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| **Big Fish in a Small Market:** |
| **The impact of Export Price on Ex-vessel Price of Tuna in the Maldives** |

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**Abstract**

The paper assesses the relationship between export and ex-vessel prices for tuna fish in the Republic of Maldives. The economic welfare of fishermen depends to a great extent on the price received for fish. The price of fish is set by external factors exogenous to fishermen. It is important in understanding the welfare of fishermen to understand the price links in the fish supply chain and the factors that impact the ex-vessel price of fish. This paper uses three models to investigate price determination in the ex-vessel market; ARMAX, inverse demand and margin equation. The results provide statistically important price relationships and price flexibilities on asymmetric export price effects.

**Short Title:**  Ex-vessel Price Determination in the Maldives

**Keywords** Tuna, Price Flexibilities, Asymmetric Export Price Effects

**JEL Classification** Q22 **·** Q28

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# Introduction

The fish-harvesting sector in the Republic of Maldives represents about 5-6% of GDP.[[1]](#footnote-1) This sector accounts for about 7.6% of total employment or about 8,233 individuals. Although these numbers are not large, given that the Republic of Maldives is an archipelago of 26 natural atolls, fishing is an important industry away from the main business centre of Male (DPND, 2009). What is more, the overall importance of the fishing sector to the country is seen in that 98% of exports by value are derived from the fishing sector. The fishing sector is the important sector for earned foreign currency (DPND, 2009).[[2]](#footnote-2)

In recent time the Republic of Maldives is set on pursuing growth, development and economic wellbeing within a democratic framework. The economic welfare of fishermen depends to a great extent on the price received for fish. Of course, the level of harvest and cost of harvesting are other important variables and all in combination determine the income levels of fishermen. But in many ways fishermen have control at least to some extent over harvest and cost of harvesting. On the other hand, the price of fish is set by external factors exogenous to fishermen. These external factors are certainly dictated by world demand and supply forces but may also be influenced by monopoly and strategic pricing behaviour in downstream markets (Wohlgenant 1985). Strategic pricing can impact the magnitude of price pass through between the market segments, the length of time to adjust to price shocks and asymmetric price response to positive or negative shocks. It is important then in understanding the welfare of fishermen to understand the price links in the fish supply chain and the factors that impact the ex-vessel price of fish.

One way to approach this problem is to model and measure price effects in the fish supply chain (Asche *et al.* 2007). For the Republic of Maldives two market segments define the supply chain that link the first-hand market/ex-vessel price and the final market/export price. The vast majority of tuna harvested in the Republic of Maldives is exported as fresh, frozen, salted or canned. The focus here is the derived demand for product from export to the first-hand market. This price approach is based on the theory of derived demand where the export price of fish is exogenous in setting the ex-vessel price (Azzam 1999). We are also interested in explaining the margin between export and ex-vessel price. For this equation we want to investigate the drivers that dictate the extent and changes in the margin.

The purpose of this research is to carry out a statistical investigation of market prices in the fish supply chain for the Republic of Maldives with particular attention to price setting in the first-hand market for fish. Monthly ex-vessel price and export price data for two canneries are available for the period January 2005 to December 2010. The data represents a two sector balanced panel data over the period defined. The two canneries process almost all of the tuna fish harvest in the Republic of Maldives. For each cannery we know export value and quantity and value and quantity of fish collected. The data allows us to recover individual cannery export and ex-vessel price.

Our empirical strategy is to first, build a univariate time series model (ARMAX) for the ex-vessel price of fish. This simple but often powerful short-run forecasting technique relates current ex-vessel price to the history of ex-vessel prices in the market and current and historical stochastic shocks (Enders 2010). We include the export price of fish as an exogenous variable in the model and control for seasonality and trend to improve forecasting and to reduce forecast error. The ARMAX model is well identified with only lagged endogenous variables, exogenous variables and past stochastic shocks as defined repressors’ and will allow for dynamic forecasts of ex-vessel prices. Second, recognizing the structural links between the first-hand and export market we set up and specify a full demand and supply model and then attempt to identify the inverse demand curve based on variables available for empirical work. Finally, we ask the empirical question how has the margin between export and ex-vessel prices varied over time.

The paper proceeds in the following way: Section 2 will characterize the Maldives’ tuna fishery describing a brief history of the fishery, harvesting techniques and recent developments. Section 3 will present and describe the data available for analysis. Section 4 will describe the econometric models used in empirical work and present results. Section 5 will offer final comments.

# The Maldives Tuna Fishery[[3]](#footnote-3)

The tuna fishery in the Maldives is an export industry with approximately 70-90% of total harvest exported. There are two major companies, state owned MIFCO and a private firm Horizon Fisheries Ltd. that specialize in exporting tuna. Processed tuna for export takes a variety of forms. Figure 1 reports revenue earned for export sales of fresh or chilled tuna, frozen tuna and others. The total value of exports reached $74 million US in 2010.

Figure 1: Exports by Fish Commodity, 2007-2008

Source: Statistical Yearbook Maldives, 2009

The tuna fishery is seasonal with catches peaking around April and November at the onset and offset of Northwest monsoon. The annual fish harvest increased from 118,115 tonnes in 1998 to peak at 185,980 tonnes in 2005. However, annual fish catch has declined in recent years. In 2008, the fish catch declined by about 30% to 133,076 tonnes of which, 66% was skipjack tuna, 17% was yellowfin tuna, 5% was other tuna species and 12% was other marine fish (MOFA, 2009).

In Maldives, fish is landed on almost all the inhabited islands. Most of the skipjack tuna caught are landed to collector vessels. These collector vessels belong to the four skipjack tuna collection permit holders who have exclusive contracts with the government to purchase, process and export skipjack fish from designated fishery zones. The collector vessels brine freeze the fish and transport to centres for storage.[[4]](#footnote-4) Yellowfin tuna are landed to one of the twelve EU certified processing facilities.

Skipjack (*Kalhubilamas)* tuna is the most important species and contributes 60-70% of the total fish catch in the Maldives. Skipjack is caught predominantly by live-bait pole and line. This harvesting procedure requires vast amounts of live bait, which are caught from lagoons and reefs on many islands. Industrial licensed longliners also catch skipjack tuna as a by-catch.

The main export market of skipjack tuna are Thailand (frozen), Germany (canned) and UK (canned). There is also a significant portion of dried or smoked fish exported to Sri Lanka.

Yellowfin (*Reedhoo Uraha Kanneli)* tuna constitutes around 17% of the total fish harvested. Yellowfin tuna[[5]](#footnote-5) catches have increased substantially in recent years. The yellowfin fishery is a live-bait handline and accounts for over 95% of the total yellowfin tuna catch with troll vessels and longliners taking the remainder of the harvest (MOFA, 2009).

With the increase in price and demand for yellowfin tuna in the fresh fish markets in Japan, Europe and America, there has been a shift in effort from the skipjack tuna industry to the yellowfin tuna industry. Fishermen also tend to change between pole and line fishery for skipjack and handline fishery for yellowfin depending on the fishing season.

The major portion of the yellowfin tuna caught in the Maldives is exported, with the remainder going to the local hotels and restaurants trade. The yellowfin tuna industry is a competitive market with no restriction on new fish processors entering the market. There are 11 European Union certified yellowfin-processing factories in Maldives. Yellowfin tuna is exported mainly as frozen loins and steak and fresh to Japan, Europe, United States, United Kingdom, France and Germany, and canned to United Kingdom and Germany.

In recent years, the fisheries sector has modernized and expanded, with larger vessels with greater engine horsepower. However, the number of vessels engaged in fishing has declined gradually over the years. Modern vessels (mechanized *Masdhoni*) are equipped with satellite navigation systems, hydraulic line haulers, fish finders, sonars and other technological equipment. These vessels also include crew accommodation and are used mainly for long trips (2-3 days) as opposed to the single day trips that were more common in the past.

Table 1 reports the number of vessels for the period 2000-2008 for different types of vessels in the fishery. The total number of vessels declined from 1,376 in 2000 to 979 in 2008, of which 867 were mechanized pole and line vessels (Masdhoni), 40 mechanised trolling vessels (Vadhu Dhoni), 17 sailing trolling vessels and 7 row boats (Bokkura). Mechanised Masdhonis are responsible for the largest share (more than 95%) of the annual catch followed by trolling vessels (Vadhudhonis) (MOFA, 2009).

Table 1. Number of Fishing Vessels by Type from Year 2000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Masdhonia) | 1137 | 1128 | 1102 | 1104 | 1092 | 1002 | 923 | 894 | 867 |
| Vadhudhonia) | 58 | 49 | 59 | 46 | 67 | 56 | 44 | 42 | 40 |
| Vadhudhonib) | 72 | 40 | 9 | 4 | 17 | 22 | 17 | 16 | 17 |
| Masdhonib) | 41 | 66 | 90 | 115 | 8 | 5 | 3 | 10 | 34 |
| Bokkurac) | 19 | 13 | 16 | 18 | 26 | 18 | 14 | 16 | 7 |
| EEZ | 49 | 20 | 43 | 31 | 36 | 37 | 24 | 25 | 13 |
| Micellaneous |  |  |  |  |  | 2 | 1 | 2 | 1 |
| Total | 1376 | 1316 | 1319 | 1318 | 1246 | 1142 | 1026 | 1005 | 979 |
| a) Mechanised  b) Sailing  c) Row boats | | | | | | | | | |

*Source: Statistics Unit, Ministry of Fisheries and Agriculture*

Currently, the tuna fishery is open access with some regulations imposed to control harvest. Regulations, what there are, are indirect with restrictions limiting the number of agents in the processing sector. In 2010, a programme was introduced to encourage and enhance competition in the post-harvesting sector by allowing for Small and Medium Enterprises (SME’s) to purchase skipjack tuna for processing. A total of 35 such enterprises are now registered with the Ministry of Fisheries and Agriculture. Yellowfin processors pay a royalty charge on harvest tonnage, which, of course, increases the cost of processing.

A licensing scheme was introduced from November 2010 for vessels intending to catch fish for the export market. This scheme could provide the basis for a future management regime in the Maldives.

There are some concerns that the stocks of tuna may be declining with the consequence of lower tuna harvest in the future. However, the Scientific Committee of the Indian Ocean Tuna Commission suggests that stocks of skipjack do not appear threatened, whereas stocks of yellowfin and bigeye are a concern.

# Harvest and Process Data

The main data set represents the monthly value and quantity of tuna collected from fishermen and the monthly value and quantity of exports of processed tuna for two canneries over the period 2005 to 2010. As such the data will not only show historical trends but also a comparative analysis across canneries. The data are used to calculate the ex-vessel and export price by cannery and transformed to real values using the CPI.

Figure 2 shows both historical trends and comparative effects for ex-vessel prices received by fishermen for two canneries (1, 2) for the period January 2005 to December 2010. The graph shows that the trends in ex-vessel prices for each cannery are similar and relatively flat over the period with some increase in real ex-vessel price near the end of the series. Comparatively, ex-vessel prices received from cannery 2 appear generally higher over the period and less variable.

It is surprising that we observe such sustained differences in ex-vessel prices across canneries.[[6]](#footnote-6) One would suppose that fishermen would sell to the highest bidder. The fact that prices consistently deviate suggests that there exist constraints in the market restricting the first-hand sale of fish. Perhaps the answer is that cannery 2 is small relative to cannery 1. We observe this effect in Figure 3, which reports quantity of fish purchases by cannery.

Figure 2: Real Ex-vessel Prices received from Canneries 1 and 2

Figure 3: Harvest Collected by Processor 1 and 2

Figure 3 shows that cannery 1 is large relative to its rival. Cannery 2 seldom purchases more than 2,000 tonnes of fish monthly compared to cannery 1 with purchases as high as 12,000 tonnes of fish a month. What is interesting about the figure and speaks directly to the income level of fishermen is that harvest has declined over the six-year period. Real income to fishermen will decline unless the rise in the real price offsets the fall in harvest.

We show real revenue to fishermen for each company over the six-year period in Figure 4. Revenue shows seasonal variation but both curves show a drastic fall in revenue the first month of 2009. Revenue earned from cannery 2 shows little recovery from this decline but for cannery 1, revenue earned does rebound to earlier levels late in the data period.

Figure 4: Real Revenue Fishermen from Cannery 1 and 2

Export prices received by the two canneries are similar as can be seen in Figure 5, which graphs out both the historical and comparative trends in the export price series. Notice that over the first few years’ the prices received by the canneries are similar with perhaps cannery 1 receiving slightly higher prices. In the latter months of the data we observe substantially more variation in prices in both series, however the price variation appears to be on the up-side indicating good returns to the canneries.

Figure 5: Real Export Prices, Cannery 1 and 2

For completeness we graph out quantity exported by the two canneries over the period January 2005 to December 2010 and see the results in Figure 6. The quantity data is consistent with harvest data reported in Figure 3 with cannery 1 exporting the largest share and a declining trend in exports sales for both firms. The fact that exports are declining does not bode well for fishermen because it is a general indication that revenue in the fishery is declining.

Figure 6: Quantity Exported, Processor 1 and 2

Figure 7 reports real fuel price over the six-year period of study. The trend in fuel prices is surprisingly flat over much of the period with a large spike in prices during 2008. The Government controls most of the fuel supply in the Maldives through the State Trading and Organization agency. The graph certainly represents a regulated policy on fuel prices for the Maldives. It is worth noting that such a policy will distort incentives in the market place. In this case, with fuel prices less than market value the subsidy will encourage fishermen to exert more fishing effort than optimal. On efficiency grounds lump sum income transfers are to be preferred to subsidies.

Figure 7: Real Fuel Price

# The Econometric Model

In this section we are concerned with combining the variables at hand within time series and economic models that provide useful information on the price relationship between the export and ex-vessel sectors in the tuna market. The initial modelling will be to fit an ARIMA[[7]](#footnote-7) model to the real ex-vessel price data. This is a univariate modelling technique based on the maintained assumption that current realizations of price can be explained by lagged values of the price (dynamic shocks) and current and lagged values of the stochastic error term (stochastic shocks). ARIMA modelling is particularly useful if the process can be characterized as an autocorrelated series of unobserved shocks.[[8]](#footnote-8) The ARIMA can be considered a reduced form price model for the purpose of short-run forecasting and most importantly identification is maintained by only lagged dependent and stochastic values appearing on the right-hand-side.[[9]](#footnote-9) Because the ARIMA model is well identified a maximum likelihood estimator will generate consistent parameter estimates. It is possible to augment the ARIMA price model by including exogenous variables in specification for the purpose of improving forecasting possibilities and to reduce forecast error.[[10]](#footnote-10) These extensions are defined as ARMAX or transfer function models and for the case at hand we include the export price as a predetermined variable that may impact the behaviour of ex-vessel price.[[11]](#footnote-11)

The specification of the univariate price model is defined as:

(1)

where is the ex-vessel price of fish in period *t*, is export price in period *t*, represents the autoregressive (AR) component (dynamic shocks),  represents the moving average (MA) component (stochastic shocks) and  is an *iid* random error term. Estimation of equation (1) is based on maximum likelihood procedures.[[12]](#footnote-12)

Selecting the correct lag specification for equation (1) is critical for generating an estimated equation with good forecasting potential. Our research strategy is to evaluate alternative AR and MA lag structures based on review of the autocorrelation and partial autocorrelation functions with possible candidate specifications defined on testing *iid* conditions in the stochastic error term using a Box-Lung Q-statistic. Among those candidate specifications the preferred model is identified by measured BIC statistics.[[13]](#footnote-13)

Prior to estimation we test for stationarity in prices. Stationarity refers to the condition where the probability structure for the variables does not change over time. We use a Dickey-Fuller statistic and find that both ex-vessel and export prices are non-stationary in level form but gain the condition at less than the 5% level in first-differences.[[14]](#footnote-14) As such ARIMA estimation will be carried out in first-differences.

Our strategy is to fit an ARMAX model to the data for each company separately and then combine the data in a final regression. Table 2 reports the final results for each estimation process. The results are somewhat odd yet interesting. For each of the equations no lagged stochastic term is measured to impact the ex-vessel price. This is odd in that a market-generated price should show signs of autocorrelated stochastic behaviour. On the other hand, we do observe a statistically important one period dynamic shock for each equation implying a one period lagged ex-vessel price is important in setting current ex-vessel price. Finally, for company 1 and the combined equation the current valued export price is an important determinant of the ex-vessel price.

What do we make of such an equation? From our experience it is likely that the ex-vessel price for tuna in the Maldives is a regulated price and not determined by purely market forces. The ex-vessel price is set based on past behaviour implying that the regulator is looking for stability in price trend but at the same time the price must respond to real shocks in the export market. The problem is that because the ARMAX does not capture the behaviour of the regulator, dynamic forecasts from such an equation are likely to be biased.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 2: ARMAX of Ex-Vessel Price | | | |
|  | Company 1 | Company 2 | Total |
| Export Pricea) | 0.1314  (0.019)b) | 0.0175  (0.070) | 0.0838  (0.007) |
|  | -0.2697  (0.042) | -0.2529  (0.036) | -0.2217  (0.006) |
| Cons. | 0.0137  (0.530) | 0.004  (0.818) | 0.007  (0.560) |
| Obs. | 59 | 66 | 125 |
| BICb) | -9.839 | -47.720 | -63.153 |
| a) First difference lagged twice export price  b) p-value in parentheses  c) Bayesian Information Criteria  We carry out a dynamic forecast using the estimated combined ARMAX equation. The dynamic forecast uses the actual values of the export price combined with the predicted value of the AR component for forecasting. For purposes of presentation in-sample forecasting (using only actual values of all variables) is carried out for the period January 2005 to April 2010 with dynamic forecasts over the period May 2010 to the end of the period. Figure 8 graphs out the forecast over the defined period. The graph shows that the in-sample forecasts are very good but this is to be expected as we are merely following the series. The important validation of the model is the dynamic forecast and here we see that the model fails badly and is not able to follow the trend or pick up major turning points in the series. Consequently, we must conclude that because the estimated ARMAX does not model the behaviour of the regulator it fails as a useful short-run forecast of ex-vessel price determination. | | | |
|  | | | |

Figure 8: Predicted Ex-vessel Price, dynamic after May 2010

We turn next to a structural approach to modelling ex-vessel price determination. We follow Gordon (2011) in setting up the population regression model. Gordon argues that econometric research should proceed by first setting out the full population regression model. In this case, the full population regression model is the harvest-supply equation and the demand equation for tuna. Then take this model to the data to write down the final specification of the sample regression equation. Gordon argues that writing down the population model allows the researcher to clearly define what variables end up in the model and those variables that find their way to the error term. This may not mitigate econometric problems but it does clearly define the problems that must be addressed.

On the harvest side we can define the harvest function where harvest in period *t,* is determined by fishing effort , biomass of the fish stock and a stochastic error component Write this expression as:

(2)

the stochastic term will pick up all factors influencing harvest not accounted for by effort and biomass.

The tuna fishery in the Maldives is managed as regulated open access, so the fishing vessel will set fishing effort (i.e. endogenous) and we model fishing effort as a function of current inputs used in harvesting (represented by the vector *Z*), ex-vessel price of fish and a stochastic error term that accounts for all other factors impact fishing effort, or:

(3)

Combining equations (2) and (3) we define the population harvest equation as:

(4)

Now we see that harvest is a function of the ex-vessel price of fish, a vector of harvest input costs, the state of the biomass and stochastic error terms impacting harvest and effort.

On the demand side the ex-vessel price of fish depends on harvest level, the export price of fish , the cost of processing, transportation, etc. (represented by the vector *X*) and other stochastic error factors impacting ex-vessel price . We write the population ex-vessel price equation as:

(5)

Equations (4) and (5) represent the population structural model for the fishery. The second stage is to make assumptions on the functional forms used in estimation (linear), clearly define the endogenous variables (harvest and ex-vessel price) and exogenous variables (input costs, current biomass, export price, and costs of processing), and most importantly what empirical variables are available to write-up the sample regression equation. We do have information on harvest, ex-vessel and export price, but the data available to proxy *Z* and *X* are sparse. We do have the real price of fuel that we will use to proxy the harvest input costs (*Z*) but we have no information on the vector *X.* In addition, we do not have stock estimates and will proxy the stock using a trend and trend squared variables.With these assumptions and data restrictions we can write down the sample harvest function as:

(6)

where . The residual also represents sampling variation in the data.

The sample ex-vessel price regression is written as:

(7)

where . Again, the residual also represents sampling variation in the data.

Equations (6) and (7) represent the sample regression equation for the harvest and price function, respectively. The price function is the equation of interest for this study but because harvest is a right-hand-side endogenous variable a standard least squares estimator will produce inconsistent estimates for all coefficients. We can address this problem by using the exogenous variables in equation (5) to build an instrument to replace harvest. The instrumental variables (IV) equation is written as:

(8)

Our estimation strategy is first to estimate equation (8) and predict harvest level based on predetermined and exogenous variables. Predicted harvest satisfies the conditions necessary for an IV variable i.e., correlated with actual harvest but not correlated with the error term in equation (7). The IV is then used to replace actual harvest in equation (7) prior to estimation.

Now it is important to state the conditions under which such a procedure will in fact produce consistent estimates of the parameters in equation (7); for consistency what is required is that the residual term must not be correlated with any of the right-hand-side variables in equation (7). So to be clear this says that processing costs must not be correlated with harvest or export price, moreover the stochastic terms associated with harvest and effort must also not be correlated with harvest or export price, and finally the sample residual must also not be correlated with harvest or export price. In as much as these conditions are satisfied our two-stage approach to estimation of equation (7) will produce consistent estimates of the parameters of interest.[[15]](#footnote-15)

The data available for analysis are panel series and we will use an instrumental variable fixed effects estimator to recover the parameters of equation 7. The results of the estimation are reported in Table 3.

Results reported in column 2 under heading (1) assume symmetry in ex-vessel price response to increases and decreases in export price. The equation also includes the instrumental variable for harvest and we control for seasonal effects. The data represent log transforms and allows us to interpret the coefficients of interest as price flexibilities. The price flexibility with respect to harvest is statistically important and valued at -0.19, or in other words a 1% increase in harvest generates downward pressure on ex-vessel price by 0.19%. The implication of this result is that the demand curve facing tuna fishermen is downward sloping and indicates that increased fishing effort to harvest more will be rewarded with lower ex-vessel prices, all else equal. This implies that the Maldives’ tuna fishery is important in the world market for tuna and fishermen’s behaviour impacts price. This is in contrast to a small fishing nation selling into a big market and thus facing a horizontal demand curve for fish, or in this case fishermen’s behaviour will not impact price.

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| Table 3: Inverse Demand Curve: dependent variable ex-vessel price | | |
|  | (1) | (2) |
| Harvestiv | -0.1852  (0.0.00) | -0.1642  (0.001) |
| Export Price | 0.0867  (0.124) | - |
| Export Price\_pos | - | 0.1259  (0.034) |
| Export Price\_neg. | - | 0.1542  (0.028) |
| Q1 | -0.1407  (0.025) | -0.1179  (0.063) |
| Q2 | -0.0382  (0.54) | -0.0285  (0.643) |
| Q3 | 0.0115  (0.97) | 0.0115  (0.856) |
| Cons. | 3.981  (0.00) | 3.523  (0.00) |
| Obs. | 140 | 140 |

The export price flexibility assuming symmetry is small only 0.09% and statistically valid at a 13% p-value. On the one hand this result is consistent with our earlier comments on the ex-vessel price of fish being regulated and targeted with respect to the export price. But the fact that the coefficient is not statistically important leads us to an alternative strategy to categorized and separate export price shocks as either positive or negative and asks the question is there asymmetric response in ex-vessel price to export price shocks. The results for this extension are report in column three of Table 3 under the heading (2). The results for the harvest coefficient are robust to the changes in definition of export price but now we observe a substantial change in the impact of export price on ex-vessel price. Either the positive and negative price shocks are strongly statistically important but notice the positive shock is measured at 0.13% compared to the negative shock at 0.15%, or in other words the ex-vessel price of fish is more responsive to negative export price shocks than to positive export price shocks.

With only a very few downstream markets for tuna fish the firms are able to manipulate the price and pass on negative price shocks compared to positive price shocks. This does not seem all that surprising in a market where market power rests with the canneries. Perhaps what is surprising is that the effect is less strong than expected and in fact a simple test that the positive and negative coefficient are equal can only be rejected at a 0.13 p-value. Consequently, there does appear to be serious market rigidity in terms of export price shock pass through and the degree of monopsony pricing is limited.

Finally we turn to a slightly different question and ask what is happening to the margin overtime between export and ex-vessel price. The margin represents the difference between the export price and ex-vessel price and we are interested in the trend in the margin.[[16]](#footnote-16) If the margin is increasing over time this suggest that the players in the export market are able to withhold a greater share of the final price with less recovered at the vessel level. The margin model is a reduced form equation written as:

(9)

Where is margin in period *t,* is a stochastic error term picking up all other factors not defined explicitly in the equation and all other variables are as previously defined. The right hand side variables; harvest, export price and trend variables to proxy linear and nonlinear trends in the margin, are predetermined in respect to the margin and a fixed-effects panel data estimator will provide consistent estimates of the parameters. The results of the estimation are reported in Table 4.

The main regression results are reported in the column headed (1) and show that harvest has no important impact on the margin. The harvest variable is included in the equation to proxy the supply side of the market and clearly the insignificant result tells us that fishermen have little control over the margin. The export price variable assuming symmetry in the margin response to a price change is strongly statistically significant showing that size of the margin is positively related to export price. This suggests that the market power to set the margin rests with the canneries. The trend and trend-squared variables tell us that the margin has been falling over time but the rate of decline is slowing down. The column headed (2) repeats the regression but allows for asymmetry in export price shocks. This modification does not change the results for harvest or trend variables but now we measure very similar coefficients on both the positive and negative export price shocks. What this tells us is that the margin is maintained regardless of the direction of change in export price.

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| Table 4: Margin Equation | | |
|  | (1) | (2) |
| Harvest | 0.0873  (0.151) | 0.094  (0.126) |
| Export Price | 1.1369  (0.00) | - |
| Export Price\_pos | - | 1.343  (0.00) |
| Export Price\_neg. | - | 1.322  (0.00) |
| Trend | -0.0047  (0.021) | -0.0048  (0.018) |
| Trend2 | 0.00002  (0.057) | 0.00002  (0.025) |
| Cons. | -2.4634  (0.012) | -2.474  (0.011) |
| Obs. | 128 | 128 |

The margin results are interesting in that as we would expect the many players on the harvest supply side of the market have no impact on the margin. The market power to set the margin is held by the few players in the export market i.e. canneries. Moreover the canneries maintain the margin regardless of positive or negative price shocks at the export level. Finally and a positive note for fishermen is that the margin has been declining over time albeit the negative trend is decreasing.

# Summary and Discussion

*Purpose of research:* The focus of this research is the derived demand for product from export to first-hand market. This price approach is based on the theory of derived demand where the export price of fish is exogenous in setting the ex-vessel price. The empirical strategy was to first, build a univariate time series model (ARMAX) for the ex-vessel price of fish for the purpose of dynamic forecasting. We include the export price of fish as an exogenous variable in the model and control for seasonality and trend to improve forecasting and to reduce forecast error. Second, recognizing the structural links between the first-hand and export market we set up and specify a full demand and supply model and then attempt to identify the inverse demand curve based on variables available for empirical work. Finally, we ask the empirical question how has the margin between export and ex-vessel prices varied over time.

*Summary of results:* Summary statistics show both declining harvest and exports overtime. The consequence is that real income to fishermen will decline unless a rise in the real ex-vessel price offsets the fall in harvest. In fact total real income to fishermen has declined over the period of study except for the last few months of the period.

The ARMAX results show that no lagged stochastic term is measured to impact the ex-vessel price. We do observe a statistically important one period dynamic shock for each equation implying a one period lagged ex-vessel price is important in setting current ex-vessel price. Also the current valued export price is an important determinant of the ex-vessel price. These results indicate that the ex-vessel price for tuna in the Maldives is a regulated price and not determined by purely market forces. The ex-vessel price is set based on past behaviour implying that the regulator is looking for stability in price trend but at the same time the price must respond to real shocks in the export market.

For the structural model and assuming symmetry in ex-vessel price response to increases or decreases in export price we find negative price flexibility with respect to harvest. This parameter is statistically important and valued at -0.19, or in other words a 1% increase in harvest generates downward pressure on ex-vessel price by 0.19%. The implication of this result is that the demand curve facing tuna fishermen is downward sloping and indicates that increased fishing effort to harvest more will be rewarded with lower ex-vessel prices, all else equal. Cleary, the Maldives’ tuna fishery is important in the world market for tuna and fishermen’s collective behaviour impacts ex-vessel price. This is in contrast to a situation where a small fishing nation selling into a big market and thus facing a horizontal demand curve for fish then the collective behaviour of fishermen does not impact ex-vessel price.

We investigate asymmetry in the export price variable. We categorize and separate export price shocks as either positive or negative and ask the question is there asymmetric response in ex-vessel price to export price shocks. Both variables are important in ex-vessel price setting. The positive shock has a measured flexibility of 0.13% compared to the negative shock flexibility of 0.15%, or in other words the ex-vessel price of fish is more responsive to negative export price shocks than to positive export price shocks.

With only a very few downstream markets for tuna fish, pass path through is stronger for a negative price shock compared to a positive price shock. This does not seem all that surprising in a market where market power rests with the canneries. Perhaps what is surprising is that the effect is less strong than expected and in fact a simple test that the positive and negative coefficient are equal can only be rejected at the 0.13 p-value. Consequently, there does appear to be market rigidity in terms of export price shock pass through but the degree of monopsony pricing seems limited.

The margin is an interesting variable and tells a story as to how much of the rent is captured at the export level relative to the first-hand market. The margin results are what we would expect in that the many players on the harvest-supply side of the market have no impact on the margin. The market control to set the margin is held by the few players in the export market i.e. canneries. Moreover the canneries maintain the margin regardless of positive or negative price shocks at the export level. Finally, and a positive note for fishermen, is that the margin has been declining over time albeit at a decreasing rate.

*Policy Discussion:* On efficiency grounds policy regulators should avoid subsidies. In the Maldives, fuel prices are regulated to try and stabilize an important input price to the fishery. Regardless of the merits the consequence of subsidies is to distort the economic incentives facing fishermen. For the case at hand, a subsidy that lowers the price of fuel below market level results in increased fishing effort above the efficient level of harvesting. If we define fishing effort by the number of fishermen then the consequence of the subsidy is to encourage a greater number of fishermen than can be maintained efficiently in the fishery. It may well be that fishermen in the Maldives are deserving of increased income but on economic efficiency grounds this is best accomplished by direct income transfers.

There is concern with overfishing of tuna stocks. Certainly, the results reported in this study show a general decline in harvest levels and export quantities. Tuna are a migratory fish stock and efforts to sustain the stock near optimal levels will require international cooperation. Such cooperation will take time and success is uncertain. The consequence is that the Maldives may face declining tuna stocks for some time. With a measured price flexibility of -0.19% a fall in harvest will generate an ex-vessel price increase but the increase will not be sufficient to offset the harvest decline and revenue to fishermen will decline. This is a particularly serious problem for Maldives with a small economy, alternative employment from the fishery is limited and likely outcome is that existing fishermen will see their living standard decline.

The structure of the tuna market in Maldives is not unlike other small fishing nations with many small first-hand suppliers of fish selling to only a few processors. Such a structure sets the buying power to the processors and reduces the resource rent that could go to the fishermen. There are two ways to counter this buyer market power; first, would be to increase the number of processors, which will increase competition for raw fish and push the ex-vessel price of fish upwards. On the other hand, a fishermen’s cooperative could set up a single-desk seller operation where all fish harvested are marketed through the single desk. Single desk selling could oppose the buying power of the canneries and prices could be set in a cooperative manner to the benefit of both parties.

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1. Statistical Yearbook Maldives, 2009. Roughly 2% of fishermen are female. [↑](#footnote-ref-1)
2. See, Hussain (2011) for an overview of the fishing sector in Maldives. [↑](#footnote-ref-2)
3. The information in this section is taken from ‘Maldives Background Report’ by Hussain Sinan, FAO Rome. [↑](#footnote-ref-3)
4. The vessel crew take a portion of the catch for personal consumption. [↑](#footnote-ref-4)
5. Studies suggest that bigeye *(Thunnus obsesus)* tuna may account for up to 5% of the total yellowfin catch (Anderson and Hafiz, 1991). [↑](#footnote-ref-5)
6. We should keep in mind that the canneries do produce somewhat different products. They both produce frozen skipjack and yellowfin tuna and salted dried or canned skipjack, however, cannery 1 produces steamed skipjack loins. [↑](#footnote-ref-6)
7. Autoregressive Integrated Moving Average Model. [↑](#footnote-ref-7)
8. For an excellent review of applied time series econometrics see, Enders (2004). [↑](#footnote-ref-8)
9. For an interesting discussion of the first serious price forecasting model see, Gordon and Kerr (1997). [↑](#footnote-ref-9)
10. The restriction on the exogenous variables requires that there be no feedback effect to the dependent variable (Enders, 2010) [↑](#footnote-ref-10)
11. Seasonal and trend variables were also included in specification but did not statistically improve the forecast. [↑](#footnote-ref-11)
12. Estimation is carried out using STATA 11 software. [↑](#footnote-ref-12)
13. Bayesian Information Criteria. [↑](#footnote-ref-13)
14. Tests of stationarity are carried out in levels and first-differences for both ex-vessel and export prices for each cannery separately. Dickey-Fuller Statistics

    |  |  |  |  |  |
    | --- | --- | --- | --- | --- |
    |  | Company 1 | | Company 2 | |
    |  | Ex-vessel | Export | Ex-vessel | Export |
    | Levels | -2.16 (0.509)a) | -3.24 (0.076) | -3.24 (0.078) | -3.12 (0.099) |
    | First-Differences | -4.29 (0.003) | -4.91 (0.000) | -4.94 (0.000) | -4.99 (0.000) |
    | a) p-values | | | | |

    [↑](#footnote-ref-14)
15. In estimation we will include seasonal dummies in the harvest equation but not in the price equation. As seems reasonable, initial testing showed that the price relationship does not vary with the season. [↑](#footnote-ref-15)
16. The margin could be defined with respect to ex-vessel prices lagged one or two periods but this makes little difference in the estimation. The correlation between the current margin and a one and two period lagged margin effect is 0.997 and 0.995, respectively [↑](#footnote-ref-16)