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Estimate of Armington substitution elasticity for fishery products in Iran

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Abstract

The price transmission from the international market to the domestic market of tunas was investigated in the present research. For this purpose, the elasticity of substitution between tuna imports with goods produced in Iran (Armington Elasticity) was calculated. Armington elasticity reflects a degree of substitution between commodities produced domestically and those produced abroad. A greater elasticity indicates that buyers did not discriminate between domestic and foreign produced commodities and the buyers considered them the same. Therefore, any policy to influence the price of imported commodities will be effective in regulating the prices of commodities produced domestically. In the present study, in order to calculate Armington elasticity, the annual data for the year between 1974 and 2014 were used along with the technique of maximum entropy (ME). In addition to Armington elasticity, the least square estimated and vector error correction model (ECM) was estimated using entropy maximization. The results showed that Armington tension in the long-term was greater than that in the short-term. Even though this means the product has been imported, it serves as an alternative for domestically produced commodities; therefore, buyers do not see any difference between them. Additionally, the prices of these products have been affected by global prices and the swings in global prices can be transported more easily to the internal market for these products in the long-term than in the short-term.

Keywords: Price transfer, Maximization of entropy, Armington

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Introduction

Since 1974 when the FAO reported the condition of global stocks of fish, we have been able to review the harvesting status of the resources. In summary, a trend that has been practiced in the exploitation of these resources in the past decades is that there has been an increase in the percentage of those portions of resources that have been over-exploited. Conversely, the percentage of that portion which has been harvested lower than normal has experienced a decrease.

The supply of seafood and aquaculture in 2010 in the world was more than 148 million tons (worth 217.5 billion dollars), of which 128 million tons was used as food for people. In 2011, production increased to 154 million tons of which 131 million was used for food. With a continuous upward trend in fish production and improving the distribution channel of the global supply of fish as food, a dramatic growth has been recorded in the past five years with an average growth rate of 3.2% from 1961 to 2009 (FAO, 2014).

Aquatic per capita food supply increased averagely from 9.9 kg in 1960 to 18.4 kg in 2009, and exceeded18.6 kg in 2010 (FAO. 2014). More than 126 million tons of fish was available for human consumption in 2009. Note that the lowest level of fish consumption was in Africa (equivalent to 9.1 million tons, which is equivalent to 9.1 kg per capita consumption) While Asia accounted for two-thirds of the total consumption, with 85.4 million tonnes (20.7 kg per capita), of which 42.8 million tonnes was consumed outside China (15.4 kg per capita). The harvest of fish in Iran has increased since 2002 and in the years before it, it experienced an almost constant status. Increase in total production in the country is due to the increased harvest in the southern coast of the country as well as the upward trend of production in aquaculture. According to Table 5, the level of aquaculture production more than doubled within a period of 10 years. This increase suggests a significant investment in this sector over the past decades (Iranian Fisheries Statistical Yearbook, 2011). The interesting point is the sharp decline in harvest in waters north of the country, which has occasionally shown a sharp decline in production in recent years compared to the past years. One of the most important reasons for the decline in fish harvest in the northern part of the country is due to the presence of aggressive *Mnemiopsis leidyi*, which has greatly reduced the kilka fish stocks by threatening and destroying them (Iranian Fisheries Statistical Yearbook, 2011).

Table 1 shows the harvest of the fishes in the country over several years.

Table 1: Fishing and aquaculture harvests between 2001 and 2013 (tons).

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fishing in South	262805	269000	299128	314165	343492	374447	3295711	341980	-	368505	411898	459701	473658
Fishing in North	62550	42843	32533	35775	44887	46435	39174	36967	-	43805	37831	40341	40433
Aquaculture	73645	89827	110175	124560	134180	154678	193677	183647	-	251374	285351	338888	370876
Total	399000	401670	441836	474500	522559	525560	562422	562594	-	962684	735079	838892	884957

Source: Iranian Fisheries Statistical Yearbook (2013)

The subject of the World Trade Organization (WTO) has created opportunities for members to take advantage of by accessing global markets. More than 50 % of world fish trade is done in third world countries while industrialized nations mainly import fish so that Europe, America and Japan are importing half of the world's aquatics. Certainly, in terms of exports and imports of fishery products in the country, implementation of appropriate policies requires the use of domestic prices and a variety of trading instruments that are appropriate to the business situation. Studies that have been carried out in this area include: Nunez (2004) Consider the Maximum Entropy approach is a suitable tool to estimate such elasticities for fishery and other activities in Mexico. Also, Estimate the Armington elasticities using the 72 Activities disaggregation level of the System of National Accounts of Mexico (SNAM) is to be mentioned in this regard. Specifically, we use three main model specifications to estimate short run and long run elasticities. The first model is just the simplest regression in levels, while the second one is a partial adjustment model, and the third one an error correction mechanism model.

Yu Zhao (2010) in a study evaluated the effect of fluctuations of global prices on domestic prices of China's bean market. To this end, he used the vector error correction model. The results obtained suggested the effectiveness of the global market on domestic prices of these products. Minot (2011) in a study investigated the levels of effectiveness of world prices of food on domestic prices in Saharan Africa. For this purpose, he used more than 60 series of food prices in eleven African countries and the vector error correction model or VECM. The results showed that an increase in world prices from the middle of 2007 to 2008 precipitated an increase in domestic prices by 63 %.

Dawe (2008) in a study entitled "Is the recent increase in global grain prices transferable to the domestic economy of countries?" reported the experience of seven major Asian countries which investigated the effects of increase in grain prices in 2003 and the years after on the domestic price of these products in seven major Asian countries using currency elasticity. The results suggest that governments can contribute to the stability of domestic prices against international price movements in these countries if they adopt the right policies in this respect. Of course, this was the case regarding the two important products of the area, i.e. rice and wheat.

Cheng (1997) developed an Armington model to assess the demand for scallops in the United States. Time series data for 1980-1998 are used in the estimation of the model. Results indicate that the demand for U.S. domestic scallops is less elastic in the short run than in the long run. The substitution elasticities and the cross-price elasticities of U.S. scallops with respect to scallop imports are relatively small, indicating that they may be imperfect substitutes. U.S. domestic scallops and scallop imports from other countries may serve different market segments, and there exists little direct competition between them.

Finally, we can say that the aim of this study was to answer the question of whether the increase in international price affects the domestic price of the product, and whether the tuna produced in one country can completely replace the same type produced in other countries.

Materials and methods

Generally, the two methods of Armington elasticity calculation and transmission elasticity calculation were used to investigate the effect of global prices on domestic prices. Armington elasticity is an indication of the degree of substitution between domestic products and foreign manufactured products. Greater elasticity indicates greater substitution between goods produced within and outside the country. Transmission elasticity indicates the effects of global prices on the domestic price of imported goods (Balliu and Baukez, 2004; Berben, 2004).

Equation 1

$$H_m = \frac{\partial \ln p_d}{\partial \ln p_m}$$

$\partial \ln p_d$ → Productpricesin the domestic market

$\partial \ln p_m$ → Price of imported products

H_m → Transmission elasticity

It should be noted that this elasticity is related to each other such that in stable conditions, the larger the Armington elasticity, the larger will be the transmission elasticity (Warr, 2005).

In this study, in order to study the effect of global prices on domestic prices for tuna production, Armington elasticity, entropy maximization approach and annual statistics between 1989 and 2014 for tuna were used. Variables included in this model are:

The amount of product imports: M

The value of product imports: VM

The amount of production: D

Domestic price of the product: P_D

Now, if we divide the value of imports by the amount of imports, then the import price for each product can be calculated.

For each product, the ideal ratio is equal to: Equation (2)

The Armington demand model is derived from the following utility function:

$$U = [\delta D D^{\frac{\sigma-1}{\sigma}} + (1-\delta).M^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \ where\ M = [\sum ¢_i.M_i^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}$$

U is the total utility from the consumption of domestic beef (D) and imported fish (M). σ and θ are the elasticities of substitution between domestic and imported fish and among various sources of imported fish,

respectively and δ and ¢ are the distribution parameters that reflect the relative preference between different sources; To maximize the total utility subject to the budget constraints, the following optimal conditions need to be satisfied:

$$\frac{M}{D} = \left(\frac{\delta}{1-\delta} . \frac{P_D}{P_M}\right)^{\sigma}$$

Thus, we have:

Eq. (3)

$$\mathrm{Ln}\left(\frac{M}{D}\right) = \sigma \mathrm{Ln}\left(\frac{\delta}{1-\delta}\right) + \sigma \mathrm{Ln}\left(\frac{P_D}{P_M}\right)$$

Therefore, the econometric model stated will be:

Eq. (4)

$$Ln\left(\frac{M_t}{D_t}\right) = \beta_1 + \beta_2 Ln\left(\frac{P_{Dt}}{P_{Mt}}\right) + e_t$$

Where t = 1,..., 18 will be changed and represents the years studied. β_1 is the constant coefficient and β_2 is the Armington elasticity. The error term for each of the equation.

The base model

In this model, there will be only one dependent variable and an explanatory variable (Equation 4) meaning that vector parameter $\beta = (\beta_1, \beta_2)$.

Estimation of the model using the same entropy maximum method was similar to the issue that was mentioned in the methodology section; which means that:

Eq. (16 to 19)

$$\max_{p,w} H(p,w) = -\sum_{k=1}^{2}\sum_{m=1}^{5} \rho'_{km} \times \ln(p_{km}) - \sum_{t=1}^{18}\sum_{j=1}^{3} w'_{tj} \ln(w_{tj})$$

St:

$$\sum_{k=1}^{2}\sum_{m=1}^{5} \rho'_{km} . z_{km} . x_{tk} + \sum_{j=1}^{3} w'_{tj} . v_{tj} = y_t \qquad for\ t = 1,2,\ldots,18$$

$$\sum_{m=1}^{5} \rho_{km} = 1 \qquad for\ K = 1,2$$

$$\sum_{j=1}^{3} w_{tj} = 1 \qquad for\ t = 1,2,\ldots,18$$

Maximum entropy

Basis for entropy discussion dates back to the 19th century. In 1948, Shannon introduced the concept of entropy as a measure of uncertainty. Finally Golan *et al*. (1996) introduced an estimator called Generalized Maximum Entropy or GME and opened new topics in econometrics. Finally, the above formula was used and expanded by many researchers including Golan *et al*. (1996), Heckelei and Hendrik (2003), Ozan (2005) and Yafeng and Brett (2009). Among the advantages of this method is its insensitivity to the collinearity of explanatory variables in the model as well as its structural failures in the economy of the study.

The principle of maximum entropy presents a logical measure to choose the best probability distribution function. The best distribution would be the one, which maximizes entropy function according to the limitations or minimum errors (Mir Abbasi *et al*., 2011).

In the Generalized Entropy Maximization, the coefficients are obtained through optimization of the objective function to limitations. In this method, the model coefficients are estimated by a probability distribution for each coefficient and error term rather than by direct estimation of coefficients. The probability distribution for an unknown coefficient is determined by selecting a few of the probability values and assigning an initial probability to each of them, these probability values are recognized as support values and were taken from previous studies or economic theories. Probabilities related to these values are unknown and must be estimated in the process of maximization. After calculating the related probabilities, the mean of coefficients are calculable.

In general, the entropy function is defined as follows:

Eq. (5)

$$\max H(\rho_m) = -\sum_{m=1}^{M} \rho_m . \ln \rho_m$$

Here $H(\rho_m)$ is system entropy and ρ_m is the probability related to a support variable or probability density function. The concept of entropy can be extended for both variables through joint entropy, which is described as follows:

To maximize entropy function in the following regression, we should do the following:

Eq. (6)

$$y_t = \beta_1 + \beta_2 x_t + e_t$$

In this case the vector parameters $\beta = (\beta_1, \beta_2)$ support vector variables $z_k = (z_{k1}, \dots, z_{kM})$ with probabilities $p_h = (p_{k1}, \dots, p_{km})$, In other words, support vector variables explain the supportive space where each of the β_k coefficients are placed between two bands $\overline{z}_{kM}$ and z_{kM} (Golan, 2006) such that $m = 1, \dots, M$. In the case of error sentence, ε also has support variables vector, $v = (v_1, v_2, \dots, v_j)$; to determine the range of this vector, the principle three sigma:is used, and its weight will be $w_t = (w_{1t}, \dots, w_{jt})$ so that "j" is larger and equal to the two. According to the above principle, this amount will be equal to three (Golan *et al*., 1996; Golan, 2006). Thus, we have:

Eq. (7)

$$B = zp = \begin{vmatrix} z_1' & 0 \\ 0 & z_2' \end{vmatrix} \begin{vmatrix} p_1 \\ p_2 \end{vmatrix}$$

Eq. (8)

$$e = VW = \begin{vmatrix} V' & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & V' \end{vmatrix} \begin{vmatrix} W_1 \\ \vdots \\ W_T \end{vmatrix}$$

Thus, the maximum entropy function is expressed as follows:

Eqs. (9 to 12)

$$max_{p,w}H(p,w) = -\sum_{k=1}^{K}\sum_{m=1}^{M}\rho'_{km} \times ln(p_{km}) - \sum_{t=1}^{T}\sum_{j=1}^{J} w'_{tj}\, ln(w_{tj})$$

$$\sum_{k=1}^{K}\sum_{m=1}^{M}\rho'_{km}\cdot z_{km}\cdot x_{tk} + \sum_{j=1}^{J} w'_{tj}\cdot v_{tj} = y_t \qquad for\ t = 1,2,\ldots,T$$

$$\sum_{m=1}^{M}\rho_{km} = 1 \qquad for\ t = 1,2,\ldots,k$$

$$\sum_{j=1}^{J} w_{tj} = 1 \qquad for\ t = 1,2,\ldots,T$$

In order to maximize the above function, the non-linear programming method was used after the estimation of the probability values, beta coefficients were estimated in the following ways:

Eq. (13 and 14)

$$\hat{\beta}_k = \sum_{m=1}^{M}\rho'_{km}\cdot z_{km} \qquad for\ \ k = 1,2,\ldots,k$$

$$\hat{u}_t = \sum_{j=1}^{J} w'_{tj}\cdot v_{tj} \qquad for\ \ t = 1,2,\ldots,T$$

Here, based on a general rule, a vector is selected as support variables vectors where normalized entropy is equal to 0.999 (Golan *et al*., 1996).

In order to calculate the normalized entropy the equation below was used:

Eq. (15)

$$s(\hat{\rho}) = \frac{-\sum_{k=1}^{K}\sum_{m=1}^{M}\rho'_{km} \times ln(p_{km})}{k\ \log\ (M)}$$

Vector error correction model

The second model on which the determination of Armington elasticity is based is the vector error correction model (Kapuscinski and Warr, 1999; Gallawy *et al*., 2003); for this purpose, we will have:

Eq. (21)

$$\Delta\ln\left(\frac{M_t}{D_t}\right) = \beta_1 + \beta_2\Delta\ln\left(\frac{p_{Dt}}{p_{mt}}\right) + \beta_3\ln\left(\frac{M_{t-1}}{D_{t-1}}\right) + \beta_4\ln\left(\frac{p_{Dt-1}}{p_{mt-1}}\right) + e_t$$

Here:

β_2 is the short run Armington elasticity

$-\frac{\beta_4}{\beta_3}$ is the long run Armington elasticity (Kapuscinski and Warr,; 1999,Gallawy *et al*., 2003);

Results

In the present study, the Armington elasticity was estimated for fish products. For this purpose, annual data from 1986 – 2010 and two models were used. These models include:

A) The base model (least squares)

B) Error correction model

Information on the Armington elasticity and calculated entropy is given in the table below.

Table 1: Results of sensitivity tests on the GME estimates regarding tunas Armington elasticity in the based model.

Normalized entropy	Value of entropy	Estimated elasticity	Support parameter
0.715	17.56	0.595	[-10 50510]
0.8800	18.10	0.420	(-40 -2002060)
0.886	18.11	0.71	(60 -4004060)
0.888	18.12	0.82	[-100 -80080100]

Based on the above table, Armington elasticity in the base model for maize is equal to 0.82 so that positivity of the elasticity indicates the substitution relationship between the imported goods and domestic goods.

Estimation of this model using maximum entropy is done in such a way that the parameter vector $\beta = (\beta_1, \beta_2, \beta_{3\,,} \beta_4)$; therefore, in equations related to entropy calculations, K will be equal to 4.

The results of this model are presented in the table below. As the results indicate, Armington elasticity in the long run is greater than the elasticity in the short run meaning that for this product in the long run, there is a close substitution relationship between imported goods and domestic goods. Finally, an increase in the price of these products in the long run will lead to an increase or decrease in the share of imports. Therefore, in the long run, global prices are further transmitted increasing inward. In a study carried out by Gallawy *et al.* (2003) entitled 'Estimating Armington elasticity in the short and long run for the industrial sector in the United States', the results showed that the elasticity in the long run was more than that in the short run. In a study carried out by Tavakoli (2000), the results also showed that consumers acquired the probability of replacing foreign goods with domestic goods over time (in the long run).

Table 2: Results of sensitivity test on GME estimates regarding Armington elasticity for tuna in ECM.

Normalized Entropy	Value of Entropy	Estimated Elasticity		Support Parameters
		Long run	Short run	
0.982	20.742	1.41	½	$[-20 \ldots\ldots -10 \ldots\ldots 0 \ldots\ldots\ldots 10 \ldots\ldots\ldots 20]$
0.983	21.07	1.1	1.01	$[-20 \ldots\ldots -10 \ldots\ldots 0 \ldots\ldots\ldots 10 \ldots\ldots\ldots 20]$
0.987	21.2	1.17	1.01	$[-150 \ldots\ldots -130 \ldots\ldots 0 \ldots\ldots\ldots 130 \ldots\ldots\ldots 150]$
0.988	21.4	1.77	1.33	$[-170 \ldots\ldots -140 \ldots\ldots 0 \ldots\ldots\ldots 140 \ldots\ldots\ldots 170]$

Discussion

Fisheries and aquaculture play an important role in nutrition, food security and livelihoods. Direct consumption of fish provides protein and a range of other nutrients, particularly essential fats, minerals and vitamins. Increased attention is now being given to fish as a source of essential nutrients in our diets, as a unique source of micronutrients and long chain omega-3 fatty acids (Toppe, 2014).

The small cross price elasticities also support the argument that Iranian domestic fishery products and imports from other countries are imperfect substitutes with relatively weak competition. At the producer level it creates uncertainty and volatility in profit margins and reduces the incentive to invest. At the consumer level, it translates to large price fluctuations that reduce their purchasing power (Gardner and Gardner, 1977). In most cases, the government becomes concerned about the effect on fiscal policy. In a volatile commodity price regime, there are periods of high volatility and periods of tranquility (Enders, 2004).

This paper has attempted to clarify the relationship between two methods of modeling the relationship between the prices of imports and domestic prices. These are the pass-through elasticity and the 'Armington' elasticity of substitution between imported and domestically produced goods. The relationship is illustrated empirically in the context of fish imports into Iran.

In general, Armington elasticity in the long run is much higher than the elasticity in the short run, which means that international prices are transmitted more to the domestic market for these products in the long run than in the short run. In other words, use of any policy that could lead to support of imports in the long run can lead to an increase in imports and price transmission in to the domestic market. For the fishery products whose import demands are elastic to import prices, it is expected that the decline of import prices by tariff reduction results in the increase in import demands, and then the loss of domestic production of these products. Thus, the policies for these sectors should be the ones that help to restructure these sectors rather than the ones resulting in excess supply.

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