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| Price transmission relationships along the seafood value  |
| chains in Bangladesh: aquaculture and capture fishery species |

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**Abstract**

This paper investigates causal and price transmission relationships between wholesale and retail prices for five fish species in Bangladesh that include: hilsa (*Tenualosa ilish*), rohu (*Labeo rohita*), catla (*Catla catla*), pangas (*Pangasius hypophthalmus*), and tilapia (*Oreochromis mossambicus/ O. niloticus*). Causal relationships between wholesale and retail prices were tested using the Granger causality test while asymmetries in price transmission were examined using the Houck and Ward approach as well as the error-correction approach. The results show that the direction of causality in prices was from retail to wholesale in many of the value chains analyzed, indicating influence of retail price on wholesale price in the Bangladesh fish sector. In general, the price transmission was found to be symmetric in the short-run while a mix of symmetric and asymmetric in the long-run. The results also show variation in price transmission behaviour between aquaculture and capture fisheries products.

**Running Head:** Price Transmission Relationships in Bangladesh Seafood Markets

**Keywords:** asymmetry, Granger causality, price transmission, fish, Bangladesh

**JEL Classification Codes:** Q22, Q11, L11, M31.

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# Introduction

Bangladesh is ideally suited for fish production, having one of the highest man-water ratios in the world, at 20 persons per hectare of water area (Task Force 1991). The fisheries sector contributed nearly 58% of animal protein to the daily diets of the country’s population, about 4% to the Gross Domestic Product, 4% to the export earnings, and 21% to the agriculture in 2007-08 (Alam et al. 2010). The fisheries resources of the country are generally classified as inland open waters, inland closed waters and marine waters. The total fish production of the country was 2,563,296 metric tons in 2007-08, out of which 41% came from inland open waters, 39% from inland closed waters (aquaculture), and 19% from marine fisheries. Aquaculture has been growing at a much faster rate than those of the inland open waters and the marine waters (Alam 2011).

Seafood[[1]](#endnote-1) value chains in Bangladesh are generally long and complex. There are many intermediaries between producers and final consumers of seafood products in the country (Alam et al. 2012). Fish production/landing points are scattered all over the country, many of which are quite distant from the final consuming markets. The four main types of domestic seafood markets are primary markets located near the source of production, secondary markets located usually in the sub district (*upazila*) headquarters, higher secondary markets located in big cities, and terminal markets. With a growth in commercial pond aquaculture, a new pattern is emerging in fish marketing that increasingly involves direct participation by farmers (Faruque 2007; Alam et al. 2012). After their pond harvest, some farmers directly approach wholesalers (*aratdars*) at the higher secondary market. The farmers bear the costs of transporting fish to the *aratdars* in the markets, and then the *aratdars* arrange open bidding by small-scale wholesalers (*paikers*) ⁄ retailers. The seafood market structure is not the same for all market levels in Bangladesh; the market appears to be relatively more competitive at the higher secondary-terminal level than in the primary-secondary level (Dey et al. 2010). There is a general concern among policy makers that seafood prices may not be proportional along the value chains in Bangladesh. The bulk of the fish sold in markets is unprocessed, and the perishability of products also affects the price transmission process. The price transmission mechanism among different value chain levels and the resulting price transmission elasticity play an important role in determining the size and distribution of welfare effects of various technological changes and policy reforms.

The extent of price transmission from one level of the supply chain to another and its direction are important aspects that can be explored to obtain valuable information on market adjustments of supply and demand shocks. Price transmission has widely been studied in agriculture food marketing as well as in the aquaculture and fisheries sector. In the agricultural sector, price transmission relationships have been studied in many commodities such as milk (Kinnucan and Forker 1987; Frigon, Doyon, and Romain 1999; Lass, Adanu, and Allen 2001; Capps and Sherwell 2007), pork (Goodwin and Harper 2000; Abdulai 2002), lamb (Ben-Kaabia and Gil 2007), wheat (Mohanty, Peterson, and Kruse 1995), and maize (Acquah and Dadzie 2010). Similarly a few studies have examined co-integration and price transmission asymmetry for different fish species (Jaffry 2005; Floros 2006; Asche, Jaffry, and Hartmann 2007; Shinoj et al. 2008). Meyer and von Cramon-Taubadel (2004) provide a comprehensive review of price transmission studies. Despite a large number of studies on price transmission mechanisms in agricultural markets, it is difficult to draw strong conclusions on the direction of price transmission and underlying causalities. Though many studies found asymmetric and imperfect pass through of prices, the evidence is mixed and varies widely across commodities and geographic locations. Meyer and von Cramon-Taubadel (2004) argue that there is still a need for more research to understand the increasingly complicated relationships among prices along the value chain and the underlying behaviour of marketing agents. So far, no study has been conducted on the price transmission asymmetry for different fish species in Bangladesh or in other south Asian countries.

 The objectives of this paper are to examine the causal relationships between wholesalers and retailers; and to compute elasticities of price transmission between wholesale and retail markets, and investigate their asymmetries for five different fish species in Bangladesh. This study is the first of its kind in Bangladesh and expected to generate valuable information on the direction of price transmission across traders involved in fish marketing. The remainder of the paper is organized as follows: the next section explains methodology which includes data used, selection of value chains, and a detailed description of the model. Subsequently, results and discussions are presented followed by conclusions and policy implications.

# Methodology

* 1. Data

Five fish species - hilsa (*Tenualosa ilish*), rohu (*Labeo rohita*), catla (*Catla catla*), pangas (*Pangasius hypophthalmus*), and tilapia (*Oreochromis mossambicus/ O. niloticus*) - were selected for this study. Hilsa is the most dominant species constituting about 11% of the capture fish production in Bangladesh. It is virtually a marine species but gets caught in both marine as well as riverine environments. The other four species (rohu, catla, pangas, and tilapia) mostly originate from aquaculture and also have great economic significance in Bangladesh, constituting 23%, 18%, 7%, and 4% of total aquaculture production, respectively (Alam 2011).

We obtained wholesale and retail monthly price series for the chosen species from October, 2005 through July, 2010 for four old administrative divisions, namely Dhaka, Chittagong, Khulna, and Rajshahi from the Department of Agricultural Marketing (DAM), Ministry of Agriculture. The price series are averages of all markets, wholesale/retail, within the division. We could not find a continuous reliable price series for farmers/fishers. However, wherever we had this information, most of wholesale prices were found to be proportional to farmer/fisher prices. This is because most of the wholesale centres (from where DAM[[2]](#endnote-2) collects wholesales price data) are located close to the primary markets or production/landing centres.

* 1. Value Chain

Although there could be a number of combinations of wholesale and retail price series among different fish species across different subdivisions, we have selected only a few of the possible combinations to study price transmission relationships. The selection was based on the following: the important wholesale markets for a particular species based on highest production share, and the main retail market for that particular species-as an example the wholesale and retail market for tilapia is presented in figure 6 in the appendix. Dhaka, being the major retail market for all the species considered, has been included as one of the retail markets for each species. The market pairs chosen for studying price transmission are: i) Dhaka wholesale and Dhaka retail (pangas), ii) Khulna wholesale and Dhaka retail (hilsa and tilapia), iii) Chittagong wholesale and Dhaka retail (hilsa, catla, pangas, rohu, and tilapia), iv) Rajshahi wholesale and Dhaka retail (catla and pangas), v) Khulna wholesale and Khulna retail (hilsa and tilapia), vi) Chittagong wholesale and Chittagong retail (hilsa, catla, rohu, and tilapia), and vii) Rajshahi wholesale and Rajshahi retail (catla and pangas).

* 1. Testing unit root, co-integration and long-term causation

While studying the price relationships over time, it is important to investigate: a) whether the time series under study are stationary or not, b) if they are non-stationary with a unit root, what are the orders of integration, c) if the order of integration of two series is the same, whether they are cointegrated or not, and d) if they are co-integrated, what is the direction of casual relation. If the series under study are stationary at levels, one can use the ‘ordinary least square’ estimation procedure to determine relationships between those series. In the case of non-stationary series, regression using ‘ordinary least square’ estimation may result in spurious relationships. The non-stationary series having unit root may be co-integrated if their order of integration is the same, and one can use error correction models to determine the relationships. Models in difference can be used for non-cointegrated series having unit root.

We have used the Augmented Dickey-Fuller (ADF) (Dickey and Fuller 1979; Dickey and Fuller 1981) approach, which is a commonly used test, for testing whether a time series has a unit root or not. The null hypothesis of time series is that it contains a unit root. If we fail to reject the null hypothesis, then the series is said to be non-stationary having a unit root. The number of lags required for the ADF test was determined by using Schwarz (1978) information criteria.

If a time series is stationary at level, then it is said to be integrated of order zero [i.e., I (0)]. However, if it requires first order differencing to be stationary, then it is said to be integrated of order one [I (1)]. Cointegration between two time series having unit root can be tested either with the Engle and Granger (1987) test or the Johansen (1988) test; we have used the latter one. The Johansen (1988) cointegration test is an unrestricted cointegration test; Gonzalo (1994) discussed advantages/disadvantages of this test.

We used the Granger causality test (Granger 1969) to establish a long-term relationship between cointegrated price series. A time series P1 is said to Granger-cause another time series P2 if the series P1 provides statistically significant information about future values of the series P2. The Granger causality test was basically imperative in our study because we did not have *a priori* information on the causal relationship between the wholesale and retail fish prices in Bangladesh. The null hypothesis of the Granger causality test was formulated in such a way that its rejection led to the conclusion of the Granger causality of the particular price series to the other price series.

* 1. Testing asymmetry of price transmission

Asymmetry of price transmission exists if the response to increase in price at one level of the value chain is different to that of a decrease in price. There is a long history of studies on asymmetric price transmission in agriculture starting with Tweeten and Quance (1969), which used a dummy variable to split the input prices into two: one variable that includes increasing input prices and another that includes only decreasing input prices. Wolffram (1971) adapted Tweeten and Quance’s technique to the study of asymmetric price transmission and proposed a variable-splitting technique that explicitly included first difference of prices in the equation to be estimated. The Wolfram’s approach includes recursive sums of all positive and all negative changes in the input prices as explanatory variables. Houck (1977) modified the Wolfram’s technique to exclude the initial observations. Ward (1982) extended the Houck’s approach by including lags of explanatory variables. Von Cramon-Taubadel and Fahlbusch (1994) incorporated the concept of cointegration in testing for asymmetric price transmission. A number of studies, including von Cramon-Taubadel and Loy (1996), have used this approach or some variant of it. In brief, their approach first involves estimating a relationship between two price series by ordinary least squares and testing the presence of a spurious correlation. If tests prove that prices are cointegrated, then, in the second step, an error correction model is estimated that relates changes in one price variable to changes in another price variable as well as the so called error correction term (ECT).

 For stationary as well as the non-stationary having unit root but non-cointegrated series (Pi and Pj), we followed the Houck (1977) and Ward (1982) approach. This approach basically splits the change in explanatory variable into positive and negative changes. Following Houck (1977) and Ward (1982), the empirical model used in this paper for estimating price transmission elasticity and for testing its asymmetry can be expressed as:

1. 

Where, and ln stand for cumulative and natural logarithmic value, respectively: t is the time,, , if  and 0 otherwise, and , if  and 0 otherwise. The null hypotheses of no difference tested against the alternate hypotheses of inequality are as follows:

 *for lags k=0,1*



The equality of the coefficients of the positive change and negative change for a given period provides the test on short run asymmetry which is given by the first null hypothesis. The second null hypothesis for the equality of the coefficients for the sum of positive change and sum of negative change  gives the information on long run price transmission asymmetry. The optimal lag lengths were chosen based on Akaike Information Criterion (AIC).

 For the cointegrated series (Piand Pj), von Cramon-Taubadel’s and Loy (1996) error correction approach of asymmetry test was used. This approach splits the error term obtained from the cointegrating equation into positive and negative errors. Following von Cramon-Taubadel’s and Loy (1996), the empirical model used in the paper for estimating price transmission elasticity and for testing its asymmetry can be expressed as follows:

(2) 



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Where, β3(L), β4(L) are polynomial lags. The ECT measures deviations from the long- run equilibrium between lnPi,t and lnPj,t. Thus, inclusion of ECT+ and ECT- allows lnPi,t not only to respond to changes in lnPj,t but also to correct any positive and negative deviations from the long-run equilibrium.

We tested the following two hypotheses:





The first null hypothesis, equality of coefficient for positive and negative changes in causing price series, tests the asymmetry in short-run price transmission. Similarly, the second null hypothesis, equality of the coefficient for the positive and negative errors, tests the asymmetry in long-run price transmission. In both cases, rejection of the null hypotheses would indicate asymmetry in price transmission in the short-run and long-run, respectively.

# Results and discussion

Table 1(in the appendix) presents descriptive statistics (mean and coefficient of variation) of the different price series for each species and division. Figures 1 through 5(in the appendix) show the trend of wholesale and retail prices for different fish species over time. The trend figures are presented only for Dhaka because it is the largest retail market for seafood in Bangladesh. As depicted by Figures 1 through 5, both the wholesale and retail prices of all species show increasing trends over time. However, there seems to be less fluctuation in prices of pangas, rohu, and tilapia as compared to those of hilsha and catla. In general, both wholesale and retail prices are found to move in a similar fashion.

Table 2 (in the appendix) presents the results of the ADF unit root tests for the selected price series. Out of a total of 24 price series analyzed, nine series were found to be stationary whereas the remaining series were found to have unit roots. Similarly, Table 3 (in the appendix) shows results from the Granger-causality test for different fish species. In the case of hilsha, we found that the Khulna wholesale price Granger causes the Dhaka retail price. We found a causal relationship from retail to wholesale price in two price series combinations while no distinct directions of causality were obtained in the remaining hilsa series combinations. Out of four value chains analyzed for catla prices, we found a causal relationship from wholesale to retail (Rajshahi wholesale Granger caused Rajshahi retail) and from retail to wholesale (Chittagong retail Granger caused Chittagong wholesale) while we did not observe significant causal relationship in the other two combinations. For pangas, we found the causal relationship from retail to wholesale price in three pairs of price series out of four pairs analyzed. We did not observe any distinct causal relationship between two levels of the supply chain for all pairs considered in rohu fish species. Out of four value chains examined in tilapia, we found the direction of the causal relationship from retail price to wholesale price in two pairs, from wholesale to retail in one pair, and no relationship in the remaining one.

In most of the cases, we found that the direction of causal relationship was from the retail to the wholesale market. This might be due to the fact that retailers are more organized than wholesalers in the Bangladesh fish market. In such situations, retailers would set the price of the commodity and wholesalers would have to follow the set price. This observation would allow us to study the price transmission relationship taking the wholesale price as the dependent variable in the model involving those particular series. Moreover, following the above argument, we analyzed the wholesale price as the dependent variable even in the other series that did not demonstrate any significant Granger causality relationships.

Tables 4 and 5 (in the appendix) indicate the results of the test of asymmetry in price transmission with the price transmission elasticities for all fish species. The tables comprise results of price transmission relationships using the Houck and Ward approach for stationary and non-stationary non-cointegrated pairs (Table 4) as well as using an error correction approach of von Cramon-Taubadel and Loy for cointegrated series (Table 5). Of all non-stationary pairs analyzed, only three pairs were found to be cointegrated.

For hilsha, price transmission was found to be symmetric in the short run (Table 4). However, an asymmetric price transmission relationship was observed in the long run for all pairs except for the Chittagong wholesale and retail pair. The elasticity of price transmission ranged from 0.10 to 0.86 for rising prices and from 0.39 to 0.69 for falling prices in short run. In the long run, these elasticities ranged from 0.42 to 0.76 for rising prices and from 0.63 to 1.29 for falling prices.

Price transmission in catla species was found to be symmetric in the short run within a division (Table 4). However, it was found to be asymmetric spatially in both the short run and long run across. The elasticity of price transmission ranged from -0.88 to 1.61 for rising prices and from -2.32 to 0.98 for falling prices in the short run and from -0.205 to 1.01 for rising prices and from -0.676 to 0.732 for falling prices in the long run.

In pangas, asymmetric price transmission was found in the long run with mixed results in the short run for both pairs analyzed using the Houck and Ward approach (Table 4). The error correction approach for the cointegrated series resulted in symmetric price transmission in both the short and long run (Table 5). Overall, for the rising retail prices of pangas, the elasticities of price transmission varied from -0.182 to 1.132 in the short run and from 0.672 to 1.317 in the long run (Table 4). On the other hand, for the falling retail prices, the price transmission elasticities ranged from -0.190 to 0.533 and from -0.237 to 0.456 in the short and long run, respectively (Table 4).

In the case of rohu, asymmetric price transmission was found in both the short and long run in the price series analyzed. The elasticities of price transmission were 1.182 and 1.547 for rising retail prices and -1.214 and 0.085 for falling retail prices in the short run. In the long run, these elasticities were 1.023 and 1.249 for rising retail prices and 0.736 and -0.023 for falling retail prices.

In tilapia, results from both approaches demonstrated symmetry in price transmission in the short run for all pairs of series but asymmetry in the long run except for the Khulna wholesale-Dhaka retail pair (see Tables 6 and 7 in the appendix). Overall, the elasticity of price transmission ranged from -0.108 to 0.935 for rising retail prices and from -0.409 to 1.436 for falling retail prices in short run. In the long run, these elasticities ranged from 0.129 to 0.845 for rising prices and from -0.099 to 0.424 for falling prices.

Out of 18 pairs of price series (9 inter-market transmissions and 9 intra-market transmission) analyzed, 13 cases revealed long-run price asymmetries and only 5 cases with short-term price asymmetries. Given the highly perishable nature of fish products marketed in Bangladesh and also the use of monthly price series for this study, it is plausible that the rising and falling price response elasticities are not significantly different in the short term. But, the results indicate that price asymmetries do persist in the long run.

The characteristics of price asymmetries differ substantially across markets and species. Out of nine inter-regional price transmission cases studied, eight cases indicate asymmetric price transmission in the long-run and four cases in the short-run. As expected, price transmission within a region tends to be more symmetric. Out of nine intra-regional price transmissions studied, five cases show asymmetric transmission in the long-run, and only one case in the short-run. Various previous studies, including Capps and Sherwell (2007), emphasized the spatial dimension of asymmetric price transmission.

Though changes in retail prices are drivers of changes in wholesale prices of fish products in Bangladesh (Table 3), the asymmetric price transmission behaviour varies among the type of products (Tables 6 and 7). For hilsa, a capture fisheries product, elasticities of price transmission from retailer to wholesaler were generally greater from decreases in price than from increases in price. A greater pass-through of price changes at the time of falling prices is unfavourable to hilsa wholesalers. But the results indicate a different pattern for aquaculture products studied (catla, pangas, rohu, and tilapia). Increases in the retail price of most of the aquaculture products were passed through to the wholesale level more fully than were decreases in retail prices. This phenomenon indicates relatively more bargaining power of wholesalers of aquaculture products compared to wholesalers of captured fish. Supply of hilsa is more volatile than that of aquaculture products. In the absence of processing facilities, hilsa fishermen and wholesalers are often at the receiving end of market negotiations. But most of the aquaculture products marketed through inter-regional trade comes from commercial farmers, who are more organized and are able to adjust their harvest depending on market price. So, it is likely that the retailers of aquaculture products are not in a position to easily pass falling prices though to wholesalers and farmers.

# Summary, conclusion, and policy implication

This paper presents tests of causal relationship between wholesale and retail prices and tests of asymmetry in price transmission in five different fish species in Bangladesh (hilsha, catla, pangas, rohu, and tilapia). Unlike various previous studies on other agricultural crops, the direction of causal relationships was observed from the retail to the wholesale market in most of the value chains analyzed indicating that retailers are the price leaders. It further implies that these fish are demand driven as retail price leads the wholesale price. The lack of sufficient numbers of wholesalers capable of influencing the transmission of prices to retailers may be attributed to the limited absence of large scale wholesale demand from institutional buyers such as supermarkets, hospitals, orphanages, hotels, restaurants and wholesale buyers/firms for external/export markets. This suggests that wholesale prices may be influenced by retail prices in most of the fish species in Bangladesh, basically due to less organized behaviour of the wholesale market as compared to the retail one. Dispersed production/landing points, poor transportation, perishability of the product and lack of information about retail markets are some other factors that may influence this retail price leadership over wholesale prices.

We analyzed the asymmetric price transmission behaviour according to the Houck (1977) and Ward (1982) approach, and the von Cramon-Taubadel and Loy (1996) ECM approach. Our results suggest that, in general, the price transmission is mostly symmetric in the short-run while a mix of symmetric and asymmetric in the long-run Out of 18 pairs of wholesale and retail price series (9 inter-market transmissions and 9 intra-market transmission) analyzed, 13 cases revealed long-run price asymmetries and only 5 cases with short-term price asymmetries. This asymmetric price transmission behaviour indicates that a) changes in retail prices do not get reflected fully at the wholesale prices, and b) transmission differs according to whether retail prices are increasing or decreasing. We found that asymmetric price transmission is more common in inter-regional (i.e., between various regions of the country) markets than in intra-regional markets. This result suggests that price transmission studies be conducted on a spatial basis, either by city or region in lieu of a national analysis.

We found variation in price transmission behaviour between aquaculture and capture fisheries products. For aquaculture products, elasticities of price transmission from retailer to wholesaler were generally greater from increases in price than from decreases in price. But for a fisheries product studied (hilsa), wholesale prices were more sensitive to decreases in retail prices than to increases retail prices. These results indicate that the retailers of aquaculture products, compared to their fisheries counterparts, are less likely to be in a position to easily pass through falling prices to wholesalers and farmers. With the emergence of commercial aquaculture in the country, there might be a change in the price transmission behaviour in favour of farmers.

The results of the study have important policy implications. Various studies (Dey et al. 2008a; Dey et al. 2008b; Dey, Alam, and Paraguas 2010) indicate that, given elastic income elasticity of demand for fish, there will be tremendous increase in demand for various types of fish in Bangladesh over time due to population growth and increases in per capita income. A major share of this increased demand is expected to come from poorer households with increasing income. There is a need for commensurate increases in fish supply to maintain fish price and to protect fish consumers (Dey et al. 2008a). In recent years, almost all increases in fish production have come from aquaculture sector. However, increasing fish supply from aquaculture will exert a downward pressure on prices of aquaculture products. The findings of asymmetric price transmission of retail prices of aquaculture products , indicating that increases in the retail price of the aquaculture products are likely to pass through to the primary markets more fully than are decreases in retail prices, are beneficial to aquaculture farmers in the country. These findings reveal that fish farmers are expected to fully receive the price signals of higher market demands. But if market prices fall due to the expansion of products, retailers might not be able to easily pass through falling prices to farmers, and thereby farmers’ revenue might not fall. Thus, the results of this study imply that the market forces in Bangladesh will likely provide enabling environments for the aquaculture sector in the country to expand.

On the other hand, growing market demand for fish and constant or declining supply of capture fisheries are likely to increase retail prices of capture fisheries products in Bangladesh. A most recent available projection (Dey et al. 2008a) shows that the retail price of hilsa is expected to increase by about 5 to 6% annually. Our results show that hilsa fishermen in Bangladesh are likely to receive some share of expected increase in hilsa retail price, though the elasticities of price transmission of hilsa from retailer to wholesaler are generally greater from decreases in price than from increases in price. Given the asymmetric price transmission of hilsa retail prices to primary markets, hilsa fishermen need to be more organized.

The examination of causality and price transmission relationships using the Houck and Ward approach, and the von Cramon-Taubadel and Loy approach is the first attempt in the Bangladesh aquaculture and fisheries sector. Therefore, this study is expected to fill the gap in knowledge. Future research on the existence of market power and distribution of margins across different levels of the value chain would provide valuable guidance in understanding and management of the seafood markets in Bangladesh.

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**A****ppendix**

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| **Table 1**Average Prices for Selected Species at Wholesale and Retail Levels, 2005 to 2010 |
| Market | Statistics | Hilsha | Catla | Pangas | Rohu | Tilapia |
| Wholesale prices |
| Dhaka  | Average (Taka/kg) | 214 | 126 | 59 | 149 | 81 |
| Coefficient of variation (%) | 19.16 | 12.70 | 11.86 | 16.11 | 19.75 |
| Rajshahi | Average (Taka/kg) | 254 | 142 | 64 | 157 | 84 |
| Coefficient of variation (%) | 24.02 | 11.27 | 14.06 | 11.46 | 10.71 |
| Khulna  | Average (Taka/kg) | 247 | 123 | 59 | 146 | 80 |
| Coefficient of variation (%) | 29.55 | 13.01 | 22.03 | 15.07 | 27.50 |
| Chittagong  | Average (Taka/kg) | 264 | 150 | 72 | 156 | 105 |
| Coefficient of variation (%) | 27.27 | 16.67 | 12.50 | 17.31 | 14.29 |
| Market | Statistics | Retail Prices |
| Dhaka  | Average (Taka/kg) | 254 | 145 | 69 | 176 | 96 |
| Coefficient of variation (%) | 23.23 | 13.10 | 14.49 | 17.05 | 19.79 |
| Rajshahi | Average (Taka/kg) | 283 | 158 | 71 | 201 | 95 |
| Coefficient of variation (%) | 21.91 | 10.76 | 11.27 | 88.56 | 11.58 |
| Khulna  | Average (Taka/kg) | 282 | 134 | 69 | 161 | 91 |
| Coefficient of variation (%) | 24.11 | 9.70 | 17.39 | 14.29 | 21.98 |
| Chittagong  | Average (Taka/kg) | 225 | 126 | 61 | 135 | 88 |
| Coefficient of variation (%) | 24.89 | 13.49 | 11.48 | 16.30 | 12.50 |

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| **Table 2**Augmented Dickey Fuller Unit Root Test at Level and First Differences for the Selected Price Series. |
| Division | Species | F-statistics at level (constant & trend) | F-statistics at 1st difference (constant & trend) |
| Level | Retail  | Wholesale  | Retail  | Wholesale  |
| Dhaka  | Hilsha | -4.328 | \*\*\* |  |  | -6.815 | \*\*\* |  |  |
|  | Catla | -3.246 |  |  |  | -6.897 | \*\*\* |  |  |
|  | Pangas | -2.117 |  | -2.331 |  | -4.748 | \*\*\* | -6.857 | \*\*\* |
|  | Rohu | -3.442 |  |  |  | -8.172 | \*\*\* |  |  |
|  | Tilapia | -2.918 |  |  |  | -8.548 | \*\*\* |  |  |
| Khulna  | Hilsha | -3.621 | \*\* | -4.312 | \* | -7.740 | \*\*\* | -9.462 | \*\*\* |
|  | Tilapia | -2.808 |  | -3.215 |  | -7.256 | \*\*\* | -7.032 | \*\*\* |
| Rajshahi | Catla | -2.537 |  | -4.231 |  | -4.259 | \*\*\* | -12.388 | \*\*\* |
|  | Pangas | -2.741 |  | -2.974 |  | -6.629 | \*\*\* | -3.892 | \*\*\* |
| Chittagong  | Hilsha | -3.818 | \*\* | -4.520 |  | -7.547 | \*\*\* | -8.553 | \*\*\* |
|  | Catla | -2.441 |  | -3.607 |  | -9.311 | \*\*\* | -8.281 | \*\*\* |
|  | Pangas | -2.992 |  | -2.572 |  | -7.344 | \*\*\* | -7.200 | \*\*\* |
|  | Rohu | -2.451 |  | -1.993 |  | -7.431 | \*\*\* | -9.188 | \*\*\* |
|   | Tilapia | -3.941 |  | -5.642 |  | -8.460 | \*\*\* | -8.699 | \*\*\* |

\*\*\* and \*\* denote significance at 0.01 and 0.05 levels, respectively.

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| **Table 3**Pairwise Granger Causality Test for Wholesale and Retail Prices of Selected Fish Species |
| Null Hypothesis | Hilsha | Catla | Pangas | Rohu | Tilapia |
| F-statistics |
| Khulna RP dnGC Khulna WP | 2.06 |  | --- |  | --- |  | --- |  | 1.04 |  |
| Khulna WP dnGC Khulna RP | 2.35 |  | --- |  | --- |  | --- |  | 2.84 | \* |
| Dhaka RP dnGC Khulna WP | 1.78 |  | --- |  | --- |  | --- |  | 1.80 |  |
| Khulna WP dnGC Dhaka RP | 6.03 | \*\*\* | --- |  | --- |  | --- |  | 0.02 |  |
| Chittagong RP dnGC Chittagong WP | 10.04 | \*\*\* | 3.25 | \*\* | --- |  | 0.93 |  | 6.68 | \* |
| Chittagong WP dnGC Chittagong RP | 1.63 |  | 0.24 |  | --- |  | 1.05 |  | 1.17 |  |
| Dhaka RP dnGC Chittagong WP | 6.36 | \*\*\* | 0.93 |  | 3.93 | \*\* | 0.56 |  | 2.79 | \* |
| Chittagong WP dnGC Dhaka RP | 0.29 |  | 1.44 |  | 1.09 |  | 0.77 |  | 0.70 |  |
| Rajshahi RP dnGC Rajshahi WP | --- |  | 2.79 |  | 1.19 |  | --- |  | --- |  |
| Rajshahi WP dnGC Rajshahi RP | --- |  | 8.71 | \*\*\* | 0.85 |  | --- |  | --- |  |
| Dhaka RP dnGC Rajshahi WP | --- |  | 2.20 |  | 4.18 | \*\* | --- |  | --- |  |
| Rajshahi WP dnGC Dhaka RP | --- |  | 0.84 |  | 0.23 |  | --- |  | --- |  |
| Dhaka RP dnGC Dhaka WP | --- |  | --- |  | 12.15 | \*\*\* | --- |  | --- |  |
| Dhaka WP dnGC Dhaka RP | --- |  | --- |  | 1.69 |  | --- |   | --- |  |
| dnGC = does not Granger Cause; RP = Retail price; WP = Wholesale price; \*\*\*, \*\*, and \* indicate rejection of null hypothesis at 0.01, 0.05 and 0.10 significance levels, respectively. |

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| **Table 4** Estimates of the Model using Houck and Ward Approach for Testing Asymmetry in Price Transmission |
| SpeciesMarketVal. Chain  |  Hilsha  |  Hilsha  |  Hilsha  |  Hilsha  |
| Khulna |  | Khulna | Dhaka |  | Khulna  | Chittagong | Chittagong | Chittagong | Dhaka |
| WS(i) | ← | Retail(j) | Retail(i) | ← | WS(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) |
| Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. |
| t | 0.0451 | \*\*\* | 0.0097 | 0.0109 |   | 0.0085 | -0.0006 |   | 0.0074 | 0.0218 |   | 0.0162 |
|  | 0.8691 | \*\*\* | 0.1739 | 0.1023 |   | 0.1316 | 0.1667 |   | 0.2357 | 0.1917 |   | 0.4438 |
|  | 0.6957 | \*\*\* | 0.1991 | 0.4503 | \*\* | 0.1356 | 0.6526 | \*\* | 0.2698 | 0.3976 |   | 0.4485 |
|  | -0.2794 | \* | 0.1582 | 0.4188 | \*\* | 0.159 | 0.602 | \*\* | 0.2184 | 0.2308 |   | 0.4328 |
|  | 0.5994 | \*\*\* | 0.1767 | 0.1889 |   | 0.1167 | 0.1235 |   | 0.2642 | 0.4502 |   | 0.3863 |
| Adj. R-squared  | 0.9683 |  |  | 0.956 |  |  | 0.8775 |  |  | 0.8526 |  |  |
| SpeciesMarketVal. Chain  |  Rohu | Pangas | Pangas | Catla |
| Chittagong | Dhaka | Rajshahi |  | Dhaka  | Chittagong | Dhaka | Chittagong | Chittagong |
| WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) |
| Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. |
| t | -0.0296 | \*\*\* | 0.0061 | -0.0272 | \*\* | 0.0101 | -0.0421 | \*\*\* | 0.0078 | -0.0087 |   | 0.0054 |
|  | 1.5478 | \*\*\* | 0.3777 | -0.1826 |   | 0.5485 | 1.132 | \*\* | 0.4258 | 1.0401 | \*\*\* | 0.293 |
|  | -1.2149 | \*\* | 0.415 | -0.1514 |   | 0.5849 | -0.1902 |   | 0.4283 | 0.223 |   | 0.4482 |
|  | -0.2983 |   | 0.3983 | 1.3258 | \*\* | 0.4478 | 0.185 |   | 0.3483 | -0.03 |   | 0.3204 |
|  | 1.1912 | \*\* | 0.4085 | 0.1963 |   | 0.5309 | -0.0478 |   | 0.4123 | 0.3675 |   | 0.4091 |
| Adj. R-squared  | 0.9055 |   |   | 0.4061 |   |   | 0.6275 |   |   | 0.9501 |   |   |
| \*\*\*, \*\*, and \* indicate rejection of null hypothesis at 0.01, 0.05 and 0.10 significance levels, respectively. |
| **Table 4 (continued)**Estimates of the Model using Houck and Ward Approach for Testing Asymmetry in Price Transmission |
| SpeciesMarketVal. Chain  | Tilapia |   |   | Tilapia | Tilapia |  Rohu  |
| Khulna |  | Dhaka | Chittagong | Dhaka | Chittagong | Chittagong | Chittagong | Chittagong |
| WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) |
| Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. |
| t | 0.0015 |   | 0.011 | 0.0006 |   | 0.0039 | -0.0075 | \*\* | 0.0036 | -0.0101 | \*\* | 0.0038 |
|  | -0.1082 |   | 0.5471 | 0.2346 |   | 0.1920 | 0.9352 | \*\*\* | 0.2112 | 1.1823 | \*\*\* | 0.2270 |
|  | 1.4361 |   | 1.1328 | -0.4095 |   | 0.3976 | 0.934 | \*\* | 0.3945 | 0.086 |   | 0.2227 |
|  | 0.6107 |   | 0.5647 | -0.1053 |   | 0.1982 | -0.0901 |   | 0.2453 | -0.1586 |   | 0.2515 |
|  | -1.0528 |   | 1.3078 | 0.3097 |   | 0.459 | -0.5091 |   | 0.3673 | 0.6509 | \*\* | 0.2061 |
| Adj. R-squared  | 0.6861 |   |   | 0.9049 |   |   | 0.9466 |   |   | 0.9481 |   |   |
| SpeciesMarketVal. Chain  | Catla | Catla | Catla |  |  |  |
| Chittagong |  | Dhaka | Rajshahi |  | Rajshahi | Rajshahi |  | Dhaka  |  |  |  |
| WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) | WS(i) | ← | Retail(j) |  |  |  |
| Coeff. |  | S.E. | Coeff. |  | S.E. | Coeff. |  | S.E. |  |  |  |
| t | 0.0025 |   | 0.0061 | 0.0014 |   | 0.0022 | 0.0261 | \*\*\* | 0.0043 |  |  |  |
|  | 1.6195 | \*\* | 0.5400 | 0.9715 | \*\*\* | 0.1606 | -0.8805 | \*\* | 0.2885 |  |  |  |
|  | -2.3282 | \*\*\* | 0.5488 | 0.8035 | \*\*\* | 0.1989 | 0.9818 | \*\* | 0.3347 |  |  |  |
|  | -1.8866 | \*\*\* | 0.4684 | -0.1799 |   | 0.2026 | 0.6751 | \*\* | 0.2570 |  |  |  |
|  | 1.6513 | \*\* | 0.6095 | -0.0709 |   | 0.1786 | -0.3952 |   | 0.3160 |  |  |  |
| Adj. R-squared  | 0.9160 |   |   | 0.971 |   |   | 0.9349 |   |   |   |   |   |
| \*\*\*, \*\*, and \* indicate rejection of null hypothesis at 0.01, 0.05 and 0.10 significance levels.  |

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| **Table 5** Estimates of the von Cramon-Taubadel and Loy Model for Testing Asymmetry in Price Transmission |
| MarketSpeciesValue chain  | Dhaka Pangas WS (i) ←Retail(j) | Khulna Tilapia WS(i) ← Retail(j) | Rajshahi Pangas WS(i) ← Retail(j) |
| Coeff. |   | S.E. | Coeff. |   | S.E. | Coeff. |   | S.E. |
|  | -0.5208 | \*\* | 0.1706 | 0.3097 | \* | 0.1753 | 1.1979 | \*\*\* | 0.3089 |
|  | 0.3093 |   | 0.1890 | 0.3558 | \*\* | 0.1367 | 0.5332 |   | 0.4149 |
|  | 0.6728 | \*\* | 0.2027 | 0.4155 | \*\* | 0.1419 | 0.8867 | \*\* | 0.4283 |
|  | 0.4563 | \*\* | 0.2136 | 0.0059 |   | 0.1611 | 0.4003 | \*\* | 0.1827 |
|  | 0.0136 |   | 0.1273 | -0.0784 |   | 0.1324 | 0.1090 |   | 0.1606 |
|  | -0.0107 |   | 0.1348 | 0.1021 |   | 0.1144 | 0.0593 |   | 0.2100 |
|  | -0.0048 |   | 0.0112 | -0.0148 |   | 0.0240 | -0.0247 |   | 0.0207 |
|  Adj. R-squared |  0.4394 | 0.2346 | 0.3970 |
| \*\*\*, \*\*, and \* indicate rejection of null hypothesis at 0.01, 0.05 and 0.10 significance levels, respectively. |

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| **Table 6**Results of Price Asymmetry Test using Hock and Ward Approach |
| Value chain | Time | β+ | β- | p-value | Conclusion |
|   |   |   |   | (Ho: β+= β-) |   |
| Hilsa |
| Khulna WSP ← Khulna RP | SR | 0.8690 | 0.6950 | 0.5690 | Symmetry |
| LR | 0.5890 | 1.2950 | 0.0000 | Asymmetry |
| Dhaka RP ← Khulna WP  | SR | 0.1020 | 0.4500 | 0.1170 | Symmetry |
| LR | 0.5210 | 0.6390 | 0.0050 | Asymmetry |
| Chittagong WSP← Chittagong RP  | SR | 0.1660 | 0.6520 | 0.2280 | Symmetry |
| LR | 0.7680 | 0.7760 | 0.8790 | Symmetry |
| Chittagong WSP ← Dhaka RP  | SR | 0.1910 | 0.3970 | 0.7840 | Symmetry |
| LR | 0.4220 | 0.8470 | 0.0030 | Asymmetry |
| Catla |
| Chittagong WSP← Chittagong RP | SR | 1.0400 | 0.2230 | 0.1820 | Symmetry |
| LR | 1.0100 | 0.5900 | 0.0010 | Asymmetry |
| Chittagong WSP← Dhaka RP | SR | 1.6190 | -2.3280 | 0.0000 | Asymmetry |
| LR | -0.2670 | -0.6760 | 0.0100 | Asymmetry |
| Rajshahi RP← Rajshahi WSP | SR | 0.9710 | 0.8030 | 0.5440 | Symmetry |
| LR | 0.7910 | 0.7320 | 0.1830 | Symmetry |
| Rajshahi WSP← Dhaka RP | SR | -0.8800 | 0.9810 | 0.0090 | Asymmetry |
| LR | -0.2050 | 0.5860 | 0.0000 | Asymmetry |
| Pangas |
| Rajshahi WSP← Dhaka RP | SR | -0.1820 | -0.1510 | 0.9740 | Symmetry |
| LR | 1.1430 | 0.0440 | 0.0000 | Asymmetry |
| Chittagong WSP← Dhaka RP | SR | 1.1320 | -0.1900 | 0.0700 | Asymmetry |
| LR | 1.3170 | -0.2370 | 0.0000 | Asymmetry |
| Rohu |
| Chittagong WSP← Chittagong RP | SR | 1.1820 | 0.0850 | 0.0050 | Asymmetry |
| LR | 1.0230 | 0.7360 | 0.0010 | Asymmetry |
| Chittagong WSP← Dhaka RP | SR | 1.5470 | -1.2140 | 0.0150 | Asymmetry |
| LR | 1.2490 | -0.0230 | 0.0000 | Asymmetry |
| Tilapia |
| Khulna WSP← Dhaka RP | SR | -0.1080 | 1.4360 | 0.2530 | Symmetry |
| LR | 0.5020 | 0.3830 | 0.5350 | Symmetry |
| Chittagong WSP← Chittagong RP | SR | 0.9350 | 0.9340 | 0.9980 | Symmetry |
| LR | 0.8450 | 0.4240 | 0.0000 | Asymmetry |
| Chittagong WSP← Dhaka RP | SR | 0.2340 | -0.4090 | 0.1750 | Symmetry |
| LR | 0.1290 | -0.0990 | 0.0140 | Asymmetry |
| RP= retail price; WSP = wholesale price; SR= short-run; LR=long-run |
| **Table 7**Results of Price Asymmetry Test for Cointegrated Pair of Series using von Cramon-Taubadel and Loy Approach |
| Value chain | Time | β+ | β- | p-value | Conclusion |
|  |  |  |  | (Ho: β+= β-) |  |
| Pangas |
| Dhaka WP← Dhaka RP | SR | 0.5200 | 0.3090 | 0.4890 | Symmetry |
| LR | 0.6720 | 0.4560 | 0.5100 | Symmetry |
| Rajshahi WP← Rajshahi RP | SR | 1.1970 | 0.5330 | 0.2880 | Symmetry |
| LR | 0.8867 | 0.4000 | 0.3440 | Symmetry |
| Tilapia |
| Khulna RP← Khulna WP | SR | 0.3090 | 0.3550 | 0.8500 | Symmetry |
| LR | 0.4150 | 0.0050 | 0.0830 | Asymmetry |
| RP= retail price; WP = wholesale price; SR= short-run; LR=long-run |



**Figure 1**. Monthly Wholesale and Retail Prices (taka/kg) of Hilsha for Dhaka



**Figure 2.** Monthly Wholesale and Retail Prices (taka/kg) of Catla for Dhaka



**Figure 3.** Monthly Wholesale and Retail Prices (taka/kg) of Pangas for Dhaka



**Figure 4.** Monthly Wholesale and Retail Prices (taka/kg) of Rohu for Dhaka



**Figure 5.** Monthly Wholesale and Retail Prices (taka/kg) of Tilapia for Dhaka

**Figure 6.** Selection of Value Chain (Wholesale and Retail Market) for Tilapia

1. Seafood is defined in board terms as all edible aquatic life, including freshwater organisms. [↑](#endnote-ref-1)
2. The Department of Agriculture Marketing collects wholesale prices from one secondary market in each district and farm gate prices from two primary markets in each district. Theses wholesales markets are usually located in sub-district (*upazila*) or district headquarters and are not very far away from primary markets. [↑](#endnote-ref-2)