Price Dynamics and Cointegration in the Major Markets of Aquaculture Species in the Philippines

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ABSTRACT

This study explores the interdependencies of aquaculture markets in the Philippines by establishing the price cointegration between the wholesale and retail prices of three major species commonly farmed in the country, i.e., milkfish, tilapia, and shrimp. The co-movements of wholesale prices between and among key markets for each species are also investigated. Moreover, exogeneity in prices is established using the Granger-causation model to determine the existence of price leaders among these markets. These information are crucial because they may provide a better understanding of the efficiency in price formation across production and consumption centers. Thus, aquaculture producers and traders may use these information as basis for more efficient farm management and marketing decisions. Appropriate policies for the development of markets for the three aquaculture species are also identified in this study. Such policies are expected to contribute towards more efficient pricing and distribution of benefits among market players and stakeholders. These benefits are expected to manifest through the system of grading standards for fish traded in local markets, and the choice of cost-effective technologies in grow-out and post-production practices.

INTRODUCTION

Aquaculture has always been a major source of food fish and animal protein for many households, especially those belonging to the poorer sector. It has significantly provided income to fish farmers, entrepreneurs and exporters in many developing countries in Asia. The case of Philippine aquaculture is not different from the global trends. As noted by the Food and Agriculture Organization (FAO), "nearly half of all fish eaten today is farmed, and not caught in the wild". To illustrate the growth of aquaculture, data from FAO (2009) show that while this industry provided only nine percent of the world food fish in 1980, its share in total fish production had ballooned to around 52 percent by 2006.

In the Philippines, three major aquaculture species have significantly contributed to the overall availability of fish for human consumption in the country and in various export destinations for over three decades now. These are the milkfish (*Chanos chanos* Forsskal), tilapia (*Tilapia nilotica*), and tiger shrimp (*Peneaus monodon*). The rising production of aquaculture products in the country has significantly augmented the declining supply of fish captured from the wild. This has been made possible through improved aquaculture technologies, e.g., improved broodstock domestication, better hatchery protocol, fish health management, feed development, and modern grow-out/culture practices.

In spite of production increases due to improved culture technologies, the development of the aquaculture sector of the country has been challenged by the efficiency in pricing and its implications on the distribution, and consumption of fish products in various areas around the country. As such, pricing efficiency comes under close scrutiny when tackling the role of aquaculture towards ensuring food sufficiency and improving access to food among the poor in the Philippines. Note that sufficiency in food fish does not come from production increases alone. Efficiency in marketing is equally important in ensuring an adequate supply in consumption areas, given equilibrium prices.

The role of prices in the efficient distribution of aquaculture produce has critical implications for developing countries such as the Philippines where aquaculture recorded 10.4 percent growth rate in 2006; while the capture fisheries showed only 2.6 percent growth [Bureau of Agricultural Statistics (BAS) 2008]. The dynamics in transmitting price information from the production base to the consumption areas is an important component of price formation, more so because the Philippines is an archipelagic country where markets are spatially separated. Often, price is the most important signal that defines the demand and supply situation in the market. Aside from other market forces, variation in fish prices is usually associated with production uncertainty which is generally greater in markets that are closer to the product origin or in the upstream end of the marketing chain. These production uncertainties are often due to biotic constraints like water quality, fish diseases, and weather conditions which traditionally threaten the aquaculture farmers. Establishing the relationship between the wholesale and retail prices, and between wholesale prices among geographically separated markets, can help provide farmers a better understanding of the efficiency in transmitting market information, which in turn defines the movement of prices and products in the market.

OBJECTIVES OF THE STUDY

This study aims to test for "price cointegration" and "price leadership" between the wholesale and retail prices in a given market; and between wholesale prices among geographically separated markets for three major aquaculture species in the Philippines, namely: milkfish, tilapia, and shrimp. In particular, the study seeks to:

1. determine the existence of price cointegration within markets (vertical integration), and among markets (horizontal integration) in the domestic trade of these aquaculture species;
2. measure the speed of price adjustments in the event of a market shock, given cointegrated prices within a market or between two markets;
3. establish the occurrence of price leader(s) in various market centers for the three fish species;
4. suggest policies to improve the production and marketing of these fish species, based on a better understanding of the price interdependencies between production and consumption centers; and
5. recommend policy options that will

generate benefits among producers, traders, consumers, and other stakeholders in the aquaculture sector.

METHODOLOGY

In the study of price and market integration, marketing has to be regarded as a complex network of economic interactions that makes productive activities performed by a variety of economic agents (no matter how widely dispersed over time and space) interrelated so as to sustain a national economy (Jones 1974). Thus, methodologies for evaluating relationships between geographically separated markets that are related by trade of commodities and services become an area of interest among market analysts. Univariate tools for analyzing price time series have been instrumental in comparing the price movements between markets (Ravallion 1986). The pioneering work of Granger (1969) on the causality between pairs of price series brought forth studies such as Sims' (1972) that demonstrated methods for comparing prices using two-sided distributed lag models; Haugh's (1976) which dealt with cross-correlation techniques; and that of Pierce and Haugh (1977) on the test of market independence. These methods were followed by other studies that modeled market performance using structural time-series models. These models were often found desirable as they elucidated relationships among factors that better explained price movements and influenced production decisions.

The dynamics in transmitting price information from the production base to the consumption points is an important component of price formation. Often, the price is the most important market signal that characterizes the demand and supply situation in the market. Establishing the price relationships among geographically separated markets can help provide a better understanding of the efficiency in transmitting market information which defines the movement of products among these markets.

Studies on price cointegration are useful in establishing the existence of a common trend and long-term relationship between prices. However, available studies on price dynamics and market integration for fisheries are mostly focused on large-scale market chains in developed markets (Ling 2003 and Petersen and Muldoon 2007). In spite of the long history of fish culture and the contribution of aquaculture in securing food and livelihood in the Philippines, only a few studies such as Salayo (1989); Paraguas and Garcia (2006), Salayo (2006) have been done to analyze the demand, pricing, and market integration for aquaculture fish species in the country.

This study attempts to fill the gap in the analysis of vertically- and spatially-related prices of milkfish, tilapia, and shrimp in the Philippines in order to assist the aquaculture farmers in defining trading options for their harvests. Understanding the movements and relationships of prices of these aquaculture species will also aid production and investment decisions in terms of intensity of operations, timing of stocking, harvesting, and product destinations.

Our investigation on the price cointegration of the three fish species targets both vertically-related markets (i.e., wholesale vs. retail prices in a given market), as well as horizontally-related markets (among wholesale markets) in the country. The test for cointegration is used to determine if these markets form part of an integrated market or are spatially independent. Also, we attempt to establish exogeneity in prices ─ that is, whether there is interdependence, independence or price leadership between wholesale and retail prices within markets, and between wholesale prices in pair-wise markets) ─ using the test for Granger-causality.

Cointegration Analysis

To determine whether the prices of major aquaculture species are spatially independent or integrated, the retail and wholesale prices in selected markets are tested for cointegration. The test for cointegration is used to establish whether the relationship between the retail and wholesale prices within a market, or the wholesale prices between markets, exhibits co-movements or is simply spurious, meaning, the regression between two price series results in a meaningless relationship. The latter occurs when both prices are highly stochastic or non-stationary such that the regression model fails to capture the common trend between the prices and leaves out a residual term that is still laden with nonrandom elements. This is often indicated by very high R^2 but very low Durbin-Watson statistic due to high autocorrelation in the model. In most cases, the regression coefficients will also turn out to be highly significant. Note that these model characteristics are not consistent with each other, indicating some anomalies in the regression results.

To test for cointegration, the Augmented Dickey-Fuller (ADF) test is employed to establish the stationarity or randomness of the error term of the cointegrating regression of the price series. If the error term is found to be stationary, then it is considered as a white noise (i.e., purely random) and hence, the two prices are deemed cointegrated. This means that the price series being tested for cointegration have a long-term relationship. Furthermore, this implies that the prices are trending together towards equilibrium in a synchronized manner. (The ADF test is described in greater detail in the following section.) Note that the test for cointegration can only be applied to price series that are integrated of order one or I(1). This means that each of the price series in the regression model must be non-stationary in its level form but stationary in its first difference. The ADF test can likewise be used to establish the level of integration of the price series prior to the cointegration test.

Cointegration test among markets. In this study, the cointegration tests among markets were conducted using the deflated wholesale prices between pairs of provincial markets. The choice of the wholesale price as basis for horizontal price integration is based on the practice of middlemen to trade at the wholesale level and not at the retail level. Let A and B represent two geographically separated markets. The cointegrating regression for the wholesale prices in the two markets is specified as follows:

$$Wholesale\ Price_A = \alpha + \beta\ Wholesale\ Price_B + \mu \quad (1)$$

To test for cointegration, the ADF test was employed to determine whether the error term μ of the cointegrating regression in equation (1) is a white noise (meaning randomly distributed). The test follows the following model specification:

$$\Delta\mu_t = \beta\ \mu_{,t-1} + \varepsilon_t \quad (2)$$

If β in equation (2) is found to be statistically significant (i.e., accept Ha: $\beta \neq 0$ at level of significance $\alpha = 5\%$), then the error term of the cointegrating regression is considered random and hence, the prices in the regression model are deemed cointegrated. This means that the wholesale prices in the two markets have a long-run relationship. Otherwise, if β is found to be statistically non-significant (i.e., accept Ho: $\beta = 0$), then the error term is considered non-stationary. This implies that the two wholesale prices have a spurious relationship such that the generated regression parameters are not valid for inference.

Cointegration test within a market. The cointegration test within a given market aims to determine the relationship between the retail price and the wholesale price. Let the equation below represent the cointegrating regression between these two price levels, i.e.,

$$Retail\ Price = \alpha + \beta\ Wholesale\ Price + \mu \qquad (3)$$

Note that in equation (3), the retail price serves as the dependent variable, and the wholesale price, the independent variable. This specification conforms to the observed practice of retailers to set the retail price by imposing a fixed margin on the wholesale price. However, a reverse specification can also be used for testing the cointegration of the wholesale and retail prices. The two models will yield similar test results.

The ADF test for μ in equation (3) follows exactly the same procedure employed in equation (2) above. If the error term is found to be stationary, then the retail and wholesale prices are cointegrated. Otherwise, if the error term is found to be non-stationary, then the relationship between the retail and wholesale prices is simply spurious and their trends are considered independent.

Error-Correction Model

Given that prices within a market or between two markets are cointegrated, then it can be concluded that there is a long-run trend that is followed by these prices. However, external shocks can cause disequilibrium to occur in the short run. The error-correction model can be used to measure the speed of price adjustments with respect to a market shock that may disturb their long-run equilibrium. The speed of price adjustment can be investigated by running the following error correction models:

a. Within markets:

$$\Delta RP = \alpha + \beta \Delta WP + \delta \mu_{t-1} + \varepsilon_1 \qquad (4)$$

b. Between markets:

$$\Delta WP_A = \alpha + \beta \Delta WP_B + \delta \mu_{t-1} + \varepsilon_2 \qquad (5)$$

The ΔRP and ΔWP in the model capture the short-run disturbances in the respective prices, while μ_{t-1} captures the adjustment of the two prices towards their long-run equilibrium. The speed of adjustment is measured by the coefficient δ of the lagged error term μ_{t-1} which determines the proportion of the disequilibrium in one period that can be corrected in the next period. If the error term is found to be statistically significant, then the model is in disequilibrium and the size of δ determines how quickly the equilibrium can be restored. Specifically, the length of time required to complete the adjustment process is measured by the absolute value of the reciprocal of δ or $|1/\delta|$.

For example, if δ = -0.09, this means that about 9 percent of the discrepancy in the actual long- run equilibrium price is eliminated or corrected in the succeeding period. The negative sign indicates that the adjustment process reduces the length of time for the prices to converge back to equilibrium from period to period. When applied to monthly data, δ = -0.09 means that it will take |1/-0.09| =11.11 months for the two prices to complete the adjustment process and return to their common trend. On the other hand, if δ is found to be statistically non-significant, this suggests that prices adjust concurrently to changes in each other. Since the δ coefficient is deemed to be equal to zero, therefore, there is no lag time required for the prices to go back to equilibrium. This further implies that both prices respond to the shock simultaneously.

Granger Causality Analysis

Exogeneity in prices or price leadership within markets can be established using the test for Granger-causality. By definition, the price in market A is said to Granger-cause price in market B when the changes in price A precede the changes in price B. In this study, the exogeneity or endogeneity between the wholesale and retail prices is investigated using the following Granger-causality models:

$$WP_t = \Sigma\, \alpha_i\, RP_{t-i} + \Sigma\, \beta_j\, WP_{t-j} + \mu_{1t} \quad (6)$$

$$RP_t = \Sigma\, \delta_i\, RP_{t-i} + \Sigma\, \theta_j\, WP_{t-j} + \mu_{2t} \quad (7)$$

The statistical significance of α and θ in equations (6) and (7) determines whether the retail or wholesale price is the price leader. There are four possible relationships that can exist between the wholesale and retail prices depending on the significance of α and θ. These are as follows:

a) The retail price is Granger-causing the wholesale price. ($\Sigma\alpha i \neq 0$ and $\Sigma\theta j = 0$);
b) The wholesale price is Granger-causing the retail price. ($\Sigma\alpha i = 0$ and $\Sigma\theta j \neq 0$);
c) Bilateral relationship between the wholesale and retail prices. ($\Sigma\alpha i \neq 0$ and $\Sigma\theta j \neq 0$);
d) Independence between the wholesale and retail prices. ($\Sigma\alpha i = 0$ and $\Sigma\theta j = 0$).

A case of price leadership or an exogenous price relationship occurs between the wholesale and retail prices in cases *a* and *b* above. Specifically, the retail price is considered the leader in the first case, and the wholesale price acts as the leader in the second case. The absence of a price leader is established in cases *c* and *d*. Incidentally, the third case results in a two-way relationship between the wholesale and retail prices. This implies endogeneity in their relationship such that the interdependence of the two prices prohibits the existence of a single price leader. Similarly, the fourth case fails to identify a price leader since the wholesale and retail prices are independent of each other under this situation.

Sources of Data

This study used time-series price data for milkfish, tilapia, and shrimp, as compiled from the monthly wholesale and retail prices published by the Bureau of Agricultural Statistics (BAS) from 1990 to 2005. Since all the price data were in real terms, the monthly price index for "food and beverages" from the National Statistics Office (NSO) was used as price deflator to remove the effect of inflation in the price series. Thus, any price changes that could be observed in the series could be treated as pure responses to demand and supply forces or any likely shocks (other than inflation) that occurred in the market.

Aside from the price data, the other pieces of information needed for market appraisal were gathered through key informant interviews (KIs), either on site or via telephone. Specifically, the KIs were done to gather information about fish landing operations, price determination procedures, and other trade practices in selected fish production areas around the country. The key informants included traders at different market levels, fish farmers, and service providers such as credit facilitators and input (i.e., feed) suppliers whose transactions potentially influenced the prices and movements of farmed fish products.

Limitations of the Study

One of the limitations of this study is the lack of complete time-series data of prices at the wholesale and retail levels in various market locations around the country. Data have, in fact, been more sparse in recent years, i.e. 1995 and onwards, than in earlier years. Some production and consumption areas around the country, especially in the Visayas and Mindanao, were not included in this analysis because the BAS no longer collected data in the said areas due to the limited budget for data collection.

Another limitation of the study is its inability to link market-related infrastructure developments that took place in the vicinity of the identified markets to the observed behavior of the wholesale and retail price series. This shortcoming proved to be restrictive in formulating the recommendations and policy implications based on findings of the study. Ideally, the influence of infrastructure developments on the behavior of prices in the respective markets should have been included for a more holistic approach in the analysis of price dynamics and market integration.

PRESENTATION AND ANALYSIS OF RESULTS

Aquaculture, which is the largest among the three sectors comprising the Philippine fisheries industry, contributes 46 percent (Figure 1) to total production, with its share amounting to 1.9 million metric tons valued at PhP 49.2 billion in 2005 (BAS 2006). The two other sectors are the municipal and commercial capture fishery sectors, both contributing 27 percent each to total production. The municipal fishery sector is composed of small-scale operators that are engaged in fishing activities using boats that are less than three gross tons and operating within the allowable 15 km distance from the municipal shoreline. On the other hand, the commercial fishery operators use fishing vessels that are greater than three gross tons and operate in off-shore fishing grounds beyond 15 km from the shore.

Fisheries production accounts for about 4.3 percent of the country's GDP at constant prices (BFAR 2005). On the whole, the industry provides employment to an estimated 1.6 million fishing operators, and food to over 80 million Filipinos. Specifically, fish is an

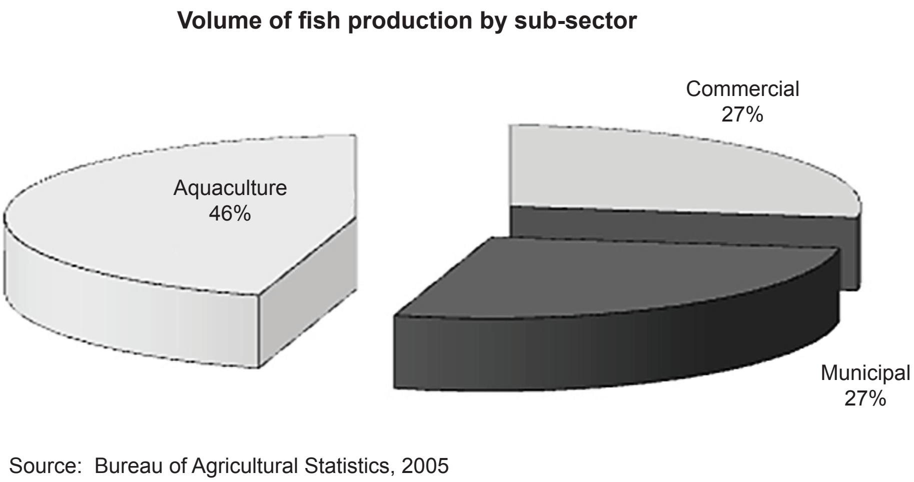
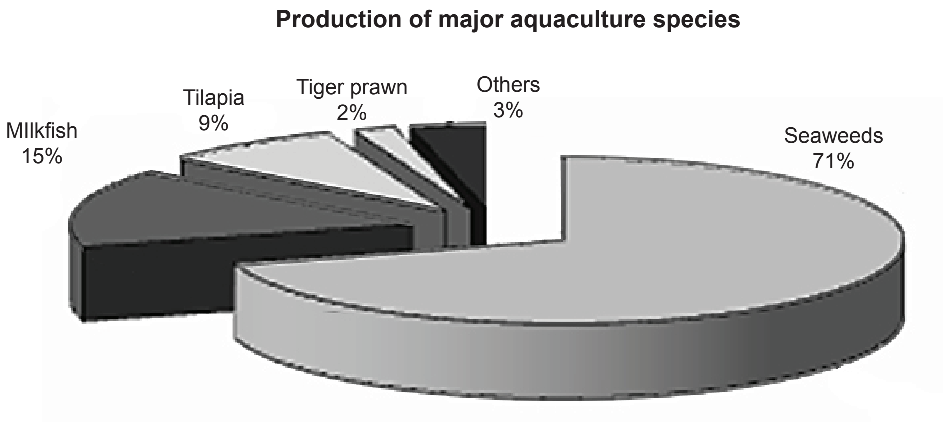


Figure 1. Share of fisheries sub-sector to total volume of fish production (%) Philippines, 2005

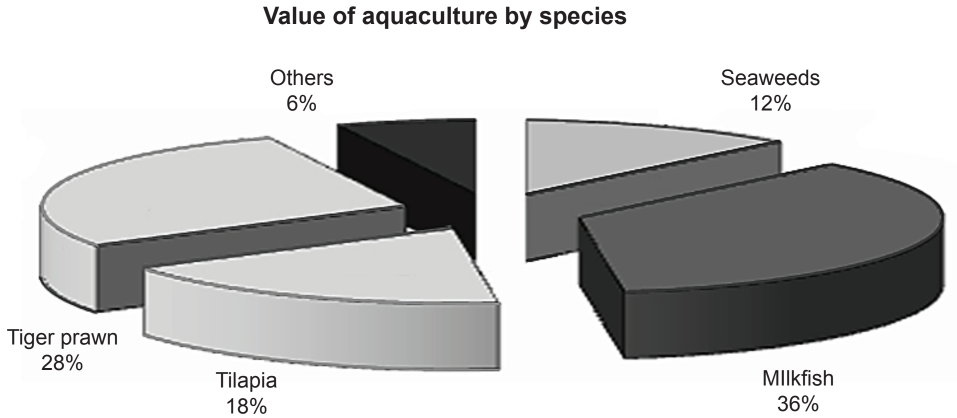
important source of animal protein, especially among the poorer segment of the society due to its affordable price.

The major aquaculture species farmed in the country are seaweeds (71%), followed by milkfish (15%), tilapia (9%), and shrimps (2%) (Figure 2). Other aquaculture species, which altogether account for the remaining three percent of production volume, include carp, oyster, mussel, mud crab, and catfish. Milkfish, tilapia, and shrimp constitute 26 percent of the country's aquaculture production in terms of volume and 82 percent in terms of value (Figures 2 and 3). Although seaweed ranks first in aquaculture production, the value of its production is only 12 percent due to the low value of fresh seaweeds. Notwithstanding the role of seaweeds in Philippine aquaculture, this



Source: Bureau of Agricultural Statistics, 2005

Figure 2. Share of aquaculture production (%) by major species, Philippines, 2005



Source: Bureau of Agricultural Statistics, 2005

Figure 3. Share in the value of aquaculture production (%) by major species, Philippines, 2005

paper focuses primarily on food fish markets, which directly impinge on the production, consumption, and food security of a key staple food in the country.

In terms of the value of production, milkfish production contributed the largest share (36%) to aquaculture production in 2005 (Figure 3), which was valued at PhP 17.6 billion (BAS 2006). Shrimp production ranked second, contributing 28 percent to the total value of aquaculture production valued at PhP 13.6 billion. Despite the meager share of shrimp production in the total volume of production (only 2%), its total value contributed a significant share since shrimp is a high-value crop. Tilapia ranked third with value share of 18 percent amounting to PhP 8.9 billion.

Selection of Key Market/Trading Centers

The markets selected in this study represent the country's major production and trading areas for milkfish, tilapia, and shrimp. Where available, the price time series were investigated to establish the existence of price leaders and price cointegration in these production/ trading centers.

Tables 1, 2, and 3 present the output share of the major producers of milkfish, tilapia, and shrimp, respectively. For milkfish, the 11 key trading centers include the first three provinces with the highest production, namely: Pangasinan (20%), Bulacan (11.6%), and Iloilo (7.9%). Aside from the National Capital Region (NCR), the seven other provinces leading milkfish production are Samar, Mindoro Occidental, Misamis Oriental, Cebu, Davao del Sur, Pampanga, and Quezon which altogether constitute 48.5 percent of total production. Overall, these eleven provinces represent 88 percent of milkfish production in the country.

In the case of tilapia, six provinces, together with NCR, had been selected as key trading centers with Pampanga leading at 33.6 percent, followed by Bulacan (6.2%). The other four provinces, namely, Pangasinan, Mindoro Occidental, Cagayan, and Cavite, altogether contribute 29 percent to total production (Table 2). These six provinces constitute about 69 percent of overall tilapia production in the country. Incidentally, tilapia is not as popular in the Visayan and Mindanao regions, where there is greater preference for marine fish. This observation is explained by the abundance of marine fish in the central and southern regions, making them more affordable locally. In contrast, marine fish, although also highly preferred in the northern regions are relatively scarce, hence highly priced. Thus, tilapia has gained wider acceptance among fish consumers in Luzon than in other regional markets of the country.

Finally, in the case of shrimp, five provinces, including NCR, were selected to represent the key trading centers. Pampanga, which is the largest shrimp-producing province in the country, tops the list contributing 38.1 percent to overall production. The four other provinces include Mindoro Occidental, Bulacan, Quezon, and Cebu which together account for about 21.4 percent of total production. Overall, the selected provinces covers about 60 percent of total shrimp production in the country. It is interesting to note that except for Bohol, all the shrimp-producing areas register negative growth rates over the 2001–2005 period (Table 3). This is mainly due to the diseases that have been infesting the country's shrimp farms for several decades now.

For all the three species, NCR is included as a key market since it serves as the biggest net consumption center. Note that there are more regional markets that are included in the analysis for milkfish and tilapia since these species are often locally traded. This has enabled BAS to collect price data in many geographic markets. On the other hand, shrimp (specifically the tiger shrimp, which is the species considered

Table 1. Milkfish production by top producing provinces, Philippines, 2001-2005.

PROVINCE	PRODUCTION (MT)					AVERAGE SHARE (%)	AVERAGE GROWTH (%)
	2001	2002	2003	2004	2005		
Bulacan	45,513	42,404	35,833	34,785	33,502	11.6	-7.24
Pangasinan	30,782	35,269	38,806	46,302	57,837	20.0	17.21
Capiz	15,897	16,518	17,740	18,514	19,088	6.6	4.69
Iloilo	16,414	15,156	15,897	20,484	22,811	7. 9	9.36
Negros Occidental	14,351	14,043	14,406	15,540	15,598	5.4	2.17
Other provinces	102,380	108,772	123,823	137,968	140,317	48.5	8.30
TOTAL	**225,337**	**232,162**	**246,505**	**273,593**	**289,153**	**100.0**	**6.47**

Table 2. Tilapia production by top producing provinces, Philippines, 2001-2005.

PROVINCE	PRODUCTION (MT)					AVERAGE SHARE (%)	AVERAGE GROWTH (%)
	2001	2002	2003	2004	2005		
Bulacan	10,040	7,077	8,503	8,807	7,236	6.2	-5.91
Pampanga	32,654	46,111	46,179	47,595	54,245	33.6	14.60
Batangas	22,918	22,391	28,566	32,860	36,039	21.2	12.50
Laguna	6,206	6,653	7,787	8,374	9,196	5.7	10.40
Sultan Kudarat	2,018	6,026	6,935	7,509	6,836	4.4	53.25
Other Provinces	32,910	34,141	38,025	40,724	49,451	29.0	10.91
TOTAL	**106,746**	**122,399**	**135,996**	**145,868**	**163,003**	**100.0**	**11.26**

Source of basic data: Fisheries Statistics of the Philippines, BAS, 2006

Table 3. Shrimp production by top producing provinces, Philippines, 2001-2005.

PROVINCE	PRODUCTION (MT)					AVERAGE SHARE (%)	AVERAGE GROWTH (%)
	2001	2002	2003	2004	2005		
Pampanga	16,638	13,082	13,407	13,781	15,037	38.1	-1.75
Lanao del Norte	5,102	4,973	4,570	4,221	4,805	12.5	-1.11
Zamboanga Sibugay	--	4,033	4,120	3,997	3,880	10.6	-1.25
Zamboanga del Sur	6,516	2,948	3,074	3,067	3,153	9.9	-11.98
Bataan	2,767	1,677	1,020	1,064	1,189	4.1	-15.63
Bohol	1,093	1,157	1,271	1,335	1,349	3.3	5.45
Other provinces	8,582	7,623	7,536	8,451	8,308	21.4	-0.47
TOTAL	**40,698**	**35,493**	**34,998**	**35,916**	**37,720**	**100.0**	**-1.63**

Source of basic data: Fisheries Statistics of the Philippines, BAS, 2006 in this study) is often directly traded or sold to processor-exporters, hence, only an insignificant amount of farm produce is traded in the local markets. Thus, there are few price series in the BAS compilation even if tiger shrimp is widely grown and traded in many regional production centers such as Zamboanga, Lanao del Norte, and Misamis Occidental.

Trends in Prices

Table 4 shows the mean and coefficient of variation (CV) in the monthly wholesale and retail prices of milkfish, tilapia, and shrimp from 1990 to 2005. Current prices of milkfish (both wholesale and retail) are on an uptrend from 1990–2005 with growth rates of 5.2 percent and 5.4 percent annually (Figure 4). In contrast, the real or deflated prices (after removing the effect of inflation) both exhibit downward trends, implying that the real retail and wholesale prices of milkfish are declining over time. This supports the popular claim among farmers that their returns from milkfish production have been decreasing due to this price squeeze.

The average retail price of milkfish in the Philippines is estimated at PhP 71.86 per kg from 1990 to 2005 while the average wholesale price is PhP 58.21 per kg (Table 4). The CVs of the two price series are almost the same (16.57 and 16.53 percent, respectively) indicating similar variability in the movements of these prices. Computing for the difference between the retail and wholesale price shows that the marketing margin amounts to an average of PhP 13.59 per kg. This margin captures all the marketing

Table 4. Descriptive statistics of monthly milkfish prices and marketing margins by aquaculture species, Philippines, 1990-2005.

PRICES	MILKFISH		TILAPIA		SHRIMP	
	Mean (PhP)	CV (%)	Mean PhP)	CV (%)	Mean(PhP)	CV (%)
Retail price	71.86	16.57	56.47	16.29	291.72	30.06
Wholesale price	58.21	16.53	41.93	19.98	268.91	28.93
Marketing margin	13.59	23.49	14.54	24.14	22.81	130.64

Source of basic data: BAS, 1990-2005

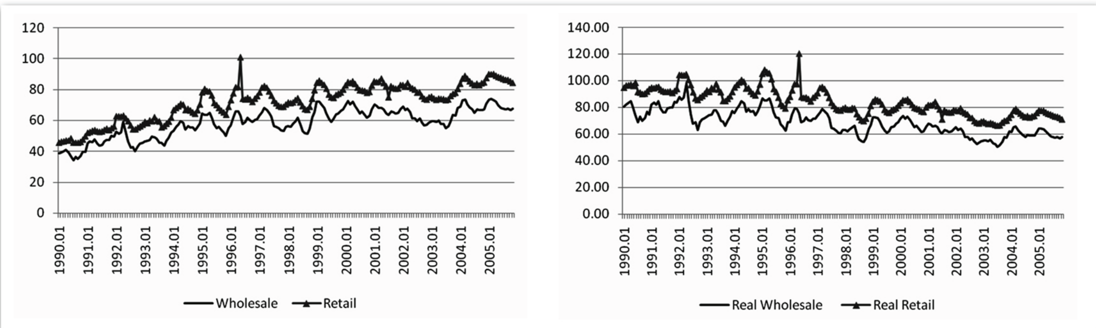


Figure 4. Current and real value of wholesale and retail prices of milkfish, Philippines, 1990-2005

costs (e.g., chilling / freezing / refrigeration, packing, transport costs, hauling) and the profits of traders, which together comprise about 23 percent of the wholesale price.

While the production volumes of tilapia have been increasing over time, Figure 5 likewise shows an increasing trend in the monthly wholesale and retail prices of tilapia from 1990 to 2005. Specifically, current prices (both wholesale and retail) are growing at annual rates of 9.72 percent and 6.12 percent, respectively. However, its deflated price series show relatively downward trends with negative annual growth rate of -3.84 percent and -0.36 percent, respectively. The estimated average retail price of tilapia over the period is PhP 56.47 per kg while the average wholesale price is PhP 41.93 per kg. The variation in the wholesale price is found to be larger than the retail price as shown by their respective CVs (19.98 vs. 16.29 percent). This suggests that the movements in the wholesale price have a higher degree of variability than the retail price.

The marketing margin between the average retail and wholesale prices of tilapia amounts to PhP 14.54 per kg. This is equivalent to 35 percent of the wholesale price, and comprises all the marketing costs incurred in bringing the product from the point of production to the consumption centers at its desired product form (live, chilled, frozen, whole, and fillet), including the profits of the middlemen.

Figure 6 shows the trend in the monthly current and deflated wholesale and retail prices for tiger shrimp from 1990 to 2005. Both actual wholesale and retail series exhibit increasing

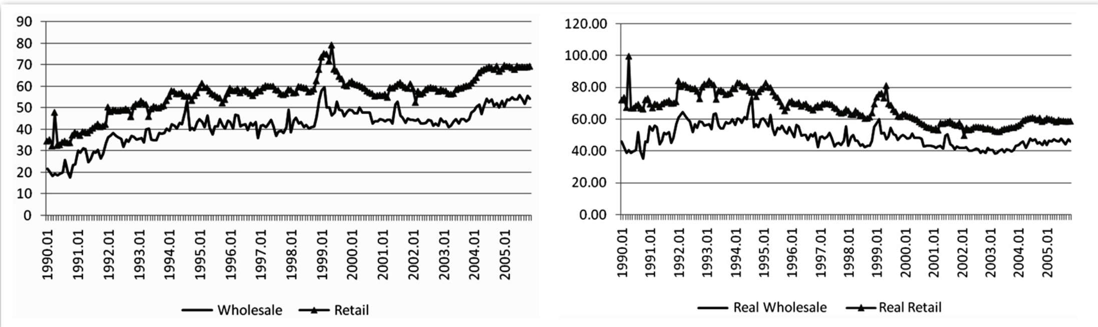


Figure 5. Current and real value of wholesale and retail prices of tilapia, Philippines, 1990-2005

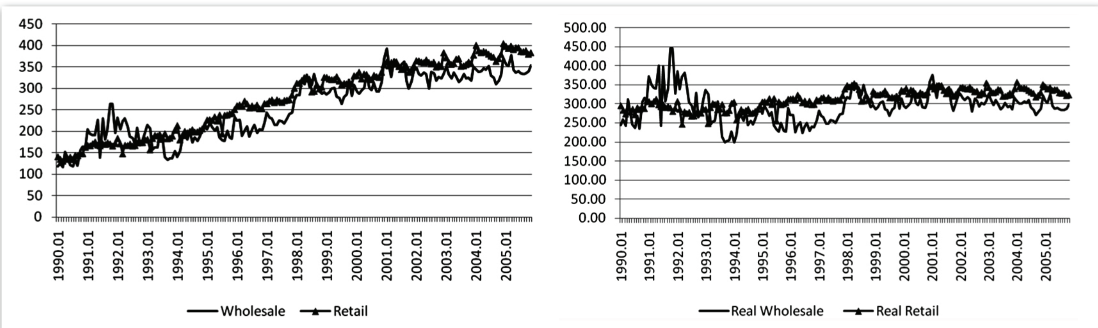


Figure 6. Current and real value of wholesale and retail prices of shrimp, Philippines, 1990-2005

trends at the rate of 13.1 and 7.3 percent, respectively. The deflated wholesale and retail price series similarly show upward pattern, with growth rates of 7.9 and 1.7 percent, respectively. On the other hand, the deflated wholesale series is more variable during the early 1990s than in 2000 to 2005; this is attributed to the disease crisis in the shrimp aquaculture which emerged during this period. As discussed earlier, these bio-physical uncertainties had directly affected prices in the upstream end of the marketing channel. In fact, fluctuations even in real prices had been apparent in the mid-1990s.

The average price of tiger shrimp is recorded at PhP 291.72 per kg at the retail level and PhP 268.91 per kg at the wholesale level. The respective CVs are suggestive of large fluctuations in shrimp prices over the period (30% vs. 29%). These large variations in the movement in shrimp prices during the 15-year period reflect the industry's responses to various production, technology, disease, and marketing problems. In fact, this period represents the worst times for the Philippine shrimp industry, so far, and is said to mirror the global scenario.

The average marketing margin is recorded at PhP 22.81 per kg, which amounts to only about 8.5 percent of the wholesale price. This margin includes all the marketing costs ─ packaging, chilling/freezing/refrigeration, grading, sorting, transportation costs and all other postharvest services rendered by traders (who also function as assembler-processor-exporters) ─ and the profits of middlemen. The CV of the marketing margin is computed to be 130.64 percent which strongly suggests wild fluctuations in the profits from the shrimp industry.

As evident in Figure 6, there were occasions when the wholesale price had been higher than the retail price, implying that retailers were unable to recover their buying price for shrimp, and hence, incurred losses during these periods. Specifically, these happened during the early and late 1990s, and early 2000s. There are two possible explanations for these incidents. First, the lower retail price could indicate the quality deterioration of shrimp from the farm site to the retail market. Shrimp deteriorates easily with inefficient handling, causing a drop in the retail price. Incidentally, the resulting poor quality is readily observable in the shrimps' physical attributes like a drooping head, incomplete appendages, broken tail, and the lack of luster, especially for black tiger shrimp. Secondly, there may have been an oversupply of shrimp in those periods which could be due to the substitution of the lower-priced white shrimp or "suahe" for the more expensive tiger shrimp. Both factors, i.e., the over-supply and the deterioration of shrimp quality, are likely to drive the retail prices down.

Price Cointegration within markets (Vertical Integration)

Vertical price integration refers to the cointegration of prices in a given market at two price levels, e.g., wholesale and retail levels. Table 5 shows the results of the Augmented Dickey-Fuller (ADF) tests on the error term μ of the cointegrating regressions between the wholesale and retail prices of milkfish, tilapia, and shrimp at the national and provincial markets. Specifically, cointegration between these prices is established when the ADF test on μ is found to be statistically significant, i.e., the test statistic is higher than the critical value of τ in the ADF Tau table. Recall that deflated prices were used in all the cointegration tests to isolate the effect of inflation in the price series and capture the real movements in the retail and wholesale prices.

In the case of milkfish, all the prices that are included in the study are found to be integrated of order one or I(1), except for the wholesale price in Samar (Appendix Tables 1-2). Incidentally, the wholesale price in Samar is found to be I(0) or stationary in its level form. This violates the

Table 5. Vertical cointegration of deflated wholesale and retail prices using the augmented Dickey-Fuller (ADF) Tau test within markets by aquaculture species and provinces, Philippines, 1990 – 2005.

PROVINCES	MILKFISH		TILAPIA		SHRIMP	
	ADF τ statistic	Vertically cointegrated?	ADF τ statistic	Vertically cointegrated?	ADF τ statistic	Vertically cointegrated?
PHILIPPINES	**-5.88***	**Yes**	**-5.14***	**Yes**	**-3.68***	**Yes**
LUZON						
Manila	-7.16*	Yes	-6.03*	Yes	-3.86*	Yes
Cagayan	-	-	-2.04ns	No	-	-
Pangasinan	-4.08*	Yes	-4.12*	Yes	-	-
Bulacan	-6.00*	Yes	-2.74ns	No	-3.18*	Yes
Pampanga	-2.92ns	No	-4.20*	Yes	NA	-
Cavite	-	-	-3.24*	Yes	-	-
Quezon	-5.23*	Yes	-	-	-7.08*	Yes
Mindoro Occidental	-3.39*	Yes	-5.13*	Yes	-5.00*	Yes
VISAYAS						
Iloilo	-2.69ns	No	-	-	-	-
Cebu	-6.93*	Yes	-	-	-2.64ns	No
Samar	NA	-	-	-	-	-
MINDANAO						
Misamis Oriental	-7.29*	Yes	-	-	-	-
Davao del Sur	-5.28*	Yes	-	-	-	-

Critical value of ADF $\tau_{\alpha=5\%}$ = 2.942
* - Significant at α = 5%
ns - Statistically non-significant
NA - not applicable, at least one of the price series is I(0)

rule for the application of the cointegration test. Intuitively, the stationarity of the wholesale price in Samar suggests randomness in its behavior. This implies that market competition must have largely influenced the wholesale price, thus stabilizing its movements.

Results of the cointegration tests show that vertical integration exists in most of the provinces included in the study except Pampanga and Iloilo (Table 5). Vertical cointegration means that the wholesale and retail prices exhibit a common trend or act in a synchronized pattern. However, the wholesale and retail prices in Iloilo and Pampanga seem to behave otherwise. Note that the wholesale price is generally supply-driven while the retail price is demand-driven. The explanation for the divergent trends in the milkfish prices in Iloilo and Pampanga may be traced to the fact that Iloilo is a major milkfish production center while Pampanga is more popular for propagating tilapia rather than milkfish. Hence, the demand-supply situation in these areas may yield prices that do not follow a common trend.

Moreover, the wholesale price could decrease due to an oversupply of milkfish from production farms while the retail price may remain high due to ample consumer demand. In particular, the oversupply of milkfish could be attributed to mismanaged production planning which can lead to lower wholesale/farm price. Nevertheless, prices in the retail markets could remain high despite the oversupply at the farm level due to the high demand which, in turn, is associated with the increasing preference for fish by health-conscious consumers, or due to the traditional practice of eating fish especially during the Lenten season. Both situations may reflect inadequate price information at the farm level which can exacerbate the diverging price movements at the wholesale and retail levels. Note that these situations can be highly advantageous to Pampanga and Iloilo middlemen, especially among the buyer-traders who could be buying at a low price at the wholesale level due to the oversupply. They can then ship the fish to other destinations, thereby controlling milkfish volume to prevent the retail price from falling in the local markets.

The estimates for the speed of adjustments between cointegrated wholesale and retail prices are presented in Table 6. Note that the error-correction model is applied only to markets with cointegrated prices. Based on the δ parameter of the model for milkfish prices, Misamis Oriental and Cebu exhibit the quickest convergence of the prices to the common trend, i.e., about one and a half months for both cases. On the other hand, Cagayan's prices are found to be the slowest to adjust, taking approximately 3.5 months which is equivalent to half of a production cycle for milkfish. Negros Occidental and Davao del Sur also show slow adjustments, (3.4 and 3.3 months, respectively). The speed of adjustment of the wholesale and retail prices is affected by how quickly the variations in marketing margins can function as incentives or disincentives to the producers, middlemen, and retailers. A fast adjustment can mean the smooth flow of product movement from one market to another. On the other hand, a slow adjustment may indicate limited trading which can be due to a variety of reasons, including the absence of marketing infrastructures that can facilitate fish trade.

For tilapia, all the wholesale and retail prices are found to be I(1) (Appendix Tables 3 and 4). The findings yield two market centers where prices are not vertically integrated, namely, Cagayan and Bulacan (Table 5). One possible reason why the prices in Cagayan and Bulacan

Table 6. Estimates of the speed of price adjustment from the error-correction model between deflated wholesale and retail prices of milkfish within cointegrated markets by provinces, Philippines, 1990-2005.

PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Pangasinan	-0.47**	2.1
Cagayan	-0.28**	3.5
Quezon	-0.47**	2.1
Negros Occidental	-0.30**	3.3
Cebu	-0.66**	1.5
Misamis Oriental	-0.69**	1.4
Davao del Sur	-0.30**	3.4
Philippines	-0.36**	2.8

** Statistically significant at α = 1%

are not vertically integrated can be because these provinces are more of consumption centers rather than production centers for tilapia. Therefore, the behavior of the retail price may not completely mimic the wholesale price in the said markets. Although both provinces produce their own tilapia from either fishponds or inland water bodies, their production levels are not as high as in the other provinces. Hence, the demand-supply situation in these provinces may lead to unique relationships between the wholesale and retail prices that are not defined by co-movement.

The figures denoting the speed of adjustment between the wholesale and retail prices among cointegrated tilapia markets are presented in Table 7. Manila, Cavite and Pampanga exhibit quicker rates of convergence, i.e., 2.1, 2.2, and 2.6 months, respectively. Pangasinan, on the other hand, shows the slowest speed of adjustment at 4.7 months or about one production cycle. Note that tilapia ranks second only to milkfish as a dominant aquaculture product in Pangasinan. Therefore, even if the wholesale and retail prices are found to be cointegrated, trend reversion back to equilibrium in case of shocks may take a longer time in in this province due to limited production.

In the case of tiger shrimp, all provinces included in the study show I(1) prices except Pampanga where the wholesale and retail prices are found to be stationary or I(0) (See Appendix Tables 5 and 6). Since Pampanga is the largest producer of tiger shrimp, price competition in the area must be very strong, leading to more stable and uniform wholesale and retail prices.

The test for cointegration between wholesale and retail prices shows that all the selected market centers in Luzon exhibit vertical integration, in contrast to the lone Visayan market (Table 5). Specifically, Cebu shows non-cointegrated wholesale and retail prices which could be attributed to the presence of many institutional buyers such as direct bulk buyer-processor-exporters, restaurants, and hotels. These institutional buyers can play an influential role in the movement of prices in the province, especially at the wholesale level, hence dissipating the expected unified movement between the wholesale and retail prices. With respect to the speed of price adjustment, the fastest adjustment among cointegrated shrimp markets is found in Quezon and Mindoro Occidental, i.e., 1.9 and 2.0 months, respectively (Table 8). On the other hand, it takes about 5.3 months for Bulacan prices to adjust to shocks. Note that aquaculture production in Bulacan is adversely affected by perennial flooding. This aggravates the already struggling disease-ridden

Table 7. Estimates of the speed of price adjustment from the error-correction model between deflated wholesale and retail prices of tilapia within cointegrated markets by provinces, Philippines, 1990-2005.

PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Manila	-0.48**	2.1
Pangasinan	-0.21**	4.7
Pampanga	-0.38**	2.6
Cavite	-0.46**	2.2
Philippines	-0.41**	2.4

** - Statistically significant at $\alpha = 1\%$

Table 8. Estimates of the speed of price adjustment from the error-correction model between deflated wholesale and retail prices of shrimp within cointegrated markets by provinces, Philippines, 1990-2005.

PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Manila	-0.27**	3.7
Bulacan	-0.19**	5.3
Quezon	-0.53**	1.9
Mindoro Occidental	-0.49**	2.0
Philippines	-0.33**	3.0

** - Statistically significant at α = 1%

shrimp industry in the province, thus affecting the price movements.

At the national level, the speed of adjustment of the wholesale and retail prices appears to be faster in the tilapia market (2.4 months) than in the milkfish and shrimp markets (i.e., 2.8 and 3.0 months, respectively). One important factor that could help explain this observation is the practice of partial harvesting employed in tilapia farming. At any stage in the production cycle, tilapia can be partially harvested depending on the preferred size of the consumers or the traders. On the other hand, total harvesting is traditionally practiced in milkfish and shrimp production. This culture practice can pose as a constraint to the producers who have to wait until the growing cycle is completed before the crop can be harvested and sold in the market. This flexibility in tilapia harvesting, therefore, results in the faster price adjustment in the market compared to that for milkfish and shrimp.

Price Cointegration between Markets (Horizontal Integration)

Horizontal price integration refers to the cointegration of prices between two spatially separated markets. As mentioned earlier, the tests for horizontal cointegration were carried out for pair-wise wholesale prices of the different provinces included in the study. The results of the ADF tests on the error term μ of the cointegrating regression between the wholesale prices of milkfish are presented in Table 9. All the 28 pairs of provincial markets show significant cointegration of wholesale prices.

The matrix of price adjustments for milkfish between provincial markets is presented in Table 10. The fastest adjustments are registered for Cebu when paired with provinces in southern Philippines, namely, Misamis Oriental and Davao del Sur, with speed of 1.6 and 1.7 months, respectively. However, Cebu registers one of the slowest adjustments when paired with provinces in Luzon like Metro Manila (6 months), Pangasinan (8 months), Bulacan (8 months), Pampanga (10 months), and Quezon (10 months). These results highlight the role of geographical distance in the speed of convergence of prices in the markets. Generally, the study shows that the farther the markets are located from each other, the longer it takes for the prices to revert back to trend despite being cointegrated.

Table 11 shows the results of the cointegration tests on the wholesale prices for pairs of market centers of tilapia. Ten out of 15 pairs of markets are found to be cointegrated. The five pairs of markets found to be non-cointegrated have Cagayan and Cavite as

Table 9. Horizontal cointegration of deflated wholesale prices for milkfish using the augmented Dickey-Fuller (ADF) Tau test between pairs of provincial markets, Philippines, 1990 - 2005.

BETWEEN MARKETS	ADF τ STATISTIC	HORIZONTALLY COINTEGRATED?
Manila - Pangasinan	-4.07*	Yes
Manila - Bulacan	-4.53*	Yes
Manila - Pampanga	-5.90*	Yes
Manila - Quezon	-4.76*	Yes
Manila - Cebu	-4.34*	Yes
Manila - Misamis Oriental	-3.97*	Yes
Manila - Davao del Sur	-4.81*	Yes
Pangasinan - Bulacan	-5.87*	Yes
Pangasinan - Pampanga	-5.87*	Yes
Pangasinan - Quezon	-6.03*	Yes
Pangasinan - Cebu	-5.33*	Yes
Pangasinan - Misamis Oriental	-5.17*	Yes
Pangasinan - Davao del Sur	-3.73*	Yes
Bulacan - Pampanga	-5.21*	Yes
Bulacan - Quezon	-5.26*	Yes
Bulacan - Cebu	-5.95*	Yes
Bulacan - Misamis Oriental	-5.32*	Yes
Bulacan - Davao del Sur	-4.87*	Yes
Pampanga - Quezon	-3.79*	Yes
Pampanga - Cebu	-3.98*	Yes
Pampanga - Misamis Oriental	-3.45*	Yes
Pampanga - Davao del Sur	-3.86*	Yes
Quezon - Cebu	-3.98*	Yes
Quezon - Misamis Oriental	-3.45*	Yes
Quezon - Davao del Sur	-3.86*	Yes
Cebu - Misamis Oriental	-6.75*	Yes
Cebu – Davao del Sur	-5.71*	Yes
Misamis Oriental - Davao del Sur	-4.13*	Yes

Critical value of ADF $\tau_{\alpha=5\%}$ = -2.942
* - Significant at α = 5%
ns - Statistically non-significant
NA - Failure to apply the DF test due to stationarity in the deflated wholesale price in either market

Table 10. Matrix of the speed of price adjustment of deflated wholesale prices for milkfish between provinces (in months), Philippines, 1990-2005.

PROVINCES	PROVINCES						
	Manila	Pangasinan	Bulacan	Pampanga	Quezon	Cebu	Misamis Oriental
Pangasinan	2.1						
Bulacan	2.5	2.4					
Pampanga	3.6	2.4	3.7				
Quezon	4.2	3.7	3.6	6.3			
Cebu	5.9	7.7	7.7	10.0	10.0		
Misamis Oriental	3.8	5.6	5.3	10.0	10.0	1.6	
Davao del Sur	3.2	5.0	3.3	6.7	6.7	1.7	2.1

Note: Estimates of δ from the error-correction model is presented in Appendix Table 1.

Table 11. Horizontal cointegration of deflated wholesale prices for tilapia using the augmented Dickey-Fuller (ADF) Tau test between pairs of provincial markets, Philippines, 1990-2005.

BETWEEN MARKETS	ADF τ STATISTIC	HORIZONTALLY COINTEGRATED?
Manila - Pangasinan	-3.72*	Yes
Manila - Cagayan	-4.24*	Yes
Manila - Bulacan	-6.44*	Yes
Manila - Pampanga	-5.26*	Yes
Manila - Cavite	-2.69^{ns}	No
Pangasinan - Cagayan	-3.66*	Yes
Pangasinan - Bulacan	-3.82*	Yes
Pangasinan - Pampanga	-3.41*	Yes
Pangasinan - Cavite	-3.27*	Yes
Cagayan - Bulacan	-2.18^{ns}	No
Cagayan - Pampanga	-2.24^{ns}	No
Cagayan - Cavite	-2.43^{ns}	No
Bulacan - Pampanga	-3.43*	Yes
Bulacan - Cavite	-4.09*	Yes
Pampanga - Cavite	-2.02^{ns}	No

Critical value of ADF $\tau_{\alpha=5\%}$ = -3.04
* - Significant at α = 5%
ns - Statistically non-significant
NA - Failure to apply the DF test due to stationarity in the deflated wholesale price in either market

trading partners. Both provinces are basically consumption centers, hence their wholesale prices can be expected to have different long-term trends from the major producers.

Among the provinces that show cointegrated wholesale markets, Bulacan exhibits the fastest price adjustments, i.e., 1.8 months with Cavite, and 2.1 months with Pampanga (Table 12). The longest time of adjustment is registered by Pangasinan with Manila, Pampanga, and Bulacan as trading partners, i.e., 4.7, 4.4, and 4 months, respectively. As mentioned earlier, tilapia is not a major crop in Pangasinan; hence, the behavior of production and prices may not be as flexible as those provinces where tilapia is a prime commodity.

The results of the pairwise cointegration tests for wholesale prices of shrimps are presented in Table 13. All the 10 pairs of provincial markets that trade shrimp show significant horizontal integration of wholesale prices. This implies that the wholesale prices of shrimp in these markets exhibit common trends. Furthermore, this suggests an efficient wholesale trade of shrimp.

With respect to the speed of price adjustments, shrimp trade with Manila as trading partner is characterized by efficient price movements, with speed ranging from two to three months (Table 14). Despite the distance of Cebu to its key trading partners in Luzon, the speed of price adjustments is similarly quick except with Mindoro Occidental, which takes 10 months for the wholesale prices to revert back to trend. Furthermore, the Mindoro shrimp trade with Bulacan is similarly found to be less

Table 12. Matrix of the speed of price adjustment of deflated wholesale prices for tilapia between provinces (in months), Philippines, 1990-2005.

PROVINCES	PROVINCES		
	Manila	Pangasinan	Bulacan
Pangasinan	4.7		
Cagayan	3.5	3.2	
Bulacan	3.0	4.0	
Pampanga	3.0	4.4	2.1
Cavite	-	2.9	1.8

Table 13. Horizontal cointegration of deflated wholesale prices for shrimp using the augmented Dickey-Fuller (ADF) Tau test between pairs of provincial markets, Philippines, 1990-2005.

BETWEEN MARKETS	ADF τ STATISTIC	HORIZONTALLY COINTEGRATED?
Manila - Bulacan	-4.12*	Yes
Manila - Quezon	-4.60*	Yes
Manila - Mindoro Occidental	-4.91*	Yes
Manila - Cebu	-3.60*	Yes
Bulacan - Quezon	-3.19*	Yes
Bulacan - Mindoro Occidental	-3.18*	Yes
Bulacan - Cebu	-5.69*	Yes
Quezon - Mindoro Occidental	-6.47*	Yes
Quezon - Cebu	-6.31*	Yes
Mindoro Occidental - Cebu	-6.56*	Yes

Critical value of ADF $\tau_{\alpha=5\%}$ = -2.98
* - Significant at α = 5%
ns - Statistically non-significant
NA - Failure to apply the DF test due to stationarity in the deflated wholesale price in either market

Table 14. Matrix of the speed of price adjustment of deflated wholesale prices for shrimp between provinces (in months), Philippines, 1990-2005.

PROVINCES	PROVINCES			
	Manila	Bulacan	Quezon	Mindoro Occidental
Bulacan	2.7			
Quezon	2.3	5.3		
Mindoro Occidental	1.9	5.3	1.6	
Cebu	2.9	2.3	1.9	10.0

efficient compared to the other trading partners since the time lag of price adjustment requires four to five months.

Granger Causality

Tables 15 and 16 summarize the results of the Granger causality tests that were applied to markets showing vertical price integration. The regressions of the lagged retail price against the wholesale price and vice-versa (equations 6 and 7) within a particular provincial location show whether there is endogeneity or exogeneity in the two prices. In cases where there is a significant one-way causation from the retail price to the wholesale price (indicated by the symbol R→W), then it is said that the retail price is the price leader. The symbol is reversed when the wholesale price is the price leader, i.e., W→R. Incidentally, the symbols W↔R and W Ø R are used to indicate price endogeneity and independence, respectively.

Using deflated prices, the retail price for milkfish is found to significantly Granger-cause the wholesale price (R→W) in all the six market centers that are established to be vertically integrated, namely: Pangasinan, Quezon, Cebu, Samar, Misamis Occidental, and Davao del Sur. This indicates that in these market centers, milkfish prices are generally demand-driven; hence, the retail price leads the wholesale price.

For tilapia, the wholesale price is found to Granger-cause the retail price (W→R) in Manila, implying that the wholesale price is the price leader. This result is attributed to the large number of institutional buyers such as supermarkets, hospitals, hotels, restaurants, and wholesale-buyers in Manila which potentially influence the retail price of tilapia offered by many independent wholesalers. However, in the case of Pampanga and Pangasinan, the retail price is found to lead the wholesale price (R→W). This suggests that consumer demand is largely affecting the wholesale price of tilapia in these provinces. Meanwhile, two-way Granger causation (R↔W) is demonstrated in Cavite where the wholesale and retail prices are simultaneously adjusting to each other.

In the case of shrimp, the trend is split over the dominance of the retail and wholesale price. Results show that the wholesale price leads the retail price (W→R) in Pampanga, Mindoro Occidental, and Cebu. Since the said provinces are large production areas for shrimp, it is not surprising for the wholesale price to lead the retail price in these markets. On the other hand, the retail price leads the wholesale price (R→W) in Bulacan. This could be due to the smallness of shrimp production in Bulacan such that the shrimp supply can all be absorbed by the domestic market. Moreover, the absence of a price leader is noted in Metro Manila due to the independence of the retail and wholesale prices (i.e., R Ø W) while a simultaneous adjustment of retail and wholesale prices (i.e., R↔W) prevails in Quezon. Incidentally, Metro Manila is a huge consumption center, with the bulk of

Table 15. Results of Granger causality test between the deflated wholesale and retail prices of milkfish within provincial locations, 1990-2005.

PROVINCES	TEST FOR GRANGER CAUSALITY MODELS [a/]		OVERALL RANGER CAUSATION
	Model 1 Retail=f(lagged Retail, lagged Wholesale)	Model 2 Wholesale=f(lagged Retail, lagged Wholesale)	
Pangasinan	0.96^{ns}	3.22*	
	W Ø R	R → W	R → W
Quezon	0.48^{ns}	2.62*	
	W Ø R	R → W	R → W
Cebu	0.14^{ns}	29.19**	
	W Ø R	R → W	R → W
Samar	2.39^{ns}	3.47*	
	W Ø R	R → W	R → W
Misamis Or.	1.58^{ns}	8.21**	
	W Ø R	R → W	R → W
Davao del Sur	0.84^{ns}	4.99*	
	W Ø R	R → W	R → W

* Significant at α = 5%
** Significant at α = 1%
ns Statistically non-significant
a/ The numerical value refers to the F-statistic from the test of the restrictions in the Granger causality model. The relationship stated below the F-statistic refers to the one-way Granger causation between the wholesale and retail prices, i.e., W Ø R means there is no Granger relationship between the wholesale and retail price, while R →W means that the retail price Granger causes the wholesale price.

Table 16. Results of Granger causality test between the deflated wholesale and retail prices of tilapia within provincial locations, 1990-2005.

PROVINCES	TEST FOR GRANGER CAUSALITY MODELS [a/]		OVERALL RANGER CAUSATION
	Model 1 Retail=f(lagged Retail, lagged Wholesale)	Model 2 Wholesale=f(lagged Retail, lagged Wholesale)	
Manila	2.97*	0.17^{ns}	
	W → R	R Ø W	W → R
Pangasinan	0.76^{ns}	2.82*	
	W Ø R	R → W	R → W
Pampanga	0.21^{ns}	2.03*	
	W Ø R	R → W	R → W
Cavite	15.39**	4.78**	
	W→ R	R → W	R ↔ W

* - Significant at α = 5%
** - Significant at α = 1%
ns - Statistically non-significant
a/ The numerical value refers to the F-statistic from the test of the restrictions in the Granger causality model. The relationship stated below the F-statistic refers to the one-way Granger causation between the wholesale and retail prices, i.e., W Ø R means there is no Granger relationship between the wholesale and retail price; R →W means that the retail price Granger causes the wholesale price; and R ↔ W means that there is a two-way Granger relationship between the wholesale and retail prices.

Table 17. Results of Granger causality test between the deflated wholesale and retail prices of shrimp within provincial locations, 1990-2005.

PROVINCES	TEST FOR GRANGER CAUSALITY MODELS a/		OVERALL RANGER CAUSATION
	Model 1 Retail=f(lagged Retail, lagged Wholesale)	Model 2 Wholesale=f(lagged Retail, lagged Wholesale)	
Manila	0.20ns	1.90ns	
	R Ø W	R Ø W	R Ø W
Bulacan	0.04ns	4.12*	
	W Ø R	R → W	R → W
Pampanga	7.33**	3.19*	
	W → R	R Ø W	W → R
Quezon	9.11**	7.16**	
	W → R	R → W	R ↔ W
Mindoro Occ.	9.80**	0.34ns	
	W → R	R Ø W	W → R
Cebu	7.21**	0.43ns	
	W → R	R Ø W	W → R

* - Significant at α = 5%
** - Significant at α = 1%
ns - Statistically non-significant
a/ The numerical value refers to the F-statistic from the test of the restrictions in the Granger causality model. The relationship stated below the F-statistic refers to the one-way Granger causation between the wholesale and retail prices, i.e., R Ø W means there is no Granger relationship between the wholesale and retail price; W →R means that the wholesale price Granger causes the retail price; and R ↔ W means that there is a two-way Granger relationship between the wholesale and retail prices.

its shrimp supply coming from big provincial traders. Understandably, the wholesale and retail prices can move independently of each other without one leading the other.

SUMMARY AND CONCLUSIONS

Milkfish, tilapia, and shrimp were shown to be the major aquaculture species that have significantly contributed to the productivity of the fishery sector, thus helping to ensure food security among households (especially the lower income households), and provide incomes to fish farmers. Milkfish and tilapia production volumes generally increased over time, clearly attesting to the availability and adoption of improved aquaculture technologies that helped increase yields and sustain the production of these species.

Analysis of current prices showed a general increase in both wholesale and retail levels in most geographic markets during the period 1990-2005. On the other hand, real or deflated prices have been generally decreasing over time from 1990-2007, especially for milkfish and tilapia whose production volumes were generally increasing. Meanwhile, the opposite prevailed for shrimp whose real price continued to rise (albeit in small increments) while its production volume was highly volatile. Overall, shrimp aquaculture showed a downtrend due to the disease problems that devasted the industry during the mid-1990s.

The analysis of price dynamics conducted by this study showed a wide range of relationships regarding the movement of prices among the three aquaculture species in two market levels (wholesale vs. retail) within a market location, and between pairs of markets around the Philippines. These three species are generally widely produced in different suitable culture environments such as fishponds in land-based farms; and pens and cages in lakes, river systems, reservoirs, coastal areas, and other off-shore locations especially in coves, straits and gulfs. Yields from aquaculture— whether in live, chilled, frozen or processed forms— are widely traded around the archipelago either by land, sea, and air travel. As such, understanding price movements and market relationships is critical to achieving efficiency in production among fish farmers, and efficiency in trade among market intermediaries. Consumers also tend to benefit from the efficient pricing of aquaculture species since fish is a major source of animal protein, especially among the poorer sector of the economy.

During the period covered in this analysis (1990 to 2005), deflated wholesale and retail prices of milkfish, tilapia, and shrimp were found to be generally cointegrated. These suggest that the prices were moving together and following a common trend with a unique lead-lag relationship. Depending on the species, few provincial locations such as Cagayan, Cebu, Samar, and Davao del Sur did not show price cointegration with other market locations. In such cases, local market conditions leading to stable prices possibly prevailed over the influences of external factors such as prices from the neighboring markets.

Milkfish

Of these three species, the price of milkfish was generally cointegrated within the wholesale and retail levels, and between any of the pairs of geographic market locations. This is reflective of the wide acceptability of milkfish around the country, even in locations such as Visayas and Mindanao where marine species gain higher acceptance than freshwater species such as tilapia. As such, milkfish is most widely produced and traded in many provinces all over Luzon, Visayas, and Mindanao.

Analysis showed that price cointegration was more prevalent between wholesale and retail prices within most provincial locations, except in Pampanga and Iloilo. Moreover, the Granger causality analysis showed that the retail price of milkfish generally led the wholesale price. This suggests that milkfish prices in the Philippines are commonly demand-driven, and prices at the wholesale and farm level follow the trends of the retail market.

Two-way causation or interdependence of the retail price and wholesale prices was observed in distant and two smaller milkfish-producing provinces such as Pampanga and Misamis Oriental. Across provincial locations, the wholesale prices of milkfish were also generally cointegrated, except for price pairings involving Samar. This was due to the stationarity of the wholesale price in Samar.

The relationships exhibited by the analysis of milkfish prices tended to indicate that efficiency in pricing has generally been achieved. The cointegration of prices in most locations around the country and between pairs of provincial locations that interact through trade demonstrates that prices across locations are transmitted efficiently and that price arbitrage is guided by adequate information in the markets, including supply and demand conditions. As such, consumers, buyers and sellers tend to benefit from prices that reflect the inherent attributes of the product and commensurate with the services rendered for bringing the product from the production area to the consumption sites.

Efficiency in price transmission could be associated with the recent developments in telecommunication systems (e.g. mobile phones with short text messaging system), and the open bidding system, which are emerging in some fish landing centers. These forms of communication are generally accessible and affordable among stakeholders, i.e., fish farmers, wholesale buyers, brokers, shippers, processors, retailers, and consumers in the milkfish industry. Another factor that explains the efficiency in milkfish pricing is the recent ease of movement and the improvements in the handling of milkfish. The "roll-on-roll-off" shipping system that connects various islands and market locations has been made available and affordable almost throughout the archipelago. Unlike tilapia which generally receives premium prices when marketed live, milkfish is generally marketed chilled or frozen and these forms are acceptable among buyers and consumers. In such forms, milkfish can be shipped through these roll-on-roll-off systems. These facilitated the trade of milkfish throughout the country. Hence, prices across market levels and across locations tended to move together.

Tilapia

Results of the study showed that tilapia was more widely produced and traded in Luzon than in the Visayas and Mindanao regions. Consumers in the latter areas generally preferred marine fish species over tilapia. As such, tilapia wholesale and retail prices were found to be cointegrated in fewer market locations, e.g., where they are widely consumed such as Manila, Pangasinan, Pampanga, Cavite, and Mindoro Occidental. Wholesale and retail prices were found to be non-cointegrated in Cagayan and Bulacan. Similarly, price pairings involving these two provinces also did not show co-movements. The absence of cointegration in the pricing in markets paired with Cagayan could be attributed to the distance (483 km from Manila) that prevented active trade with other provinces. Local market conditions within the province such as the availability of supply and the level of consumer demand may have dominated the market, thereby influencing the local prices rather than prices in other production centers.

Inter-provincial trade of tilapia and consequent price influences were also limited by the preference for the live form rather than the chilled or frozen ones. With respect to the pricing in pairs of markets that actively traded with each other, the study showed that retail prices generally led wholesale prices, especially in Pangasinan and Pampanga. Meanwhile, wholesale price led the retail price in Metro Manila. However, a two-way price causation was observed in Cavite. Such variations in the lead-lag relationships could be explained by the respective volumes of production and the modes of local trade in these areas. For example, in locations where there are frequent wholesale transactions as practiced by institutional buyers, e.g., hotels and restaurants in Metro Manila, wholesale price tended to lead the retail price.

As in the case with milkfish, the price dynamics in tilapia markets that potentially influenced the presence of price cointegration could be attributed to recent developments in telecommunication facilities. Prices at the retail and wholesale levels and between pairs of market locations could be easily transmitted using mobile phones. Price information influences price arbitrage and, consequently, the efficiency in the price determination process. However, unlike milkfish, the trade of fresh and often live tilapia across distant market locations does not seem to benefit much from the "roll-on-roll-off" inter-island shipping system. Because of this unique preference for fresh tilapia, it is often traded only in nearby provinces using trucks equipped with built-in oxygen tanks and freshwater supply.

Shrimp

The black tiger species of shrimp was then still recovering from its disease-related crises in the late 1990s. Thus, the analysis of the price dynamics for shrimp was conducted only in markets where the wholesale and retail price series were available, such as Manila, Bulacan, Pampanga, Quezon, Mindoro Occidental, and Cebu. All markets showed cointegration between the wholesale and retail prices, except for Cebu. Moreover, retail prices led wholesale prices in Bulacan and Pampanga. Conversely, wholesale price led retail prices in Quezon, Mindoro Occidental, and Cebu. However, the wholesale and retail prices in Manila behaved independently. This could be attributed to the relatively huge number of retail and wholesale buyers in Metro Manila. Given the limited supply due to the existing disease crises, these factors tended to influence shrimp prices through relative price bids and arbitrage among wholesale buyers and retailers. Also, most shrimp farmers in Cebu transacted business with direct buyers, which in turn acted as suppliers to shrimp processors that were also conveniently based in Cebu. Incidentally, Cebu is an international gateway which has direct flight connections to foreign destinations where shrimp can be sold directly to importers.

RECOMMENDATIONS

Overall, the price cointegration trends and interdependencies that were established in the study suggest that recent policies promoting open bidding of traded commodities, either in fish landing sites or through electronic communication systems, have proven useful as they have improved pricing efficiency, especially for the milkfish and some tilapia markets. The published mandates of some government agencies serve to promote the availability of price information in various ways. The Department of Agriculture endeavors to implement this through the projects under its Agribusiness and Marketing Assistance Service (AMAS); the Bureau of Agricultural Statistics (BAS), through its price monitoring and documentation units; and the Department of Trade and Industry (DTI), through its price tag policy and price information dissemination campaigns through market bulletin boards.

The efficiency in pricing indicated by the results of this study could be attributed to the initiatives of the above government agencies or due to the dynamic behavior of the market industry players. Either case has facilitated the ease of decision- making among farm managers and entrepreneurs. When prices, their movements, and comparisons at different trading centers are openly discussed, decisions affecting production systems and choice of cost-effective technologies are facilitated. This study, therefore, recommends that government agencies which are mandated to promote food production and security, and the overall efficient trade of such commodities, should take serious measures beyond promotional activities that motivate the disclosure of market information. These measures should be directed to traders at levels (e.g., wholesale and retail) whose price bids lead the other markets, e.g. producers and small traders at the farm gate.

This study also recommends the nationwide upgrading of infrastructures that speed up the physical movement of aquaculture produce, similar to other perishable agricultural crops. Farm-to-market roads are needed to link aquaculture farms to fish landing sites, to roll-on-roll-off piers for inter-island product distribution, and finally to retail markets in fish-deficit communities. However, caution should be noted against the many recommendations to install ice plants in most fish landing centers. Priority must be accorded to investments in mobile freezer-container trucks rather than fixed ice plants and cold storage facilities in landing sites. While the increases in aquaculture production are being challenged by the increasing population and the demand for fish in various locations in the archipelago, maintaining fish in fixed storage is not necessary nor a relevant option that would aid efficiency in pricing and fresh fish product distribution.

Finally, both public and private investments are needed to promote the consumption of farmed fish in fish-deficit areas, particularly in locations like the Visayas and Mindanao regions where there is little preference for tilapia. Increases in demand for cultured species in new markets are expected to motivate producers and traders to produce and bring these commodities to consumers whose price bids (usually manifested through the retail price) have tendencies to lead other markets. Similarly, influencing buyers' preference for frozen forms of aquaculture products would also improve pricing efficiency and product distribution.

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Appendix Table 1. Level of integration of deflated wholesale prices of milkfish by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-2.372[ns]	0.150	-11.32**	0.000	I(1)
Luzon:					
Manila	-2.715[ns]	0.072	-15.59**	0.000	I(1)
Pangasinan	-2.853[ns]	0.051	-17.22**	0.000	I(1)
Bulacan	-2.858[ns]	0.051	-16.43**	0.000	I(1)
Pampanga	-2.856[ns]	0.051	-13.05**	0.000	I(1)
Quezon	-2.337[ns]	0.160	-15.12**	0.000	I(1)
Mindoro Occidental	-2.411[ns]	0.139	-15.33**	0.000	I(1)
Visayas:					
Iloilo	-2.531[ns]	0.108	-10.57**	0.000	I(1)
Cebu	-2.758[ns]	0.065	-21.03**	0.000	I(1)
Samar	-4.694**	0.000	-17.26**	0.000	I(0)
Mindanao					
Misamis Oriental	-2.673[ns]	0.079	-19.57**	0.000	I(1)
Davao del Sur	-2.810[ns]	0.057	-14.09**	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 2. Level of integration of deflated wholesale prices of milkfish by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-2.560[ns]	0.102	-14.92**	0.000	I(1)
Luzon:					
Manila	-2.807[ns]	0.057	-8.51**	0.000	I(1)
Pangasinan	-2.462[ns]	0.125	-14.58**	0.000	I(1)
Bulacan	-2.838[ns]	0.053	-12.24**	0.000	I(1)
Pampanga	-2.565[ns]	0.101	-12.59**	0.000	I(1)
Quezon	-2.256[ns]	0.187	-14.92**	0.000	I(1)
Mindoro Occidental	-2.728[ns]	0.069	-15.53**	0.000	I(1)
Visayas:					
Iloilo	-2.342[ns]	0.159	-11.41**	0.000	I(1)
Cebu	-2.607[ns]	0.092	-17.70**	0.000	I(1)
Samar	-2.840[ns]	0.053	-15.40**	0.000	I(1)
Mindanao					
Misamis Oriental	-2.736[ns]	0.068	-15.95**	0.000	I(1)
Davao del Sur	-2.565[ns]	0.101	-17.55**	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 3. Level of integration of deflated wholesale prices of tilapia by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-2.784^{ns}	0.061	-17.80**	0.000	I(1)
Luzon:					
Manila	-2.344^{ns}	0.158	-15.26**	0.000	I(1)
Cagayan	-2.307^{ns}	0.170	-16.00**	0.000	I(1)
Pangasinan	-2.292^{ns}	0.175	-18.15**	0.000	I(1)
Bulacan	-2.586^{ns}	0.096	-19.97**	0.000	I(1)
Pampanga	-1.777^{ns}	0.392	-15.11**	0.000	I(1)
Cavite	-2.477^{ns}	0.121	-19.50**	0.000	I(1)
Mindoro Occidental	-2.674^{ns}	0.079	-18.30**	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 4. Level of integration of deflated wholesale prices of tilapia by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-1.925^{ns}	0.321	-21.89**	0.000	I(1)
Luzon:					
Manila	-1.604^{ns}	0.481	-13.45**	0.000	I(1)
Cagayan	-2.757^{ns}	0.065	-20.51**	0.000	I(1)
Pangasinan	-2.389^{ns}	0.145	-18.08**	0.000	I(1)
Bulacan	-2.576^{ns}	0.098	-17.67**	0.000	I(1)
Pampanga	-2.448^{ns}	0.129	-22.86**	0.000	I(1)
Cavite	-2.828^{ns}	0.054	-17.06**	0.000	I(1)
Mindoro Occidental	-2.727^{ns}	0.070	-19.53**	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 5. Level of integration of deflated wholesale prices of shrimp by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-2.840ns	0.053	-21.25**	0.000	I(1)
Luzon:					
Manila	-2.842ns	0.053	-18.56**	0.000	I(1)
Bulacan	-2.573ns	0.099	-28.51**	0.000	I(1)
Pampanga	-5.542ns	0.000	-21.41**	0.000	I(0)
Quezon	-2.343ns	0.158	-24.22**	0.000	I(1)
Mindoro Occidental	-2.805ns	0.058	-24.21**	0.000	I(1)
Visayas:				0.000	
Cebu	-2.693ns	0.075	-18.00**	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 6. Level of integration of deflated wholesale prices of shrimp by province, Philippines, 1990-2005.

Province	Wholesale price (Level form)		Wholesale price (1st difference)		Level of Integration
	τ Statistic	P-value	τ Statistic	P-value	
Philippines	-2.813	0.057	-19.010	0.000	I(1)
Luzon:					
Manila	-2.492	0.117	-12.080	0.000	I(1)
Bulacan	-2.529	0.109	-27.570	0.000	I(1)
Pampanga	-2.839	0.053	-20.090	0.000	I(0)
Quezon	-2.425	0.135	-19.660	0.000	I(1)
Mindoro Occidental	-2.638	0.086	-27.610	0.000	I(1)
Visayas:					
Cebu	-2.843	0.052	-23.860	0.000	I(1)

* statistically significant at α=5%
** statistically significant at α=1%
ns not significant
I(0) integrated of order 0
I(1) integrated of order 1

Appendix Table 7. Estimates of the speed of price adjustment from the error-correction model of deflated wholesale prices of milkfish between cointegrated provinces, Philippines, 1990-2005.

BETWEEN PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Manila - Pangasinan	-0.48**	2.1
Manila - Bulacan	-0.40**	2.5
Manila - Pampanga	-0.28**	3.6
Manila - Quezon	-0.24**	4.2
Manila - Cebu	-0.17**	5.9
Manila - Misamis Oriental	-0.26**	3.8
Manila - Davao del Sur	-0.31**	3.2
Pangasinan - Bulacan	-0.42**	2.4
Pangasinan - Pampanga	-0.42**	2.4
Pangasinan - Quezon	-0.27**	3.7
Pangasinan - Cebu	-0.13**	7.7
Pangasinan - Misamis Oriental	-0.18**	5.6
Pangasinan - Davao del Sur	-0.20**	5.0
Bulacan - Pampanga	-0.27**	3.7
Bulacan - Quezon	-0.28**	3.6
Bulacan - Cebu	-0.13**	7.7
Bulacan - Misamis Oriental	-0.19**	5.3
Bulacan - Davao del Sur	-0.30**	3.3
Pampanga - Quezon	-0.16**	6.3
Pampanga - Cebu	-0.10**	10.0
Pampanga - Misamis Oriental	-0.10**	10.0
Pampanga - Davao del Sur	-0.15**	6.7
Quezon - Cebu	-0.10**	10.0
Quezon – Misamis Oriental	-0.10**	10.0
Quezon - Davao del Sur	-0.15**	6.7
Cebu - Misamis Oriental	-0.64**	1.6
Cebu - Davao del Sur	-0.58**	1.7
Misamis Oriental - Davao del Sur	-0.47**	2.1

** Statistically significant at $\alpha = 1\%$
NA refers to non-cointegrated wholesale prices between pairs of provinces

Appendix Table 8. Estimates of the speed of price adjustment from the error-correction model of deflated wholesale prices of tilapia between cointegrated provinces, Philippines, 1990-2005.

BETWEEN PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Manila-Pangasinan	-0.21**	4.7
Manila - Cagayan	-0.29**	3.5
Manila - Bulacan	-0.34**	3.0
Manila - Pampanga	-0.34**	3.0
Manila - Cavite	NA	-
Pangasinan - Cagayan	-0.31**	3.2
Pangasinan - Bulacan	-0.25**	4.0
Pangasinan - Pampanga	-0.23**	4.4
Pangasinan - Cavite	-0.35**	2.9
Cagayan - Bulacan	NA	-
Cagayan - Pampanga	NA	-
Cagayan - Cavite	NA	-
Bulacan - Pampanga	-0.48**	2.1
Bulacan - Cavite	-0.55**	1.8

** Statistically significant at α = 1%
NA refers to non-cointegrated wholesale prices between pairs of provinces

Appendix Table 9. Estimates of the speed of price adjustment from the error-correction model of deflated wholesale prices of shrimp between cointegrated provinces, Philippines, 1990-2005.

BETWEEN PROVINCES	δ COEFFICIENT	ADJUSTMENT PERIOD (MONTHS)
Manila - Bulacan	-0.37**	2.7
Manila - Quezon	-0.43**	2.3
Manila - Mindoro Occ.	-0.53**	1.9
Manila – Cebu	-0.34**	2.9
Bulacan - Quezon	-0.19**	5.3
Bulacan - Mindoro Occ.	-0.19**	5.3
Bulacan – Cebu	-0.43**	2.3
Quezon - Mindoro Occ.	-0.62**	1.6
Quezon – Cebu	-0.54**	1.9
Mindoro Occ. - Cebu	-0.10*	10.0

* - Statistically significant at α = 5%
** - Statistically significant at α = 1%

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