PRICE ANALYSIS OF SELECTED MARINE FISH AVAILABLE IN COLOMBO FISH MARKETS

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Abstract

This study aims to examine the price behavior of several key types of marine fish consumed by Sri Lankans which are commonly available in the Colombo fish market using time series econometric modeling techniques. It is based on the claim that fish prices have increased overtime and are frequently subjected to price fluctuations. Seasonal Autoregressive Integrated Moving Average (SARIMA) models in particular were employed to find a parsimonious time series model for better forecasts. The outcome of analysis revealed that certain higher order SARIMA models were able to parsimoniously track the dynamic behavior of real fish prices with acceptably accurate forecasts. Although the nominal fish prices have increased over time, real prices were steady, and seasonal patterns in real price changes were found to occur, with higher prices observed in middle months of the year. Results show that there is an increasing trend in nominal prices but not in real prices. Therefore, the apparent increasing trend in nominal fish prices may be governed largely by rising inflation in the country rather than by issues inherent to the fish industry.

Key Words: *Fish Industry, Forecasting, Real Prices, SARIMA Model*

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INTRODUCTION

Surrounded by sea, Sri Lanka is blessed with enormous ocean resources, including both biological and non-biological components, and opportunities to make full use of them: which, with careful planning, can effectively be exploited for the socio-economic development of the nation. The fisheries sector plays an indispensable role in the economy of Sri Lanka, contributing around 1.4% to the GDP in 2015. The contribution of marine fisheries (coastal, deep sea and off shore) segment to the overall fisheries sector is around 87% (Fisheries Sector Outlook, 2015). Coastal fish production contributes nearly 52% of the total fish production, to which the contribution of off shore and deep sea fisheries is around 35%.

The Medical Research Institute (MRI) of Sri Lanka pointed out that an average per capita consumption of about 60g of fish per day would be satisfactory to ensure adequate nutrition (Fisheries Sector Development Strategy of Sri Lanka, 2010). In the light of this, fish products act as an important source of animal protein, providing around more than 50% of the animal protein consumed. Further, the fisheries sector provides livelihood for the majority of people living in the coastal belt and currently provides direct employment to about 650,000 livelihoods comprising of 150,000 in fishing, 10,000 in associated service activities and 400,000 in fish trade (Anon, 2007).

As a result of the seasonal nature of fisheries industry incomes and other uncertainties (weather, ability to find fish, etc.), fishing communities find it difficult to secure a dependable livelihood. Coastal fishing depends on monsoon climate patterns and fishers must migrate between the country's major fishing areas as seasons change. Except for a small number of large commercial operators with modern facilities, the fisheries sector in Sri Lanka comprises mostly small scale operators (Anon, 2008).

Fishing industry has been undergone sizeable modernisation and witnessed remarkable growth in terms of production over the past three decades, to which introduction and application of new technologies, establishment of Exclusive Economic Zone (EEZ), and expansion of both domestic and international markets contributed significantly. All these changes in the fisheries sector ensured improved access to resources, and significant expansion of production, marketing, and trade.

Major characteristics of consumption patterns of fresh fish reveal that the most commonly preferred varieties of large pelagic include, amongst others, the *Katsuwonus pelamis* [commonly referred to as 'Balaya' (Skipjack tuna)], *Istiophorus platypterus* ['Thalapath' (Sail fish)] and *Acanthocybium commersoni* [*'Thora'*(Seer)]. Among the small pelagics, *Amblygaster sirm* ['Hurulla' (Trenched sardinella)] and *Sardinella gibbosa* ['Salaya' (Sardine)] were the most commonly preferred varieties. The total average quantity of fresh fish consumed by each person was reported to be 750 g per month (Food Balance Sheet, 2006). Various information sources related to the fisheries sector indicate that wholesale and retail prices of fish has increased gradually over the last five years and that prices of fish were considerably higher than other animal based food commodities. In this light, modelling fisheries prices is important, because it may give the performances of prices over the time and may provide forecasts of its future levels. Various techniques, from Ordinary Least Square method (OLS) to the Seasonal Autoregressive Integrated Moving Average (SARIMA) models have been used to explain the forecasting performances of prices in economics.

Floros and Failler (2006), for example, have used SARIMA models for forecasting monthly fisheries prices in the UK. Nevertheless, there are no similarly rigorous and updated models available in the literature for forecasting and studying the dynamic behavior of fish prices in Sri Lanka; thus, it is of paramount importance to update the available models with present data for accurate forecasting. With this background, this study was carried out with the objective of identifying appropriate time series models for studying dynamic behavior, forecasting of fish prices and determine the seasonal pricing patterns of fish in retail market. The outcome of this study will provide useful information to different stakeholders in the agri-food sector, in general, and particularly to those in the fish sector in Sri Lanka, for policy planners and policymakers, for those in the fish value chain from fishermen to traders, as well as for those involved in various economic and price analyses.

METHODOLOGY

Selection of Fish Types and Data

The average weekly Colombo retail prices of fish recorded at the Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) were obtained for this analysis to cover the period from January 2000 to December 2013. There were five types of fish used for the analysis, including: ‘Thalapath’ (Sail Fish), ‘Hurulla’ (Trenched Sardinella), ‘Thora’ (Seer), ‘Salaya’ (Sardine) and ‘Balaya’ (Skipjack Tuna).

Deflating Nominal Prices of Fish

As the first step of analysis, the nominal prices of fish were converted into real prices to avoid impacts of the inflation in the analysis, where the Colombo Consumer Price Index (CCPI) – a social and economic indicator constructed to measure changes over time in the general level of prices of consumer goods and services that a representative group of households acquire, use or pay for consumption - was used as the price deflator. The CCPI is compiled and published by the Department of Census and Statistics of Sri Lanka and is considered the official indicator of changes in the price level of consumer goods of the country. It measures the change over a period of time in the cost of a fixed basket of goods and services commonly purchased by a majority of households. If the quantity and quality of this market basket is held constant at the base period, the value of the index solely reflects the changes in price. It is estimated as a weighted average of the prices of a sample of goods and services obtained from selected markets in a defined geographical area.

In calculating CCPI, 334 items are categorised into 10 groups including health, transport, food and non-alcoholic beverages, communication, clothing and footwear, education, housing, water, electricity, gas and other fuels, the value of which is published on monthly basis. The CCPI has been available for different base years (1952, 2002 and 2006/07). Since the CCPI (1952=100) was more than five decades old and significant changes in consumer habits and family income had taken place on the demand side, as well as in the range and availability of goods and services on the supply side, it was no longer a good indicator of current changes in retail prices. To overcome these issues, the Department of Census & Statistics constructed a more comprehensive CPI called the Colombo Consumers' Price Index (Base 2002=100) in November 2007 addressing many of the deficiencies of the old index. This index was accepted as the official measure of inflation in Sri Lanka in November 2007, replacing the outdated CCPI (Base: 1952=100). Further, in order to have a single standard measure of inflation in the country and to fulfill other purposes, a policy decisions was taken to discontinue the compilation of old CCPI.

For this analysis, only CCPI of 1952 and 2006/07 were considered. The CCPI of 1952 base year was converted into 2006/07 base year using a conversion factor (γ) calculated using a set of CCPIs computed using both base years. It can be shown as depicted in equation (1) below.

$$\gamma = \frac{1}{n}\sum_{j=1}^{n}\frac{CCPI_{j,1952=100}}{CCPI_{j,2006/7=100}} \qquad (1)$$

CCPI (1952 = 100) values were divided by the conversion factor to get the CCPI values into 2006/07 base year. Suppose nominal price at time t is pn_t and real price at time t is prt, where t = 1, 2….T. Then prt can be defined as depicted in equation 1.2.

$$Pr_t = \frac{Pn_t}{ICCPI_t} \qquad (2)$$

where $ICCPI_t = \frac{CCPI_t}{CCPI_T}$.

$ICCPI_t$ can be interpreted as the ratio between CCPI at time t and CCPI at time T, which is the most recent value of CCPI in series. If this procedure is implemented, it can be noticed that units of real prices remain unchanged from the units of nominal prices (LKR): this is an advantage of this procedure.

Model Identification, Estimation and Diagnostic Checking

Preliminary investigation of the time series data was carried out using the summary statistics, Time Series Plots, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). Stationarity of respective time series were checked using Augmented Dickey Fuller (ADF) test, Kwiatkowski Phillips Schmidt Shin (KPSS) test, AFCs and PACFs. Seasonality and stationarity with respect to seasonality were identified using respective ACFs and PACFs. Seasonal indices were calculated employing decomposition techniques.

In time series forecasting, SARIMA model has become more popular and is widely used due to its statistical properties alongside the Box–Jenkins methodology used in the model structure (Zhang, 2003; Chen and Wang, 2007). SARIMA model is an extension of Auto-Regressive Moving Average (ARMA) class, and they facilitate more realistic dynamics. On this justification, SARIMA models were used to study the dynamic behavior of prices and obtain the forecasts.

Suppose $\{Y_t : t \in T\}$ is a time series random variable then a SARIMA process can be can be given as depicted in equation (3) (Shumway and Stoffer, 2006):

$$\Phi_P(B^s)\phi(B)\nabla_s^D\nabla^d y_t = \alpha + \Theta_Q(B^s)\theta(B)\varepsilon_t \qquad (3)$$

where ε_t is a Gaussian white noise process. $\phi(B)$ and $\theta(B)$ are the ordinary autoregressive and moving average operators of orders p and q. $\Phi_P(B^s)$ and $\Theta_Q(B^s)$ are respectively seasonal autoregressive and moving average operators of order P and Q. Ordinary differencing component is defined as $\nabla^d = (1-B)^d$ while seasonal differencing component is defined such that $\nabla_s^D = (1-B^s)^D$.

A time series is a stochastic procedure that describes the evolution of the random variable. It consists of four different components. 'Trend' (T) is a long-term component that represents a growth or a decline of a time series over an extended period of time. 'Seasonality' (S) is used for time series defined at time intervals which are fractions of a year. It is a pattern of change that repeats itself from year to year. 'Cyclical' component (C) is the changes in time series sometimes show a wave - like fluctuation around a trend, which shows the possible existence of periodicity with longer intervals. 'Irregular' component (ε) is the part of the time series represented by residuals, after the above mentioned components have been removed.

Identification of the preliminary models were completed using the respective ACFs and PACFs, while appropriate order of differencing was identified based on the results of the tests for stationary. Model fitting was carried out using the R package 'tseries' by which Maximum Likelihood Estimates of the model parameters can be obtained. Model selection was carried out based on Corrected Akaike Information Criterion (AICc) which avoids the deficiencies associated with AIC.

Diagnostic checking of the selected model was completed through a residual analysis based on Residual plots, Normal probability plots of residuals, ACFs and PACFs of Residuals and Squared residuals and Ljung-Box test on serial dependencies. Ljung - Box test is applied to the residuals of a fitted model, not the original series, and in such applications the hypothesis to be tested is that 'residuals from the model have no autocorrelation'.

Based on the results of diagnostic checking the final modes were selected. If the selected model was not sound adequate with respect to Residual analysis, then the next model choice was subjected to diagnostic checking. This procedure was continued until a parsimonious model was found. Forecasting and forecasting efficiency based on the least Mean Absolute Percentage Error (MAPE) was obtained by using R package forecasts. For computing MAPE data for the period from year 2000 to year 2012 was regarded as the training data set while data from 2012 to 2013 were used as the validation data set. If the forecasting efficiency was recognized as inadequate then diagnostic checking was repeated until a correctly specified model was found.

RESULTS AND DISCUSSION

Descriptive Statistics and Time Series Plots of Prices

Descriptive statistics of the Colombo average real fish prices were depicted in Table 1. Average real prices of 'Thalapath', 'Hurulla', 'Thora', 'Salaya' and 'Balaya' were Rs. 820.09, 334.45, 1160.00, 203.81 and 485.61, respectively. 'Thora' showed the highest average prices with a high Standard Deviation and 'Salaya' reported the lowest average price among the five fish types under the investigation.

According to the Table 1, most of the minimum fish prices were seen in the first few weeks of 2005. It might be due to a 'negative consumer reaction' on the domestic consumer demand for fresh fish during the post tsunami days (Subasinghe, 2005). 'Kurtosis', which denotes the degree of peak in a distribution, was less than 3 for all types of fish types under investigation. It can be interpreted as distributions of different fish prices were flatter than the Standard Normal Distribution which indicated wider spread of real prices around its average price. Skewness – a measure of symmetry - was also taken into account. 'Thalapath' showed a negative value for skewness while other types have showed a positive value. A negative value for the skewness indicates the fact that data are skewed left and vice versa.

Table 1: Descriptive Statistics of the Real Prices of Fish

Fish Type	Mean	Minimum	Maximum	Standard Deviation	Skew	Kurtosis
Thalapath	820.09	587.18 (2005,2)	1024.30 (2001,3)	61.36	-0.32	0.49
Hurulla	334.45	191.27 (2001,45)	502.41 (2003,20)	57	0.11	-0.33
Thora	1160	823.45 (2005,2)	1724.45 (2011,33)	150.65	0.73	0.82
Salaya	203.81	116.73 (2005,1)	418.51 (2001,28)	41.22	0.86	1.95
Balaya	485.61	315.41 (2005,6)	806.34 (2013,22)	69.21	0.86	1.53

Note: Values within parenthesis are year and week of the minimum and maximum prices were seen.

Time series plots of real and nominal prices of ‘Thalapath’, ‘Hurulla’, ‘Thora’, ‘Salaya’ and ‘Balaya’ under the investigation are depicted in Figures 1 to 5, respectively.

Figure 1: Time Series Plot of Nominal and Real Prices of Thalapath

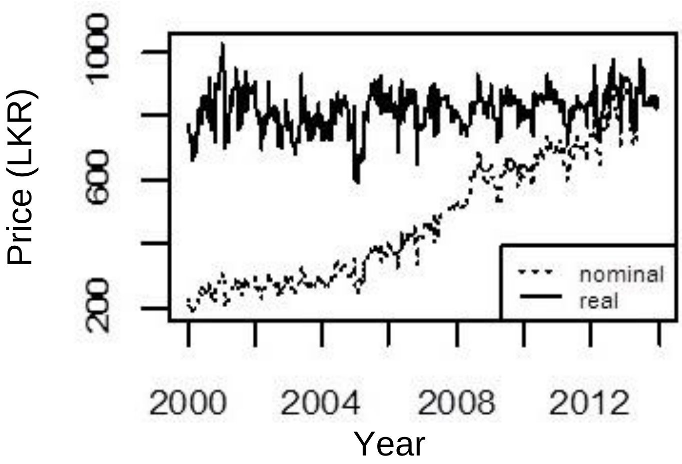


Figure 2: Time Series Plot of Nominal and Real Prices of Hurulla

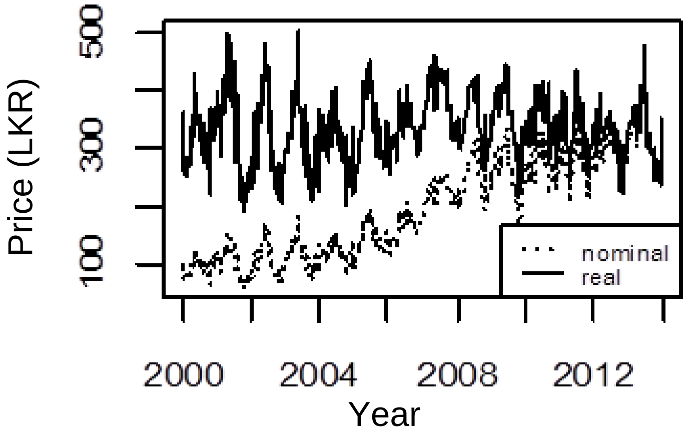


Figure 3: Time Series Plot of Nominal and Real Prices of Thora

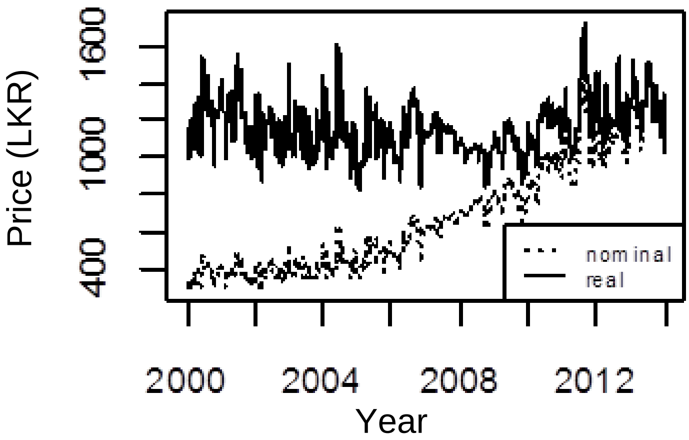


Figure 4: Time Series Plot of Nominal and Real Prices of Salaya

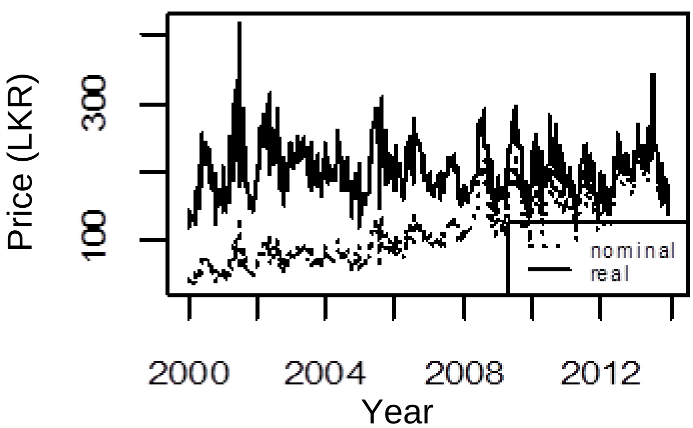
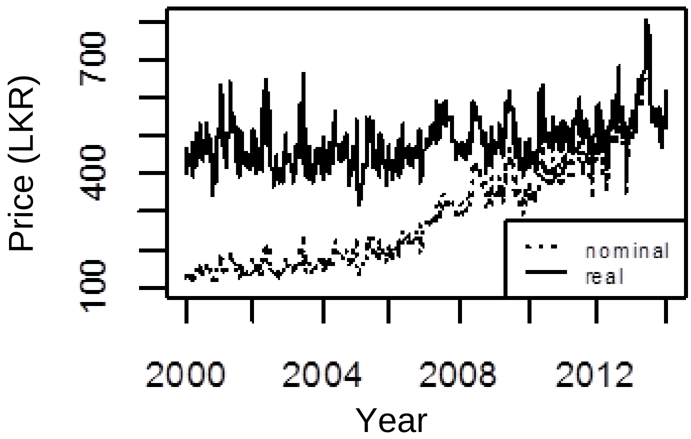


Figure 5: Time Series Plot of Nominal and Real Prices of Balaya



Although the nominal prices showed a clear increasing trend, there is no such increasing trend in the context of real prices. This signifies the fact that real fish prices have been fairly steady over time. Consequently, the trend perceived in nominal fish prices can be recognized as a consequence of rising inflation, for example the average annual rate of inflation in Sri Lanka was reported as 21.5% in 1990; 15.9 in 1996; 14.1% in 2001; 9.9% in 2006, and 7.5% in 2012. This matter should be considered by the policymakers when sectoral policies are made; especially regarding pricing and regulation.

Estimates from Price Analysis

Table 2 depicts the results of ADF and KPSS tests for the stationarity of real price series of different fish types. According to the results of ADF test, all original real price time series were ‘stationary’. The outcome of KPSS test, however, indicated that they were ‘non-stationary’, except for the ‘Hurulla’ and ‘Salaya’ series. By matching these results with respect to ACFs and PACFs, it was found that, except the ‘Salaya’ series, all other real price series were ‘non-stationary’. Further, the ADF and KPSS tests as well as the ACFs and PACFs applied on respective first-order-differenced series, except ‘Salaya’ revealed that it is sufficient to imply to make the respective series ‘stationary’.

Table 3 depicts the results of ADF and KPSS tests for Stationarity of “first-order-differenced series”. Moreover, the ACFs and PACFs of “first order differenced series” indicated that “seasonal differencing” is required for the real price series of all the fish types in concern. Consequently, it was found that a SARIMA model with d=1 and D=1 would be more appropriate for modeling real fish prices which was later confirmed during the model fitting and selection.

Table 2: Estimates of ADF and KPSS Tests to Evaluate Stationarity of Real Price Series

Fish type	For Original Real Prices		
	ADF	KPSS	
		Trend	Level
Hurulla	-6.5817**	0.2222**	0.2982
Thora	-6.0195**	0.7287**	0.987**
Salaya	-6.8014**	0.0793	0.1545
Balaya	-6.3423**	0.2724**	2.8405**
Thalapath	-7.2232**	0.1501*	1.1813**

Note: * p-value ≤0.05, ** p-value ≤0.01, *** p-value ≤0.001, For ADF test; H_0: The data is non-stationary and for KPSS test; H_0: Trend/Level is stationary.

Table 3: Estimates of ADF and KPSS Tests for 1st Order Differenced Data

Fish type	For 1st Differenced Prices		
	ADF	KPSS	
		Trend	Level
Hurulla	-7.8644**	0.0091	0.0095
Thora	-10.914**	0.0073	0.007
Balaya	-11.7414**	0.0062	0.0067
Thalapath	-10.6802**	0.0069	0.0074

Note: * p-value ≤0.05, ** p-value ≤0.01, *** p-value ≤0.001, For ADF test; H_0: The data is non-stationary and for KPSS test; H_0: Trend/Level is stationary.

Table 4: Estimates of the AICc and MAPE of the Best Fitted Models

Fish Type	SARIMA Model	AICc	MAPE
Thalapath	$(4,1,3)(0,1,1)^{52}$	6848.18	8.53
Hurulla	$(3,1,3)(1,1,1)^{52}$	6681.10	13.83
Thora	$(4,1,3)(0,1,1)^{52}$	8192.89	8.26
Salaya	$(3,0,4)(0,1,1)^{52}$	6388.77	20.11
Balaya	$(4,1,3)(0,1,1)^{52}$	6953.99	11.07

At the time of model fitting and selection, based on the least AICc, the SARIMA $(4,1,3)(0,1,1)^{52}$, SARIMA $(3,1,3)(1,1,1)^{52}$, SARIMA $(4,1,3)(0,1,1)^{52}$, SARIMA $(3,0,4)(0,1,1)^{52}$ and SARIMA $(4,1,3)(0,1,1)^{52}$ models, respectively, were identified as the 'best-fitted models' for real price of 'Thalapath', 'Hurulla', 'Thora', 'Salaya' and 'Balaya'. Estimates of the 'best fitted models' selected based on least AICc for real prices of five different fish types are given in Table 4. Fairly high orders are apparent for ordinary AR and MA components of the models given in Table 4, suggesting that the current week's real prices are significantly serially dependent on the real prices which prevailed during past few weeks. This evidence that the variability of real fish prices observed in several weeks at present would diffuse into the next week's fish prices. This is very important information for the stakeholder engaged in the sector for planning and making decisions better. As depicted in the seasonal component of the models, it can be concluded that present seasonal variability in real fish prices is dependent on the variability observed in the fish price in the previous season where the seasonal length is 52 weeks - which means that each year the same general pattern of price fluctuations are seen.

Forecasting errors of the SARIMA model for 'Thalapath' and 'Thora' reported around 8%, which is a good indicator that these models would produce more accurate forecasts. Models developed for 'Hurulla' and 'Salaya' real prices have comparatively high forecasting accuracy compared to that of the model choice for 'Salaya' real prices. Price forecasts completed for the respective models for first five week in year 2014 for selected fish types are given in Table 5.

It can be noticed that the forecasts are acceptably close to actual figures. All the actual prices were included in the 95% Coincidence Limits of the price forecasts, which provides further evidence to prove that the selected models would produce accurate real price forecasts.

Seasonal indices of real prices of 'Balaya' and 'Thalapath' are given in Figures 6 and 7, respectively, which indicates the seasonal behavior of respective fish prices. The seasonal behavior of real prices of 'Hurulla', 'Thora' and 'Salaya' resembled the seasonal behavior of 'Balaya' real prices depicted in Figure 6. However, the 'Thalapath' real prices showed some departure from the seasonal behavior shown by real prices of the other four fish types. Based on Figure 6, it can be inferred that all fish prices tends to be high during the middle few months of the year.

Table 5: Forecast Values of Prices with comparing Actual Prices

Fish Type	Point Forecast	Confidence Interval (95%)		Actual Price
		Low	High	
Thalapath	859.06	790.91	927.20	869.39
	862.20	779.99	944.41	861.85
	849.90	760.81	938.98	864.59
	837.71	745.35	930.06	814.11
	828.31	731.29	925.32	814.45
Hurulla	316.05	254.70	377.39	306.38
	335.33	266.64	404.02	302.02
	331.07	258.55	403.58	315.09
	328.61	253.12	404.09	297.17
	340.88	262.32	419.44	313.19
Thora	1408	1222	1594	1457
	1391	1172	1611	1437
	1399	1165	1633	1278
	1303	1061	1544	1197
	1326	1074	1578	1149
Salaya	183.97	134.68	233.26	194.31
	189.53	132.73	246.32	190.96
	176.29	117.58	235.00	195.66
	180.68	119.26	242.09	168.44
	182.16	117.95	246.37	155.42
Balaya	579.60	504.70	654.49	553.79
	580.03	492.79	667.27	531.48
	587.01	494.53	679.49	503.79
	550.96	455.26	646.66	422.51
	567.37	467.65	667.08	433.69

Figure 6: Seasonal Indices of Balaya Real Prices

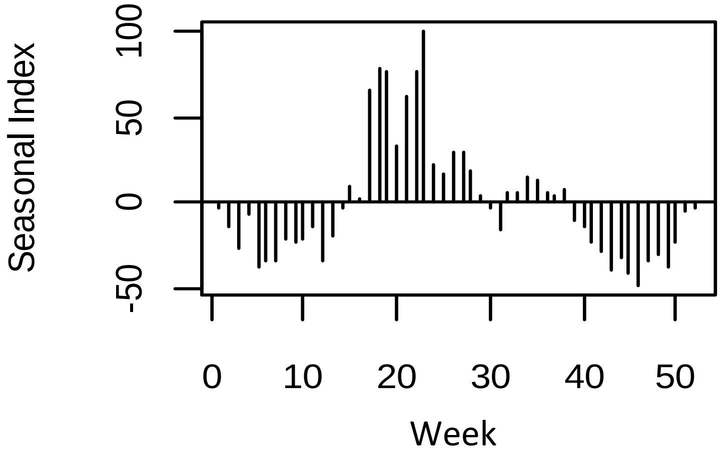
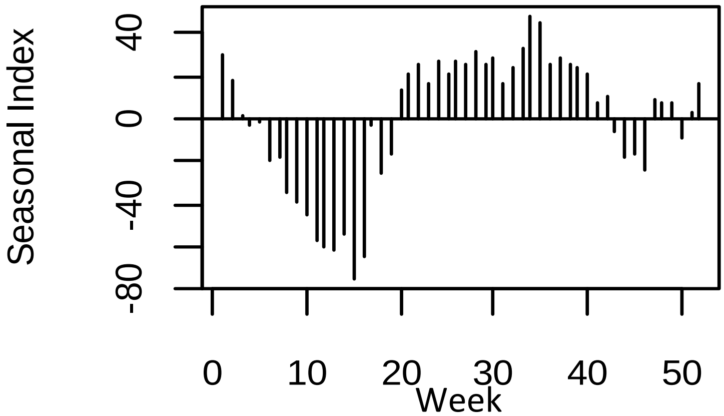


Figure 7: Seasonal Indices of Thalapath Real Prices



CONCLUSIONS

The real as well as the nominal prices of fish were studied. Results show that there is an increasing trend in nominal prices but not in real prices. Therefore, the apparent increasing trend in nominal fish prices may be governed largely by the rising inflation of the country rather than the issues inherent to the fish industry. We may consider this to be a key finding of the analysis which has not been considered in depth by policymakers. Fish prices show a seasonal behavior where prices tend to be high mid-year. The findings suggest that Box and Jenkins' Seasonal Autoregressive Integrated Moving Average (SARIMA) models can be used for forecasting fish prices reliably. Based on the models found in this study, it can be concluded that the price information available in recent weeks (3-4 weeks) would diffuse into the week ahead, thus determining the fish prices of the week. Although this information can be utilized by the relevant stakeholders for planning and to make efficient decisions, deeper analysis is warranted to determine the reasons for this seasonality and for the behavior of prices explained by the models and their consequences to the industry.

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