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FOOD SECURITY IN TUNISIA THROUGH AQUATIC PRODUCT CONSUMPTION

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Abstract

This paper examines the main factors influencing the local demand for fish compared to other meat products in Tunisia. The double logarithmic econometric model AIDS (Almost Ideal Demand System) is used in the present study. We particularly aimed by using data panel from the Tunisian National Institute of Statistics at estimating the effects of direct and cross prices, income, and geographical area on this local fish demand. Results showed that prices of this foodstuff and of others substitutable products, consumers income and geographical area are significant factors that seem to influence fish demand, thus, explaining 83% of the variability in fish demand in Tunisia. We showed disparties in fish consumption between the costal and interior regions of the country. This trend is further accentuated. We also demonstrated that fish products are of great importance for food security and could replace red meat (particularly lamb meat) once available at cheaper prices.

Keywords: *Demand, factors, food safety, fish, meat, Tunisia*

1. Introduction

Globally, fisheries and aquaculture play a vital role in the socio-economic development and in food security. Indeed, this industry constitutes a direct and indirect means of subsistence for 10% of the world population, and provides more than 4.5 billion people with at least 15% of their average animal proteins needs (Béné, et al., 2015). According to the latest FAO studies, global meat consumption is expected to increase by 15% by 2030 in the context of increasing world population and socio-economic development (Henchion, et al. 2017). Increase in meat production and consumption would certainly have a negative impact on the environment, through greenhouse gas emissions, and on naturals resources by mainly increasing the use of water and land resources (Henchion, et al., 2017). Among meat products, seafood can provides a less polluting and resource-depleting source of animals proteins.

Fish products constitute, in fact, a source of high quality proteins and with lower carbon footprint compared to other animal products (Henchion, et al., 2017). Morover, their contribution to global food security is increasingly raised in food policies (Stetkiewicz, et al. 2022).

Fish demand analysis has been the subject for several research studies worldwide. Recently, determining factors of fish consumption around several authors have analyzed. For instance, Kresic et al. (2023) studied the major factors (notably level of knowledge and information) affecting fish consumption. Pupavac et al. (2020) studied the socio-demographic factors associated with fish consumption in Croatia. They demonstrated that Croatian consumers prefer locally produced wild products much more than farmed products, and that prices is a determining factor in this demand. Qasim, et al. (2020) analyzed the factors influencing fish consumption in a sample population in Pakistan. They noted, using a linear regression model, that fish prices, proximity to rivers, and family size have negative effects on fish consumption, while the number of fishing equipment, education level and family income have a positive effect on this consumption. Supartini, et al. (2018) studied changes in fish consumption and associated factors in the United Kingdom and Singapore based on a population sample. They showed that the consumers age, prices, dietary benefits as well as religious concerns signeficantly influence fish consumption.

Other studies have dealt with barriers to fish consumption, notably Wilaya et al. (2022), Rahman (2020) Resaiepandari (2017), Chistonson (2017), Vanhonacker et al (2010), Trondsen et al. (2003), Skuland (2015), Brunso et al. (2009), etc. However, the econometric modeling of fish demand based on income, price and region, and comparing it with meat demand, through statistical panels has not been sufficiently addressed.

In Tunisia, Dhehibi, et al. (2005) analyzed the local demand for fish products. They demonstrated that this demand is inelastic with respect to prices. Consumption of seafood mainly depends on the incomes and the consumers – purchasing habits according to the same authors. Dhraief, et al. (2011) confirmed the findings of Dhehibi, et al. (2005) by proving disparities in seafood consumption between coastal and continental Tunisian inhabitants depending on the availability and supply of fish products, consumption habits and product quality.

This article contributes to the analysis of fish demand compared to other meat products in Tunisia, by studying the determining factors (particularly direct and cross prices, income of consumers and geographical area that could affect fish consumption in Tunisia. We also analyzed the contribution of these products to food security at the national level. Hence, we aimed at showing if fish products could replace other meat products, particularly red meat which industry is in crisis (variability in fodder production and its dependence on climatic hazards, increase in production costs and sales prices, instable production, etc.). We also aimed at showing if the Tunisian consumer would accept this substitution in the local consumption. These topics related to fish demand in Tunisia have not been sufficiently addressed, to our knowledge. The originality of this work, moreover lies, in verifying the following hypotheses: (i) fish consumption is influenced by fish products price, cross-prices and consumer income; (ii) fish consumption depends on Tunisian geographic regions; (iii) fish could replace meat in the Tunisian diet.

2. Contribution of fish and other meat products to national food security

In Tunisia, the meat diet mainly consists of fish and other seafood products, red meat, poultry meat. Consumption estimations values of these products per capita – year are respectively at 10.8 kg, 12.4 kg and 20.6 kg in the latest Tunisian statistics (2015). These quantities represent respectively 24.88%, 28.31% and 47.031% of global consumption of animal protein. Morover, evolution of the national consumption of these products shows that poultry meat is most demanded. Consumed quantities have indeed increased from 7.5 kg/person/year in 1990 to 20.6 kg/person/year in 2015, therefore recording a growth rate of 173.33%. Contrariwise, the average consumption per person-year of red meat fell by 18,42%, (from 15.2 kg/person/year in 1990 to 12.4 kg/person/year in 2015). That of fish products

slowly evolved over the past decades with a growth rate of 9.09%, hence ranging from 9.9 kg/person/year in 1990 to 10.8 kg/person/year in 2015.

Over the same period, although poultry products occupies the first place in term of consumed quantities, their production expenses occupied the second place (29.51% of all expenditure). Red meat occupies by far the first place (68.76% of all expenditure). Fish expenditure remains the lowest, not exceeding 2%.

Evolution of the highest budget share was recorded by red meat, with a growth rate of 237.97% over the period 1990–2015 ranging from 50.6 Dt to 171.014 Dt per person- year. That of poultry also experienced a marked increase with a growth rate of 109.33% that of fish experienced however a slight decline by –49.41% over this same period.

Table 1. *Evolution of consumption and expenditure on fish and other meat products*

	1990		2015	
	Quantity (kg/ person/year)	**Expenditure (Dt/ person/year)**	**Quantity (kg/ person/year)**	**Expenditure (Dt/ person/year)**
Fish	9.9	8.5	10.8	4.3
Red Meats	15.2	50.6	12.4	171.014
Poultry	7.5	12.4	20.6	73.4

Source: INS, 2015

3. Materials and methods

Analysis of the demand for seafood products in Tunisia was carried out using economic and econometric approach. The later, describes how consumption of a good varies following changes in prices and/or consumers' budget and by estimating the price and income elasticities of this good. The used approach allows also for predicting the evolution of this demand.

The parametric forms of complete demand systems treated in the literature are numerous. One of the reference models for estimating the demand for food is the double logarithmic econometric model (Almost Ideal Demand System or AIDS, Deaton and Muellbauer 1980). This model is general, easy to estimate and does not require specificities (Ravelosoa, 1999). It is also known for its flexibility and linearity (Khaldi, et al., 2009).

3.1. Model overview

The estimation tool used is Eviews. The logarithmic function estimating the model is as follows:

$$Log\,Q = C + \alpha i\, Log(\rho i) + \sum_{k=0}^{n} \beta j \log \log(\rho\, i)$$

With:

Qi: quantity of fish consumed from good i (fish),

C: constant

αi: direct elasticities,

βj: cross elasticities,

pi: price of good i (fish),

pj: price of good j (other meat products)

The used data part from national surveys on household budget, consumption and standard of living elaborated by the Tunisian National Institute of Statistics on a sample of households'. This sample is representative of different socio-economic categories and during the period 1980–2015. Before estimating the different parameters, and in order to improve their quality it was important to control and test this data first.

Econometric analyzes on expenditure elasticity are calculated for all fish. Those of cross elasticities concern the main products that are potentially considered as substitutable or complementary of fish products, in particular red meat (lamb and veal) and poultry meat and eggs. Descriptive statistics for these variables are presented in Table 2.

Table 2. *Descriptive statistics of explanatory variables*

	Quantity (dt)			Price (kg)		
	Moy	**Min**	**Max**	**Moy**	**Min**	**Max**
Fish	105590.43	83779.00	153572.00	5901.29	1564.50	14826.10
Red meats	219094.44	143800.00	376200.00	11466.86	2928.25	29085.50
Poultry meat	119941.66	55000.00	200000.00	2994.06	1094.00	6854.00
Eggs	1470.00	930.00	2157.00	108.14	51.00	219.00

Source: Notre élaboration

4. Direct price, cross price and income elasticity of fish demand

4.1. Effect of food expenditure

Estimation of fish and meat products demand (Table 3) shows that the coefficients of determination (R^2) as well as the F-test statistics confirm the relationship that exists between fish consumption and food expenditure. The elasticity is significant at the 5% threshold. The results obtained prove that fish is a normal good whose consumption increases in line with income increase.

Table 3. *Estimated parameters of fish demand as a function of income*

Demand's model	**Fresh fish**	**Poultry**	**Beef**	**Meats Lambs**
Variable	Coefficient	Prob.	Coefficient	Prob.
C	0.004	0.500	0.011	0.015*
Food expenses	0.594	0.000**	0.414	0.000**
R-squared	0.833**	0.992**	0.480*	0.404*
Log likelihood	82.894**	92.067**	52.631**	53.913**
Durbin-Watson stat	0.465	1.464	0.164	0.161
Prob (F-statistic)	0.000**	0.000**	0.001**	0.006**
F-statistic	29.832**	740.030**	5.533*	4.061*

*Source: Our development. * Significant by 10% **Significant by 1%*

Likewise, by comparing the average between income groups and the quantities consumed of fish and meat, the ANOVA analysis shows that the consumption of these products depends significantly on consumer income (Table 4).

Table 4. *Comparison of average meat and fish consumption in relation to consumer income*

		Sum of squares	**ddl**	**Average of squares**	**F**	**Signification**
Fish	**Inter-groups**	474.124	7	67.732	12.059	0.001*
	Intra-groups	44.935	8	5.617		
	Total	519.059	15			
Meats	**Inter-groups**	2415.804	7	345.115	5.526	0.014**
	Intra-groups	499.655	8	62.457		
	Total	2915.459	15			

*Source: Our elaboration. *Significant by 10%,** Significant by 1%*

4.2. Price effects

Overall, the estimated model and elasticities are significant at the 5% level (table 5). Indeed, the explanatory variables (fish price, red meat price, poultry meat price and egg price explain 83% of the variability of fish demand in Tunisia. The elasticity of demand for fish in relation to its price is significant at the threshold of 19% indicating a decrease of 8.8% following an increase of 1% in its price.

Compared to the red meat prices, the elasticity of demand for fish has a positive sign indicating the substitution of red meat by fish. Indeed, an increase of 1% in the real price of red meat is accompanied by an increase in demand for fish of 4%. This elasticity has a negative sign with poultry meat and eggs therefore fish is suggested as a complement to these two foodstuffs. A price increase of these products by 1% leads to a reduction in fish consumption of 23%. This complementarity is stronger with chicken meat than eggs where the cross elasticity is highest in absolute value.

Table 5. *Estimated parameters of the double logarithmic model*

Variable	Coefficient	Std. Error	Prob.
C	0.004	0.005	0.500
PFish	– 0.088	0.065	0.185
PRedmeat	0.041	0.043	0.352
PPoueltry	– 0.235	0.100	0.026**
PEggs	– 0.008	0.154	0.961
DEPALI	0.594**	0.080	0.000**
R2	0.833	F-statistic	29.832
Log likelihood	82.89	Prob (F-statistic)	0

*Source: Our elaboration. *Significant by 10%, **significant by 1%*

Fish supply was also modeled according to the different fish species prices by the Nerlove model used by Bachta, 1991. This reduced model is described according to the following equation:

$$\log(q) = c + \sum_{i=1}^{5} \log(pi)$$

The model is statistically significant and the supply theory is validated. The results illustrated in Table 6 show that the aquatic products supply depends on their prices, that explains it by 80%. Indeed, the increase in fish prices intensifies fishing activities which could lead to an uncontrolled increase in the fish supply and consequently it could threaten the sustainability of this sector. Taking into consideration these conditions, aquaculture could be an alternative and a solution to the captured fisheries resources depletion.

Table 6. *Estimated parameters of fish supply based on their producer prices*

Variable	Coefficient	Std. Error	Prob.
C	0.080	0.024	0.003
Whiting price	0.080	0.024	0.002
SARDINE PRICE	0.421	0.127	0.097
OCTOPUS PRICE	0.091	0.053	0.059
Cuttle fish Price	0.339	0.173	0.133
Moy price Fish_	–0.826	0.034	0.0106
		0.303	
R^2	0.800		
Log likelihood	43.020		
F-statistic	24.065		

Source: Our elaboration

5. Regional influence on fish consumption

Analysis of fish consumption by region shows that there is a remarkable disparity. It is the North East region which has the highest level of fish consumption with 16.5 kg / person /year, followed by the Greater Tunis area (9.9 kg/person/year) then the region from

the Central East (8.8 kg/person/year) and finally the South East region (6.5 kg/person/year). The lowest average fish consumption was recorded in the Central West, South West and North West regions where the average consumption of these products is less than 4 kg/person/year. This difference between regions could be explained by the availability of fish and its accessibility in coastal areas much more than in inland regions. Consequently, it influences the eating habits in each region.

Monitoring the evolution of fish consumption in the different Tunisian regions between 2005 and 2015, proves that the disparity in fish consumption between coastal and inland regions is increasing. It tends to increase in coastal regions and decrease in inland regions. The highest consumption rise was recorded in the North East region, going from 8.5 kg per person in 2005 to 16.5 kg / person / year in 2015. It is followed by the Central East zone which experienced a remarkable increase in the average fish consumption from 3.2 kg in 2005 to 9.3 kg. On the other hand, the highest decrease is noticed in the South East region, going from 18.9 kg / person/year in 2005 to 6.5 kg / person/year. Consumption in the Greater Tunis region is almost kept stable at around 10 kg while in the Central West and North West regions it is maintained low at around 4 kg.

The average consumption of red meats in the different Tunisian regions are comparable and very close to the national average which is around 32.5 kg / person / year. The highest level of these products consumption was recorded in the Greater Tunis region with an average of 38.6 kg/ person /year. These products consumption evolution over the period is increasing in the majority of regions over the period 2005–2015. The Central East region experienced the most notable increase, going from 24.4 kg/person/year to 34.6 kg/person/year. It is followed by the Greater Tunis region whose consumption increased by 6.4 kg/person/year. Then, it is the North-West region, which occupies the third place with an increase of 5.6 kg/person/year. It is only the South East region, which experienced a decrease of 4.1 kg per person. The national average is also increasing, from 26.9 kg in 2005 to 32.5 kg in 2015.

ANNOVA analysis was carried out in order to make a comparison between the interior regions (North-West, Central West, South-West) and coastal regions (Grand Tunis, North East, Central East and South East) in terms of fish and meat consumption (table 6). A significant difference in consumption between the two regions of 1% for fish and 10% for meat was noted. It was also observed that there was a positive correlation between the fish and meat consumption. Indeed, regions that have high averages of meat consumption they also have the highest averages for fish consumption. Thus, it's the income that determines the consumption of these products:

Table 7.*Comparison of fish and meat consumption in inland regions and coastal regions*

Product		Sum of squares	ddl	Average of squares	F	Signification
Meats	Inter-groups	106.287	2	53.144	2.824	0.082*
	Intra-groups	395.129	21	18.816		
	Total	501.416	23			
Fish	Inter-groups	161.494	2	80.747	5.863	0.009**
	Intra-groups	289.216	21	13.772		
	Total	450.710	23			

*Source: Our development *Significant by 10%, **significant by 1%*

6. Discussion

It emerges from this work that the demand for fish elasticity in relation with food expenditure is significant (at the 5% threshold) and that fish is a normal good which consumption depends significantly on consumer's income. Its consumption increases when the income improves. These results confirm the work of Dhehibi, et al (2005) where they demonstrated that the consumption of these products depends on income. Compared to direct prices, it has also been demonstrated that this elas-

ticity is also significant (at the 5% threshold), which contradicts the results obtained by the same work of Dhehibi et al (2005) where it was revealed that the demand for these products was found inelastic regarding the price. It was also demonstrated, for the first time, that the elasticity of demand for fish in Tunisia has a positive sign with red meat indicating their substitution. Consequently, aquatic products could replace red meat known by its production instability and by its continuous costs production and price increase. On the other hand, fish, chicken, meat and eggs are complementary products.

The examination of fish consumption in the different Tunisian regions showed the existence of a remarkable disparity in consumption between inland regions and coastal regions, which confirms the work of Dhraief et al. (2011). Indeed, the coastal regions (North East, Greater Tunis) have the highest level of fish consumption followed by the Central East and South East zone. Interior regions notably the South West, Center West and North West record low fish consumption levels.

7. Conclusions

We conclude that fish could play a crucial role in food security according to its production and other meat products. Thus, in a context of increasing production costs of red meat and consequently their prices increase, the Tunisian consumer could substitute red meat by fish when the latter is cheaper.

In inland regions, fish consumption remains below the national average and much lower than consumption in coastal regions. Examination of the evolution of this demand has shown that this disparity is increasing over time. The availability of a good fish quality could improve fish consumption in these regions. Promoting packaging as well as transport could guarantee a suitable supply of these products to interior regions.

Statistical data of aquatic products in Tunisia gather them into a single product even though they include several by-products with very variable prices. Improving statistical data would make it possible to carry out additional research to study fish products demand taking into consideration this variability

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