilapia grade 3 (T3)	1,824	5.35	0.86
Catfish (CF)	3,162	9.44	1.74
Mullet	587	1.73	4.17
Wild Fish			
Aswan tilapia (AT)	12,956	37.45	1.55
Mediterranean horse mackerel (MHM)	5,864	31.70	0.54
Frozen mackerel (FM)	3,486	10.02	1.66
Frozen sardine (FS)	2,744	7.89	1.24
Frozen lizardfish (FL)	925	2.64	0.95

Source: El-Obour market web site database.

Table 3. Linear regression analysis of 2012 daily market volumes and unit values ($/kg) in El-Obour wholesale market

Fish type	Linear regression equation	Statistical significance	R	R2	Y change % to 1% increase in X*
Tilapia grade 1 (T1)	Y = -0.02X + 2.742	0.000	0.645	0.416	-0.472
Tilapia grade 2 (T2)	Y = -0.015X + 2.00	0.000	0.628	0.395	-0.356
Tilapia grade 3 (T3)	Y = -0.028X + 1.01	0.002	0.168	0.027	-0.174
Catfish (CF)	Y = 0.036X + 1.397	0.000	0.342	0.116	0.196
Mullet	Y = -0.014X + 4.142	0.148	0.079	0.006	-0.004
Aswan tilapia (AT)	Y = 0.001X + 1.515	0.056	0.103	0.013	-0.024
Mediterranean horse mackerel (MHM)	Y = -0.004X + 0.675	0.004	0.212	0.045	-0.231
Frozen mackerel (FM)	Y = -0.032X + 1.981	0.000	0.352	0.124	-0.193
Frozen sardine (FS)	Y = -0.005X + 1.283	0.424	0.043	0.002	-0.032
Frozen lizardfish (FL)	Y = 0.163X + 0.505	0.000	0.854	0.729	0.460

Where, Y= Unit value (US$/Kg); X= fish quantity (t); R= correlation coefficient

* calculated as %(Δ Y/Y) as result of 1% increase in X

Table 4. Augmented Dickey-Fuller test (unit root test) for fish log nominal unit value series, January- December 2012 (n=349).

	levels[a]		First difference	
	Constant	Constant & Trend	Constant	Constant & Trend
Farmed fish				
Tilapia grade 1 (T1)	-2.010 (1)	-2.579 (1)	-24.871**(0)	-24.848**(0)
Tilapia grade 2 (T2)	-2.292 (0)	-2.899 (0)	-20.303**(0)	-20.293**(0)
Tilapia grade 3 (T3)	-1.618 (1)	-1.676 (1)	-21.2926**(0)	-21.332**(0)
Catfish (CF)	-1.412 (1)	-2.106 (3)	-15.681**(2)	-15.663**(2)
Mullet	-5.329**(1)	-5.332**(1)	-11.348 (6)	-11.396 (6)
Wild Fish				
Aswan tilapia (AT)	-2.987*(2)	-2.949 (2)	-15.823 (2)	-15.821 (2)
Mediterranean horse mackerel (MHM)	-1.391 (10)	-1.518 (9)	-24.237**(0)	-24.167**(0)
Frozen mackerel (FM)	-3.085*(3)	-3.129 (3)	-14.313 (3)	-14.293 (3)
Frozen sardine (FS)	-0.465 (3)	-1.424 (3)	-9.311**(2)	-9.400**(2)
Frozen lizardfish (FL)	-1.569 (0)	-1.622 (0)	-20.830**(0)	-20.838**(0)

a number of lags in ADF test in parenthesis.
* indicate significant at 5% level; ** indicate significant at 1% level.

Table 5. Multivariate Cointegration Test of farmed fish (T1, T2, T3, and Catfish) and wild frozen fish (MHM, FS, and FL) in El-Obour wholesale market. January - December 2012 (N= 349).

Ho: rank = P	Max Test	Trace Test	Proportionality Test - System
$P = 0$	56.51**	113.99**	8.874
$P \leq 1$	23.80	57.48	(<0.001)
$P \geq 2$	16.38	33.67	

** Indicates significance at the 1% level.

P-values in parenthesis. System estimated with three lags.

Table 6. Bivariate Johansen tests for cointegrations of T1, T2, T3 and catfish unit value series in El-Obour wholesale market. January - December 2012 (N= 349).

Prices	Null Hypothesis[a]				Law of One Price (LOP)
	Rank (ρ) = 0		Rank (ρ) ≤ 1		
	Max[b]	Trace[c]	Max[b]	Trace[c]	
T1 & T2	29.489**	33.419**	3.930*	3.930*	8.010**
T1 & T3	10.655	13.223	2.568	2.568	-
T2 & T3	12.199	14.875	2.675	2.675	-
T1 & CF	6.606	9.8	3.194	3.194	-
T2 & CF	6.359	10.505	4.146	4.146	-
T3 & CF	6.192	9.099	2.907	2.907	-

[a] the null hypothesis is that the number of cointegrating vectors is equal to ρ;
[b] maximum eigenvalue test;
[c] trace test.
** Indicates significance at the 1% level.
* Indicates significance at the 5% level.

Table 7. Bivariate Johansen tests for cointegrations of farmed tilapia unit value series with other substitutes in El-Obour wholesale market. January - December 2012 (N= 341).

Prices	Null Hypothesis[a]				Law of One Price (LOP)
	Rank (ρ) = 0		Rank (ρ) ≤ 1		
	Max[b]	Trace[c]	Max[b]	Trace[c]	
T1 & MHM	6.833	7.349	0.515	0.515	-
T1 & FS	19.261**	19.859*	0.597	0.597	13.228**
T1 & FL	9.924	13.917	3.993	3.993	-
T2 & MHM	14.257	14.445	0.188	0.188	-
T2 & FS	18.098*	18.766*	0.667	0.667	16.470**
T2 & FL	11.681	16.661*	4.981*	4.981*	16.350**
T3 & MHM	18.188*	18.844*	0.656	0.656	9.060**
T3 & FS	9.674	9.77	0.096	0.096	-
T3 & FL	19.185**	21.465**	2.279	2.279	15.264**
CF & MHM	12.475	14.436	1.962	1.962	-
CF & FS	4.056	4.546	0.49	0.49	-
CF & FL	5.643	8.967	3.324	3.324	-

[a] the null hypothesis is that the number of cointegration vector is equal to zero or one.
[b] maximum eigenvalues test
[c] trace test
* indicate significance at the 5% level; ** indicate significance at the 1% level

5. Discussion and Conclusions

The current study contributes to improved understanding of sales price formation and competition between different farmed fish in the main wholesale fish market in Egypt. The results explain why farmed fish prices usually decline from September to December due to increasing supply, while during the low supply season from March to May, farmed tilapia selling prices increase. The results show that the seasonal fluctuations in supply and prices for farmed fish result from a relative scarcity of aquaculture-produced fish, and higher prices, between February and May compared to greater abundance of product and lower prices from September to December. References [3, 6, 7, 8] reported that Egyptian fish farming is seasonal as most farmers stock in April-May and harvest in September–December before the on-set of winter. Similarly, Asche and Guttormsen [34] and Asche et al. [35] reported seasonality in supply of farmed salmon and wild cod in Norway fish markets. Similar conclusions were also reported concerning the seasonality of demand for American catfish in US market with demand peaks occurring during Lent and late summer or early fall [9].

Analysis of 2012 El-Obour wholesale market prices indicates that the quantity of farmed tilapia and similar products supplied to El-Obour market is the main factor determining wholesale prices for farmed tilapia. The study shows that there are significant inverse relationships between sales volumes and unit prices ($/kg) for tilapia grades 1, 2 and 3. Furthermore, there is also a significant inverse relationship between sales volumes and unit values of mackerel and Mediterranean horse mackerel. Similar results were reported by Macfadyen et al. [6] who found that farmed tilapia prices decreased with increasing supply to the market from September to December and prices increased in March and April as supplies declined at that time of the year. Similarly, many authors have reported that fish prices are demand driven [21, 34, 35].

Furthermore, the current study examined farmed fish price competition within the same market between different grades of tilapia and catfish. The study results indicate that markets for farmed tilapia and farmed African catfish are separate and there is no competition in the market. Also that the market for grade 3 tilapia is separate from the two other farmed tilapia grades (1 and 2), while there is a close relationship between prices for tilapia grades 1 and 2.

The study also examined the relationship between farmed fish and wild fish in the same market and found that markets for African catfish and wild fish are separate. This agrees with the findings of Norman-López [5] found that there was no relationship between prices of fresh tilapia and catfish in US markets. Norman-López and Asche [18] who found that fresh and frozen tilapia fillet not compete in the same market fresh and frozen catfish fillet. Hong and Duc [18] stated that there is a price relationship between catfish and other fish species in US fish markets in which domestic catfish and imported catfish were the closest substitutes. Moreover, they reported that there are substitution relationships between goods such as imported catfish and domestic catfish; domestic catfish and tilapia; and domestic catfish and salmon in US market. Asche and Steen [14] examined the relationship between prices for sea bass / sea bream and a number of other fish types in the EU market and found that bass and bream may compete with trout and several white-fish species. Reference [15] studied the market interaction of three groups of farmed fish (Atlantic salmon, American catfish and sea bass/sea bream) and wild fish in US and EU markets. They found that there was a close market relationship between different (farmed and wild) salmon species but little market interaction between farmed fish and other wild species.

The current study found there are several market relationships between different grades of farmed tilapia and wild frozen fish. For example, the results indicated that there was market integration between frozen sardines and tilapia grades 1 and 2. Also, there was market integration between frozen lizardfish and tilapia grades 2 and 3, while Mediterranean horse mackerel competed only with tilapia grade 3. This supports the results reported by Hebicha [10] who estimated that an increase in imported fish price of US$ 0.18/kg would lead to increase in per capita annual demand for local fresh fish of 0.26 Kg. In a study of the interaction between aquaculture products in US and EU markets, Asche et al. [15], found that there were close market relationships between different (farmed and wild) salmon species in US and EU markets. They also reported that there was little market interaction between farmed fish and other wild species in those markets. Furthermore, Asche et al. [16] found that there was a market substitution between wild salmon and farmed salmon in Japanese market.

The current study did not address the effect of consumer demand on fish price but this could be a topic for future research. There is seasonal demand for American catfish in US market with demand peaks occurring during Lent and late summer or early fall [9].

As annual production by Egypt's fish farmers continues to grow there is likely to be continued downward pressure on selling prices. On the market side, existing distribution channels are short with limited geographical reach [3] and there is little processing or value addition to diversify product outlets [6]. To maintain profitability and avoid a market crash, fish farmers are trying to become more efficient to reduce production costs. Furthermore, fish farmers have to improve post-harvest handling to extend the shelf-life of fresh fish in the market [3, 6, 7].

The implications of the current study are important as it suggests that growth in tilapia supply to existing markets will lead to further reductions in sales prices, while there is also clear evidence of market competition between tilapia and wild frozen fish, so increased imports will place further pressure on wholesale market prices. This suggests that farmers may need to diversify their production systems to increase production of other species, such as catfish and mullet, and also develop alternative marketing strategies for tilapia through processing and exports.

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