***Original Research Article***

# Estimating the Elasticity of Demand for Some Sources of Animal Protein in Egypt

**ABSTRACT:** Red meat, white meat, and fish are the most important sources of animal proteins and fats needed for human food, and they are also commodity substitutes for each other. Average daily per capita amount of protein obtained from animal sources reaches 26.2 grams/day during the period (2015-2019), which is lower than the minimum agreed upon by nutrition scientists in the United Nations recommended by the World Health Organization, which is estimated at 29 grams/day of protein. The local production of red meat, white meat, and fish cannot be fulfilling the growing local demand for it, as the food problem in Egypt is the weak ability of local production to meet the population's needs for food commodities In general, Egypt suffers from a food gap in red meat, white meat, and fish, estimated at 662, 76, and 321 thousand ton, respectively, on average during the period (2015-2019).

The research aims to analyze the current situation of the most important economic indicators related to the local demand for red meat, white meat, and fish, and to study the impact of these factors on local demand, price measurement, and spending relationships on animal protein alternatives with changing prices and spending on them. The research also aims to predict the future domestic demand for red meat, white meat, and fish.

The study relied on the methods of descriptive and inferential statistical analysis in the interpretation and description of the economic variables subject of the study, and the "Almost Ideal Demand System" (AIDS) model was used, which is one of the important models used in the study and analysis of the system of demand for goods in order to estimate the price, cross and expenditure elasticities. By using the Autoregressive Integrated Moving Average (ARIMA) and Box-Jenkins model to predict the local demand for red meat, white meat, and fish.

The results show that an increase in the population by 1% leads to a statistically significant increase in the total demand for red meat, white meat, and fish by about 1.41%, 2.58%, 2.31%, respectively during the study period as about 74%, 83%, 93% of the total changes in the total quantity required of red meat, white meat and fish respectively are reflected by the increase in the population during the study period. And an increase in real national income by 1% leads to a statistically significant increase in the total demand for red meat, white meat, and fish by about 0.47%, 1.012%, and 0.82% respectively, and this is due to about 58%, 75%, and 84% of the changes in the total quantity required of red meat, white meat, and fish due to the increase in real national income during the study period.

An increase in the real retail price of red meat, white meat and fish by about 1% leads to a decrease in individual demand for these commodities by about 0.73%, 0.17%, and 0.11%, respectively, and from the price elasticity of demand for the commodities under study, it turns out that they are all commodities with inelastic demand, meaning that the commodities under study are essential commodities. The Cross elasticities indicate the consumer's inability to purchase both red meat and fish sufficiently in case of the current prices, while the consumer can buy the right amount of white meat under current prices.

**Conclusion:**

Despite the continuous increase in the local production of red meat, white meat and fish, there is an increase in consumption rates that is greater than the annual increase in production, which negatively affects self-sufficiency rates and average annual per capita share, due to the continuous increase in the population, as well as The continuous increase in the volume of red meat, white meat and fish negatively affects the Egyptian trade balance as a result of import and the rise in international food prices,

Key words: Sources of Animal Protein - Food Gap Assessment - Gap Prediction. Consumption- self-sufficiency - food security.

# Introduction

Targeting the Egyptian Strategy for Sustainable Agricultural Development until 2030 (SADS) to provide healthy and safe food for the population[1], but as a result of the continuous increase in the population and the weak ability of local production to meet the increasing demand for red meat, meat White meat and fish led to an imbalance between supply and demand and increased consumer prices, and also led to an increase in the gap in red meat, white meat and fish, which is reflected in an increase in the food trade deficit.

The average annual per capita consumption of red meat, white meat, fish, milk and eggs was about 12, 11.1, 14.7, 64, 3.9 kg/year during the period (2015-2019) which is reflected in the average daily consumption, the average per capita consumption of protein from animal sources About 26.2 grams/day over the same period[2] which is less than the minimum agreed upon by United Nations nutrition scientists recommended by the World Health Organization 29 g/day protein[3][4], The average per capita animal protein intake is one of the measures of economic progress in countries and indicates the standard of living and health of the population.

Statistics also indicate the high prices of red meat, white meat, and fish due to their nutritional importance, as the average price of red meat was about 105 L.E. /Kg, the average price of white meat was about 34 L.E./Kg. and the average price of fish was about 30 L.E./Kg during the period (2015-2019)[5]. The prices of the commodity, its competitors, and the prevailing levels of income are among the most important factors and determinants that affect consumer demand for commodities [6]. Red meat, white meat, and fish are also the most important sources of animal proteins and fats needed for the human food, and they are commodity substitutes for each other [7],

## Material and method

**Research problem:** Despite the multiplicity and diversity of animal protein sources of red meat, white meat, and fish, as well as the continuous increase in a local production of red and white meat, as well as the diversity of fisheries production in Egypt and the expansion of its area, the local production of red meat, white meat, and fish, cannot be Fulfilling the growing local demand for it, as the food problem in Egypt is the weak ability of local production to meet the population's needs for food commodities In general, and from red meat, white meat and fish in particular, and then Egypt suffers from a food gap of red meat, white meat and fish, estimated at 662, 76, 321 thousand ton, respectively, as an average during the period (2015-2019)[8].[9].

**Research objective:** The research aims to analyze the current situation of the most important economic indicators related to the local demand for red meat, white meat and fish, and to study the impact of these factors on local demand, price measurement and spending relationships on animal protein alternatives with changing prices and spending on them. The research also aims to predict the future domestic demand for red meat, white meat and fish.

**Analysis method and data sources:** The study relied on the methods of descriptive and inferential statistical analysis in the interpretation and description of the economic variables subject of the study, and the "Almost Ideal Demand System" (AIDS) model was used [9], which is one of the important models used in the study and analysis of the system of demand for goods in order to estimate the price, cross and expenditure elasticities. By using the Autoregressive Integrated Moving Average (ARIMA) and Box-Jenkins model [11] to predict the local demand for red meat, white meat, and fish.

The study relied on published and unpublished data issued by the Ministry of Agriculture and Land Reclamation, the Central Agency for Public Mobilization and Statistics, and the World Health Organization.

## Results and Discussion:

### 1- The current position of the most important economic variables related to domestic demand for red meat.

1-1 Local production of red meat: The average local production of red meat from cows, buffaloes, sheep, goats and camels was about 528, 492, 65, 36, 9 thousand tons, representing about 47%, 43%, 6%, 3%. 1%, respectively, of the total domestic production of red meat, this amounted to about 1130 thousand tons during the period (2015-2019) [12].

By studying the development of local production of red meat during the period (2001-2019), it appears from Table (1) in the annex that the average local production of red meat amounted to about 882 thousand tons, with a minimum of about 695 thousand tons in 2001 and a maximum of about 1012 thousand tons in the year 2009 The local production of red meat gradually decreased to reach 717 thousand tons in 2019, as it appears from Table (1) that the annual increase in the local production of red meat is not significant, which indicates its relative stability around its arithmetic average of about 882 thousand tons.

1-2 **Egyptian imports of red meat:** Egypt imports its needs of red meat, whether in the form of live animal heads or fresh and frozen meat, in order to reduce the gap between the local production of these meats and consumption of it. From table (1), it appears that the Egyptian imports of red meat are increasing by a statistically significant annual rate of about 32.2 thousand tons. It represents about 11.5% of the average of these imports, which amounted to about 284 thousand tons during the period (2001-2019), as It was also shown that the value of Egyptian imports of red meat increased during the study period by a statistically significant annual amount, amounting to about 1375 million LE. Representing about 21% of the average value of red meat imports, which amounted to 7689 million LE.

**Table (1): Development of the Most Important Variables Related to the Local Demand for Red Meat During the Period (2001-2019).**

| Variable | α | $\beta_1$ | $t_\beta$ | Mean | F-test | $R^2$ | Annual change % |
|---|---|---|---|---|---|---|---|
| Production (Thousand Ton) | 861.3 | 2.17 | 0.52 | 882 | 0.27 | 0,02 | 0.2 |
| import quantity (Thousand Ton) | -37.8 | 32.2* | 6.4* | 284 | 40.9* | 0.69 | 11.5 |
| Import value (Million L.E.) | -6063** | 1375* | 6.32* | 7689 | 39.9* | 0.68 | 21.0 |
| Consumption (Thousand Ton) | 824* | 40.5* | 7.39* | 1229 | 54.6* | 0.75 | 3.3 |
| Average annual per capita (Kg.) | 14.9* | -0.21** | 2.34** | 12.9 | 5.5** | 0.20 | -1.6 |
| Gap (Thousand Ton) | -37.3 | 38.4* | 5.84* | 346 | 34.2* | 0.65 | 10.8 |
| Self-sufficiency (%) | 94.8* | -2.1* | 5.91* | 74.4 | 34.9* | 0.65 | -3.1 |

(*) significance at (0.01), (**) significance at (0.05)
Source: Collected and Calculated from Table (1) in the Appendix.

1-3 **Total available for consumption of red meat:** The available for consumption of red meat consists of local production plus net foreign trade (imports minus exports.) It is clear from table (1) that during the study period the total consumption of red meat increased by a statistically significant annual amount of About 40.5 thousand tons represents about 3,3% of the average total consumption of red meat, which amounts to about 1229 thousand tons.

1-4 **Average annual Per capita share of red meat:** The maximum average annual per capita share of red meat was about 16.9 kg/year in 2007, and the minimum reached 9.6 kg/year in 2016, as shown in the table (1) That during the study period, the average annual per capita share of red meat decreased by an annual statistically significant amount of about 0.21 kg/year, representing about 1.6% of the average annual per capita consumption of red meat, estimated at 12.9 kg/year.

1-5 **The food gap and the self-sufficiency ratio of red meat:** It is evident from Table (1) that the food gap in red meat has increased during the study period by an annual statistically significant amount estimated at about 38.4 thousand tons, representing 10.8% of the average red meat gap

estimated at about 346 thousand tons, and the percentage of self-sufficiency in red meat ranged between a maximum of about 88.8% in 2009 and a minimum of about 43.1 in 2019, as it was found that the percentage of self-sufficiency in red meat decreased by about 2.1% at an annual rate of statistical significance estimated at about 3.1% of the average rate of self-sufficiency in red meat estimated at 74.4%.

## 2- The current position of the most important economic variables related to the domestic demand for white meat:

2-1 **Domestic production of white meat:** By studying the development of the total production of white meat during the period (2001-2019), it is clear from Table (2) that the local production of white meat increased with an annual statistically significant amount estimated at about 64.7 thousand tons, which represents about 6.7% of the average local production of white meat The amount is about 882 thousand tons.

2-2 **Egyptian imports of white meat:** From table (2), it appears that the Egyptian imports of white meat are increasing by a statistically significant annual rate of about 6.29 thousand tons. It represents about 21.9% of the average of these imports, which amounted to about 39.1 thousand tons during the period (2001-2019), as it was also shown that the value of Egyptian imports of white meat increased during the study period by a statistically significant annual amounting to about 125.9 million LE. Representing about 30.5% of the average value of white meat imports, which amounted to 605 million LE.

**Table (2): Development of the Most Important Variables Related to the Local Demand for White Meat During the Period (2001-2019).**

| Variable | α | β | $t_\beta$ | Mean | F-test | $R^2$ | Annual change % |
|---|---|---|---|---|---|---|---|
| Production (Thousand Ton) | 235 | 64.7* | 6.3* | 882 | 39.3* | 0.68 | 6.7 |
| import quantity (Thousand Ton) | -12.9 | 6.29* | 8.2* | 39.1 | 67.4* | 0.81 | 21.9 |
| Import value (Million L.E.) | -456** | 125.9* | 7.1* | 605 | 49.8* | 0.75 | 30.5 |
| Consumption (Thousand Ton) | 310* | 82.4* | 5.4* | 1134 | 28.7* | 0.61 | 6.6 |
| Average annual per capita (Kg.) | 9.9* | 0.07 | 1.18 | 10.5 | 1.4 | 0.02 | 0.6 |
| Gap (Thousand Ton) | 74.5 | 17.7 | 1.5 | 252 | 2.3 | 0.07 | 5.4 |
| Self-sufficiency (%) | 77.2* | 0,12* | 0.16 | 78.3 | 0.27 | 0.06 | -0.4 |

(*) significance at (0.01), (**) significance at (0.05)
Source: Collected and Calculated from Table (1) in the Appendix.

2-3 **Total available for consumption of white meat:** Table (2) **shows** that, during the study period, the total consumption of white meat increased by a statistically significant annual amount, amounting to about 82.4 thousand tons representing about 6.6% of the average total consumption of white meat, which amounted to about 1134 thousand tons.

2-4 **Average annual Per capita share of white meat:** It is **evident** from Table (2) that during the study period, the per capita share of white meat increased by an annual statistically insignificant amount estimated at about 0.07 kg/year, which indicates the relative stability of the average per capita share of white meat around its arithmetic average of about 10.5 kg/year at a minimum. It reached about 8.7 kg/year in 2010 and reached a maximum of about 13.7 kg/year in 2019.

2-5 **The food gap and the self-sufficiency rate of white meat:** It is **evident** from Table (2) that the food gap in white meat has increased during the study period by an annual statistically insignificant amount estimated at about 17.7 thousand tons, which indicates the relative stability of the white meat around its arithmetic average of about 252 thousand tons at a minimum. It reached about 36 thousand tons in 2002 and reached a maximum of about 1273 thousand tons in 2019. And the percentage of self-sufficiency in white meat gap ranged between a minimum of about 59.3% in 2010 and a maximum of about 96.5% in 2018, as it was found that the

percentage of self-sufficiency in white meat and the average rate of self-sufficiency in white meat estimated at 78.3% during the study period,

**3- The current position of the most important economic variables related to the domestic demand for fish:**

3-1 **Domestic fish production:** By studying the development of the total production of fish during the period (2001-2019) [13], it is clear from Table (3) that the local production of fish increased with an annual statistically significant amount estimated at about 56.1 thousand tons, which represents about 4.4% of the average local production of white meat The amount is about 1075 thousand tons.

**Table (3): Development of the Most Important Variables Related to the Local Demand Fish During the Period (2001-2019).**

| Variable | α | β | $t_\beta$ | Mean | F-test | $R^2$ | Annual change % |
|---|---|---|---|---|---|---|---|
| Production (Thousand Ton) | 514* | 56.1* | 4.3* | 1075 | 16.7* | 0.50 | 4.4 |
| import quantity (Thousand Ton) | 104* | 12.3* | 4.6* | 226 | 20.7* | 0.52 | 4.9 |
| Import value (Million L.E.) | -2517** | 600* | 6.9* | 3482 | 48.4* | 0.73 | 21.2 |
| Consumption (Thousand Ton) | 675* | 82.6* | 13.1* | 1501 | 172* | 0.91 | 5.4 |
| Average annual per capita (Kg.) | 14.7* | -0.03 | 0.43 | 14.4 | 0.19 | 0.05 | -0.2 |
| Gap (Thousand Ton) | 161 | 26.5* | 3.2* | 426 | 9.9* | 0.33 | 12.9 |
| Self-sufficiency (%) | 80.1* | 0.81 | 1.28 | 72.1 | 1.65 | 0.01 | 0.1 |

(*) significance at (0.01), (**) significance at (0.05)

Source: Collected and Calculated from Table (1) in the Appendix.

3-2 **Egyptian fish imports:** Egypt imports its fish needs from abroad in order to covering the gap between local production of fish and consumption from it. Table (3) shows the increase in Egyptian fish imports by a statistically significant annual rate of about 12.3 thousand tons, representing about 4.9% of the average of these imports, which is about 226 thousand tons during the period (2001-2019), and the value of Egyptian fish imports during the study period increased by a statistically significant annual amounting to about 600 million pounds, representing about 21.2% of the average value of these imports, which is about 3482 billion pounds.

3-3 **The total fish available for consumption:** Table (3) shows that during the study period, the total consumption of fish increased by a statistically significant annual amount, amounting to about 82.6 thousand tons, representing about 5.4% of the average total fish consumption of about 1501 thousand tons.

3-4 **Average annual Per capita share of fish:** The average annual per capita share of fish during the study period was about 14.4 kg/year, with a minimum of about 12.2 kg/year in the year 2010 and a maximum of about 16.8 kg/year in the year 2019, as Table (3) shows the decrease in the average per capita share of fish during the study period by a statistically significant annual amount It reached about 0.03 kg/year, representing about 0.2%% of the average per capita share of fish amounted about 14.4 kg/year.

3-5 **The food gap and the fish self-sufficiency ratio:** the food gap represents the difference between the local production of fish and consumption from it, from table (3) it is shown that during the study period the food gap of fish increased by a statistically significant annual amount, which amounted to about 26.5 thousand tons, representing about 12.9% of the average of this gap The amount is about 426 thousand tons. It also shows that the self-sufficiency of fish for the average of this period amounted to about 72.1%, with a maximum of about 99.3% in the year 2001 and a minimum of It amounted to about 51.3% in the year 2013,

**4- Measuring the impact of the most important variables on the total domestic demand of red and white meat and fish**

The population and the level of national income are considered among the most important variables that affect the total domestic demand for red meat, white meat and fish.

4-1 **Population**: Egypt faces the problem of overpopulation, whose negative effects are reflected in many sectors, including food, as the demand for food increases with the food product not meeting the quantity required for the population's consumption. Table (1) in the appendix shows that the number of Egypt's population increased from about 67.2 million people in the year 2001 to about 98.9 million people in the year 2019, with an increase of about 31.7 million people, at a rate of about 34% over the population in the year 2001, and the annual growth rate of the population according to equation (1) in table (4) was about 2.3% during the study period.

Table (5) shows that an increase in the population by 1% leads to a statistically significant increase in the total demand for red meat, white meat and fish by about 1.41%, 2.58%, 2.31%, respectively during the study period, As about 74%, 83%, 93% of the total changes in the total quantity required of red meat, white meat and fish respectively are reflected by the increase in the population during the study period As shown from Equations 1, 2, 3 in Table (5).

## Table (4): Effect of population on the total demand for red meat, white meat and fish during the period.(2001-2019).

| Variable | No. | Simple Regression | $t_\beta$ | F-test | $R^2$ | Annual Gross ratio (%) |
|---|---|---|---|---|---|---|
| Population | 1 | $Ln(Pop)_i = -41.2+ 0.023x_i$ | 21.4* | 457* | 0.96 | 2.3* |
| National Income (Market Price) | 2 | $Ln(Inc)_i = -278+ 0.142x_i$ | 42.6* | 1813* | 0.99 | 14.2 |
| National Income (Real Price) | 3 | $Ln(Incr)_i = -111.1+ 0.059x_i$ | 12.8* | 165.7* | 0.90 | 5.9 |

Where: Ln: logarithmic values of the variable, Pop = Number of the population in million people
Inc: National Income in Billion L.E., Incr: real national Income in Billion L.E.
X: Variable that expresses time, i: (year = 1,2,3,……,19)
Annual Gross ratio % (Gr) = β*100,
(*) significance at (0.01), (**) significance at (0.05)
Source: Collected and Calculated from Table (1) in the Appendix.

4-2 **National income** : Income is one of the most important factors affecting the quantity demanded of commodities in general and food commodities in particular, as income expresses purchasing power, and national income reflects the importance of the commodity in society Table (1) in the appendix shows the increase in the value of Egypt's national income from about 392 billion L.E. in the year 2001 to reach about 3903 billion L.E. in the year 2019, with an increase of about 3511 billion, that is, more than eight times the national income achieved in the year 2001. The national income at current prices achieved an average a growth rate of about 14.2% during the study period according to the equation (2) in table (4), while the real national income achieved a growth rate of about 5.9%, according to the equation (3) in table (4)

Table (5) shows that an increase in real national income by 1% leads to a statistically significant increase in the total demand for red meat by about 0.47% during the study period, and this is due to about 58% of the changes in the total quantity required of red meat due to the increase in real national income According to the equation (4) in table (5),. The income elasticity on white meat is estimated at about 1.012, which means that an increase in national income by 1% leads to a statistically significant increase in the total demand for white meat by about 1.012%, and about 75% of the changes in the total quantity required of white meat are due to increase in the real national income According to the equation (5) in table (5),. It is evident from the value of the income elasticity of fish, which is estimated at 0.82, that an increase in the real national income by 1% leads to a statistically significant increase in the total demand for fish by about 0.82%, and

about 84% of the changes in the total quantity required of fish are due to the increase in real national income during the study period according to the equation (6) in table (5).

**Table (5): Effect of population and Real National Income on the total demand for red meat, white meat and fish during the period.(2001-2019).**

| Independent Variable | Dependent Variable | No. | Simple Regression | $t_\beta$ | F-test | $R^2$ | Elasticity |
|---|---|---|---|---|---|---|---|
| Population Log(Pop) | Red Meat $Log(Y_{RM})$ | 1 | $Log(Y_{RM})_i$= 0.404+ 1.41 $Log(Pop)_i$ | 7.3* | 53.3* | 0.74 | 1.41 |
| | White Meat $Log(Y_{WM})$ | 2 | $Log(Y_{WM})_i$ = -2.409+ 2.85 $Log(Pop)_i$ | 9.5* | 89.7* | 0.83 | 2.58 |
| | Fish $Log(Y_F)$ | 3 | $Log(Y_F)_i$ = -1.25+ 2.31 $Log(Pop)_i$ | 16.1* | 257.1* | 0.93 | 2.31 |
| Real National Income Log(Incr) | Red Meat $Log(Y_{RM})$ | 4 | $Log(Y_{RM})_i$ = 1.57+ 0.47 $Log(Incr)_i$ | 5.1* | 25.9* | 0.58 | 0.47 |
| | White Meat $Log(Y_{WM})$ | 5 | $Log(Y_{WM})_i$ = -0.247+ 1.012 $Log(Incr)_i$ | 7.34* | 53.8* | 0.75 | 1.012 |
| | Fish $Log(Y_F)$ | 6 | $Log(Y_F)_i$ = 0.51+ 0.82 $Log(Incr)_i$ | 9.64* | 92.9* | 0.84 | 0.82 |

Where: Log: logarithmic values of the variable, Pop = Number of the population in million people
Incr: Real national Income in Billion L.E., $Y_{RM}$: Total required quantity of red meat.
$Y_{WM}$: Total required quantity of white meat, $Y_F$: Total required quantity of fish,
i: (year = 1,2,3,……,19), (*) significance at (0.01), (**) significance at (0.05)
Source: Collected and Calculated from Table (1) in the Appendix

5- **Economic analysis of individual demand for red meat, white meat and fish:** The Almost Ideal Demand System (AIDS) is derived from the expenditure function that reflects consumer behavior in the differentiation of a number of goods, The estimated local consumer demand for red meat, white meat and fish in Egypt during the period (2001-2019).It is one of the important models used in analyzing the demand for food commodities

This model is characterized as a system of non-linear equations representing expenditure shares on a commodity and is based on some constraints about transactions to achieve the conditions of the demand function (Additivity, Symmetry and Homogeneity) [14][15]

**The model can be derived as follows:** Assuming that the utility expenditure function (U), which assumes a distinction between commodities according to their different types,

**The model can be derived as follows:**

$$\text{Ln } [E(P,U)] = (1\text{-}U) \text{ Ln } [a(P)] + U \text{ Ln } [b(P)] \quad (1)$$

$$\text{Ln } [a(P)] = \alpha_0 + \Sigma\, \alpha_k \text{ Ln } P_k + \tfrac{1}{2}\, \Sigma_k \Sigma_j\, \gamma_{kj} \text{ Ln } P_k \text{ Ln } P_j \quad (2)$$

$$\text{Ln } [b(P)] = \text{Ln } [a(P)] + \beta_0 \prod_k P_k^{\beta k} \quad (3)$$

By substituting equations (2,3) in equation (1), the expenditure function can be formulated as follows:

$$\text{Ln } [E(P,U)] = \alpha_0 + \Sigma\, \alpha_k \text{ Ln } P_k + \tfrac{1}{2}\, \Sigma_k \Sigma_j\, \gamma_{kj} \text{ Ln } P_k \text{ Ln } P_j + \beta_0 U \prod_k P_k^{\beta k} \quad (4)$$

By differentiating Ln [E(P,U)] with respect to its price Ln $P_i$, the commodity's share of expenditure $W_i$ can be obtained as follows:

$$\frac{\partial \text{Ln } [E(P,\ U)]}{\partial \text{Ln } P} = \frac{P_i q_i}{E(P,\ U)} = W_i \quad (5)$$

Thus, equation (4) can be reformulated as follows:

$$Wi = \alpha i + \Sigma j\, \gamma ij \text{ Ln } Pj + \beta i\, U\, \beta 0 \prod_k P_k^{\beta k} \quad (6)$$

By solving equation (4) for the utility (U) and substituting it into equation (6), the following can be obtained:

$$W_i = \alpha_i + \Sigma j\, \gamma_{ij} \text{ Ln } P_j + \beta_i \text{ Ln } \left( \frac{E}{P_{index}} \right) \quad (7)$$

where:

$$\text{Ln } (P_{index}) = \alpha_i + \Sigma_k\, \alpha_k \text{ Ln } P_k + \tfrac{1}{2}\, \Sigma_k \Sigma_j\, \gamma_{kj} \text{ Ln } P_k \text{ Ln } P_j \quad (8)$$

$P_{index}$ is considered non-linear and encounters difficulties in estimation, so it has been replaced by the engineering index Stones Price Index as follows:

$$\text{Ln}\,(P_{spi}) = \Sigma_i\, w_i\, \text{Ln}\, Pi \qquad (9)$$

Since $W_i$ refers to the percentage of expenditure, and it also represents the dependent variable in the equations, the use of this index may cause some immediate problems in the model equations, so the delay periods are used as follows:

$$\text{Ln}\,(P_{spi}) = \Sigma_i\, w_i\, \text{Ln}\, P_i \qquad (10)$$

where:

$$W'_i = ½\,(W_{it} + Wit\text{-}1) \qquad (11)$$

Noting that: The $P_{index}$ index can be considered as a linear approximation of the $P_{spi}$ index in the case of a high Multicollinearity between prices, and thus equation (7) becomes as follows:

$$W_i = \alpha_i + \Sigma_j\, \gamma_{ij}\, \text{Ln}\, P_j + \beta_i\, \text{Ln}\left(\frac{E}{P_{spi}}\right) \qquad (12)$$

By application of the special conditions of demand to equation (12), which are represented in:

$\Sigma_i\, \alpha_i = 1$ $\quad \Sigma_i\, \gamma_{ij} = 0$ $\quad \Sigma_i\, \beta_i = 0$ Additivity Terms

$\Sigma_j\, \gamma_{ij} = 0$ Homogeneity Terms

$\gamma_{ij} = \gamma_{ji}$ for $i \neq j$ Symmetry Terms

The importance of these conditions is due to the fact that they make the model in line with the theory of demand.

where:($\alpha$,$\beta$,$\gamma$): equation Parameters, ($P_i$): Price of the commodity demanded I, (m): Number of commodity demanded, ($W_i$): share of the required commodity from the expenditure, ($P_i$,$q_i$): Price and quantity of commodity demanded I, ($E_i$): Total expander on commodity demanded i.

The Own, cross and expenditure elasticities of demand are calculated as follows:

$\varepsilon_{\text{Own, Cross}} = -\,\delta_{ij} + (\gamma_{ij}/w_i) - \beta i\,(w_j/w_i)$ price and cross elasticity take a matrix (m×m)

($\delta_{ij} = 1$, where $i = j$) Price Elasticity (Matrix Diameter)

($\delta_{ij} = 0$, where $i \neq j$) Cross elasticity (outside diameter)

$\varepsilon_{\text{expend}} = 1 + (\beta_I/w_i)$ Expenditure elasticity

To verify the validity of the results, the relationship between the Expenditure elasticities of the weighted share of the required commodity from the expenditure is measured as follows:

$$\Sigma_i\, w_i\, \varepsilon_{\text{expend}} = 1$$

Autocorrelation was detected using the “Breusch Godfrey” test, and about the problem of heterogeneity of the error term using the Engel test, and the detection of the problem of the non-normal distribution of the error term using the “Jarque- Bera” test, and in the case of insignificance, there is no standard problem in the equation. In order to estimate the parameters of the Anya model of equation (12) I use the “Zellner” method to solve the Seemingly Unrelated Regression (SUR) equations [16][17]

5-1 The value of the price elasticity of demand for red meat, white meat and fish during the study period [18], which is shown in Table (6), shows that an increase in the real retail price of red meat, white meat and fish by about 1% leads to a decrease in individual demand for these commodities by about 0.73%, 0.17%, and 0.11%, respectively, and from the price elasticity of demand for the commodities under study, it turns out that they are all commodities with inelastic demand, meaning that the commodities under study are essential commodities.

5-2 The values of the cross elasticity of demand show that an increase in the real retail price of white meat and fish by about 1% leads to an increase in the individual demand for red meat by about . 0.22% and 0.51%, respectively, with an increase in the real retail price of Red meat and fish by about 1% leads to an increase in the individual demand for white meat by about 0.29% and 0.44%, respectively, and by an increase in the real retail price of both red meat and white meat by about 1% leads to an increase in individual demand for fish by about 0.42% and 0.19%, respectively. Among this elasticity, it turns out that the substitutional relationship between white meat and fish in the case of an increase in the real retail price of fish is greater than in the case of an increase in the real retail price of red meat, and white meat is a strong alternative for both red meat and fish. It is the spending elasticity shows that the total increase Per capita spending by about 1% leads to an increase in spending on red meat, white meat and fish by about 0.99%

,1.05% and 0.98%, respectively, and these elasticities indicate the consumer's inability to purchase both red meat and fish Sufficiently in case of the current prices, while the consumer can buy the right amount of white meat under current prices.

**Table (6): Results of the optimum demand per person for red meat, white meat and fish during the period (2001-2019).**

| Commodities | Price & Cross Elasticities | | | Expenditure Elasticity | $W_i$ (%) |
|---|---|---|---|---|---|
| | Red Meat | White Meat | Fish | | |
| Red Meat | -0.73 | -0.22 | -0.51 | 0.99 | 57.2% |
| White Meat | -0.29 | -0.17 | 0.44 | 1.05 | 20.1% |
| Fish | -0.42 | -0.19 | -0.11 | 0.98 | 22.7% |
| $\Sigma_i W_i \varepsilon_{expend} = 1$ | | | | | 100% |

Where: "Wi" is the commodity's share of expenditure.
Price elasticity is the diameter of the matrix,
Cross-elasticity is outside the diameter.
Source: compiled and calculated from Table (1) in Appendix

**6- <u>The future vision of the volume of demand for red meat, white meat and fish:</u>**

Studying the future demand for red meat, white meat and fish is one of the important studies that contribute to formulating production and consumption policies for these commodities on a sound basis. This part deals with a future vision of the volume of domestic demand for red meat, white meat and, fish during the years 2025 and 2030 through two scenarios. The first scenario is based on the elasticity values of the optimal demand model, and the second scenario will depend on the method of forecasting by applying the "ARIMA." model.

6-1 **The future vision of the volume of demand for red meat**: Table (7) shows that the average production, consumption, and gap achieved from red meat in 2019 amounted to 717, 1662, 945 thousand tons, with a self-sufficiency rate of 43%, with an average annual per capita 12.3 kg/year, with an estimate Forecast according to the first scenario on the basis of elasticities. The average production, consumption, and gap in red meat in 2025 are expected to reach about 915, 1995, 1080 thousand tons, with a self-sufficiency rate of 46% and an average annual per capita 10.7 kg/year, while it is expected That the average production, consumption and gap in red meat according to the second scenario using the "ARIMA" model reach about 808, 1831, 1023 thousand tons, with a self-sufficiency rate of 44%, where the average annual per capita is estimated at 10.6 kg/year, and the average production, consumption, and gap in red meat are estimated As an average for the first and second scenarios, about 802, 1913, 1052 thousand tons, an increase of about 20%. 15% and 11% from production, consumption, and the gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 45%, an increase of about 4% over what was achieved in 2019, and the average annual per capita decreased to 10.7 kg/year, a decrease of approximately 13% from the average annual per capita achieved in 2019.

It is also clear from the same table with the forecast estimate according to the first scenario that the average production, consumption, and gap in red meat in 2030 will reach about 845, 2352, 1507 thousand tons, with a self-sufficiency rate of about 36% and an average annual per capita estimated at 10 kg/year, while reaching the average production, consumption, and gap in red meat according to the second scenario amounted to 836, 2935, 1199 thousand tons, with a self-sufficiency rate estimated at 41%, and the average annual per capita is estimated at 9.8 kg/year, and the average production, consumption, and gap in red meat as an average for the first and second scenarios is about 841, 2194, 1353 thousand tons, an increase of about 17%. 22% and 27% for production, consumption, and the gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 40%, an estimated decrease of 5% compared to what was achieved in 2019, and the average annual per capita decreased to 9.9 kg/year, a decrease of approximately 20% from the average annual per capita achieved in 2019.

6-2 **The future vision of the volume of demand for white meat:** Table (7) shows that the average production, consumption, and gap achieved from white meat in 2019 amounted to 1020, 3202,

1273 thousand tons, with a self-sufficiency rate of 60%, with an average annual per capita 13.7 kg/year, with an estimate Forecast according to the first scenario on the basis of elasticities. The average production, consumption, and gap in white meat in 2025 are expected to reach about 2594, 2891, 298 thousand tons, with a self-sufficiency rate of 90% and an average annual per capita of 12 kg/year, while it is expected That the average production, consumption and gap in white meat according to the second scenario using the "ARIMA" model reach about 2102, 2462, 360 thousand tons, with a self-sufficiency rate of 85%, where the average annual per capita is estimated at 11.9 kg/year,

The average production of white meat is estimated as an average for the first and second scenarios, about 2348 thousand tons, an increase of about 20% from production achieved in 2019, The average consumption of white meat is estimated as an average for the first and second scenarios, about 2677 thousand tons, a decrease of about 16% from consumption achieved in 2019, and The average gap of white meat is estimated as an average for the first and second scenarios, about 329 thousand tons, an increase of about 74% from gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 88%, an increase of about 45% over what was achieved in 2019, and the average annual per capita decreased to 11.9 kg/year, a decrease of approximately 13% from the average annual per capita achieved in 2019.

**Table (7): Forecasting the demand for red meat, white meat and fish during the years 2025-2030 compared to the achieved in 2019.**

| Variable | 2019 | 2025 | | | | 2030 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Scenario (1) | Scenario (2) | Mean | Change (%) | Scenario (1) | Scenario (2) | Mean | Change (%) |
| **Red Meat** | | | | | | | | | |
| Production (Thousand Ton) | 717 | 915 | 808 | 862 | 20% | 845 | 836 | 841 | 17% |
| Consumption (Thousand Ton) | 1662 | 1995 | 1831 | 1913 | 15% | 2352 | 2035 | 2194 | 22% |
| Gap (Thousand Ton) | 945 | 1080 | 1023 | 1052 | 11% | 1507 | 1199 | 1353 | 27% |
| Self-sufficiency (%) | 43% | 46% | 44% | 45% | 4% | 36% | 41% | 40% | -5% |
| Average annual per capita (Kg.) | 12.3 | 10.7 | 10.6 | 10.7 | -13% | 10.0 | 9.8 | 9.9 | -20% |
| **White Meat** | | | | | | | | | |
| Production (Thousand Ton) | 1929 | 2594 | 2102 | 2348 | 22% | 3729 | 2457 | 3093 | 27% |
| Consumption (Thousand Ton) | 3202 | 2891 | 2462 | 2677 | -16% | 4026 | 2871 | 3448 | -10% |
| Gap (Thousand Ton) | 1273 | 298 | 360 | 329 | -74% | 297 | 414 | 355 | -67% |
| Self-sufficiency (%) | 60% | 90% | 85% | 88% | 45% | 93% | 86% | 89% | 42% |
| Average annual per capita (Kg.) | 13.7 | 12.0 | 11.9 | 11.9 | -13% | 12.5 | 12.4 | 12.4 | -10% |
| **Fish** | | | | | | | | | |
| Production (Thousand Ton) | 2039 | 2293 | 2103 | 2198 | 8% | 2743 | 2309 | 2526 | 13% |
| Consumption (Thousand Ton) | 2563 | 3224 | 2863 | 3044 | 19% | 4215 | 3256 | 3736 | 27% |
| Gap (Thousand Ton) | 524 | 931 | 760 | 846 | 61% | 1472 | 947 | 1209 | 81% |
| Self-sufficiency (%) | 80% | 71% | 73% | 72% | -9% | 65% | 71% | 68% | -11% |
| Average annual per capita (Kg.) | 16.8 | 15.2 | 15.5 | 15.4 | -9% | 15.3 | 15.6 | 15.5 | -7% |

Source: compiled and calculated from Tables (1:6) and table (1) in Appendix

It is also clear from the same table with the forecast estimate according to the first scenario on the basis of elasticities. The average production, consumption, and gap in white meat in 2030 are expected to reach about 3729, 4026, 297 thousand tons, with a self-sufficiency rate of 93% and an average annual per capita of 12.5 kg/year, while it is expected That the average production, consumption and gap in white meat according to the second scenario using the "ARIMA" model reach about 2457, 2871, 414 thousand tons, with a self-sufficiency rate of 86%, where the average annual per capita is estimated at 12.4 kg/year,

The average production of white meat is estimated as an average for the first and second scenarios, about 3093 thousand tons, an increase of about 27% from production achieved in 2019, The average consumption of white meat is estimated as an average for the first and second scenarios, about 3448 thousand tons, an decrease of about 10% from consumption achieved in 2019, and The average gap of white meat is estimated as an average for the first and second scenarios, about 355 thousand tons, an decrease of about 67% from gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 89%, an increase of about 42% over what was achieved in 2019, and the average annual per capita decreased to 12.4 kg/year, a decrease of approximately 10% from the average annual per capita achieved in 2019.

6-3 **The future vision of the volume of demand for fish:** Table (7) shows that the average production, consumption, and gap achieved from fish in 2019 amounted to 2039, 2563, 524 thousand tons, with a self-sufficiency rate of 80%, with an average annual per capita 16.8 kg/year, with an estimate Forecast according to the first scenario on the basis of elasticities. The average production, consumption, and gap in fish in 2025 are expected to reach about 2293, 3224, 931 thousand tons, with a self-sufficiency rate of 71% and an average annual per capita of 15.2 kg/year, while it is expected That the average production, consumption and gap in fish according to the second scenario using the "ARIMA" model reach about 2103, 2863, 760 thousand tons, with a self-sufficiency rate of 73%, where the average annual per capita is estimated at 15.5 kg/year, and the average production, consumption, and gap in fish are estimated As an average for the first and second scenarios, about 2198, 3044, 846 thousand tons, an increase of about 8%. 19% and 61% from production, consumption, and the gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 72%, an decrease of about 9% over what was achieved in 2019, and the average annual per capita decreased to 15.4 kg/year, a decrease of approximately 9% from the average annual per capita achieved in 2019.

It is also clear from the same table with the forecast estimate according to the first scenario that the average production, consumption, and gap in fish in 2030 will reach about 2743, 4215, 1472 thousand tons, with a self-sufficiency rate of about 65% and an average annual per capita estimated at 15.3 kg/year, while reaching the average production, consumption, and gap in fish according to the second scenario amounted to 2309, 3256, 947 thousand tons, with a self-sufficiency rate estimated at 71%, and the average annual per capita is estimated at 15.6 kg/year, and the average production, consumption, and gap in fish as an average for the first and second scenarios is about 2526, 3736, 1209 thousand tons, an increase of about 13%. 27% and 91% for production, consumption, and the gap achieved in 2019, which is reflected in the self-sufficiency ratio to reach 68%, an estimated decrease of 11% compared to what was achieved in 2019, and the average annual per capita decreased to 15.5 kg/year, a decrease of approximately 7% from the average share of Annual individual achieved in 2019.

**Conclusion:**

Despite the continuous increase in the local production of red meat, white meat and fish, there is an increase in consumption rates that is greater than the annual increase in production, which negatively affects self-sufficiency rates and average annual per capita share, due to the continuous increase in the population, as well as The continuous increase in the volume of red meat, white meat and fish negatively affects the Egyptian trade balance as a result of import and the rise in international food prices, so it is desirable to work on reducing the food gap in red meat and expanding meat projects and establishing farms specialized in the production of red meat, as well as expansion In fish farming projects for its importance in reducing the food gap for fish and reducing imports, providing vaccinations for poultry to avoid disease and increasing local production of white meat, and educating consumers about healthy diets in general and the consumption of red and white meat and fish in particular.

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## Appendix

Table (1): Development of Population, National Income, and Individual income, Producer Price Index, Production, Consumption, Imports and Average Per Capita Share of Red Meat, White Meat and Fish during the Period (2001-2019).

| year | Population (thousand people) | Exchange rate (L.E./$) | National income (billion L.E.) | Individual income (L.E.) | Producer Price Index (Base Year 2014/2016) | Red Meat | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Production (Thousand Ton) | Consumption (Thousand Ton) | Average annual per capita (Kg.) | import quantity (Thousand Ton) | Import value (Million L.E.) | retail price (L.E.) |
| 2001 | 67204 | 3.97 | 392 | 5288 | 34.97 | 695 | 794 | 12.2 | 75 | 519.8 | 17.1 |
| 2002 | 68303 | 4.50 | 396 | 5320 | 36.14 | 821 | 954 | 14.3 | 108 | 864.7 | 17.9 |
| 2003 | 69432 | 5.85 | 485 | 5796 | 38.17 | 804 | 930 | 13.7 | 93 | 898.2 | 21.1 |
| 2004 | 70591 | 6.20 | 487 | 7200 | 43.11 | 819 | 927 | 13.4 | 103 | 1123.5 | 25.5 |
| 2005 | 71778 | 5.78 | 517 | 7623 | 47.32 | 855 | 1053 | 14.9 | 152 | 1612 | 27.3 |
| 2006 | 72991 | 5.73 | 619 | 8190 | 52.05 | 880 | 1178 | 16.3 | 224 | 2371.6 | 27.6 |
| 2007 | 74230 | 5.64 | 742 | 9513 | 58.29 | 921 | 1247 | 16.9 | 257 | 2798 | 33.0 |
| 2008 | 75492 | 5.43 | 892 | 11403 | 62.4 | 961 | 1251 | 16.6 | 142 | 2683 | 35.8 |
| 2009 | 76775 | 5.54 | 1049 | 13167 | 66.99 | 1012 | 1139 | 14.8 | 97 | 2307 | 39.8 |
| 2010 | 78076 | 5.62 | 1206 | 13398 | 76.56 | 992 | 1183 | 10.4 | 171 | 4207 | 51.6 |
| 2011 | 79392 | 5.93 | 1364 | 14641 | 84.83 | 989 | 1203 | 10.4 | 153 | 3948 | 58.3 |
| 2012 | 80722 | 6.06 | 1653 | 16907 | 87.35 | 990 | 1155 | 9.7 | 208 | 5860 | 62.2 |
| 2013 | 82056 | 6.87 | 1932 | 20960 | 90.54 | 965 | 1298 | 11.2 | 225 | 5780 | 67.7 |
| 2014 | 90425 | 7.08 | 2111 | 22737 | 93.54 | 941 | 1284 | 10.8 | 351 | 8976 | 79.8 |
| 2015 | 92443 | 7.69 | 2515 | 29393 | 99.41 | 975 | 1695 | 13.6 | 720 | 11224 | 88.9 |
| 2016 | 94447 | 10.03 | 3293 | 46035 | 107.05 | 788 | 1220 | 9.6 | 426 | 11824 | 99.6 |
| 2017 | 96443 | 17.85 | 3427 | 35531 | 138.33 | 792 | 1417 | 10.7 | 625 | 18672 | 122.7 |
| 2018 | 97147 | 17.88 | 3665 | 38067 | 156.72 | 858 | 1760 | 13.0 | 602 | 28458 | 130.3 |
| 2019 | 98902 | 16.80 | 3903 | 39790 | 145.4 | 717 | 1662 | 12.3 | 660 | 31980 | 128.2 |

Follow Table (1): Development of Population, National Income, and Individual income, Producer Price Index, Production, Consumption, Imports and Average Per Capita Share of Red Meat, White Meat and Fish during the Period (2001-2019).

| year | White Meat | | | | | | Fish | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production (Thousand Ton) | Consumption (Thousand Ton) | Average annual per capita (Kg.) | import quantity (Thousand Ton) | Import value (Million L.E.) | retail price (L.E.) | Production (Thousand Ton) | Consumption (Thousand Ton) | Average annual per capita (Kg.) | import quantity (Thousand Ton) | Import value (Million L.E.) | retail price (L.E.) |
| 2001 | 452 | 577 | 8.8 | 4 | 24 | 8.1 | 943 | 950 | 14.5 | 179 | 367 | 8.0 |
| 2002 | 734 | 770 | 11.6 | 5 | 34 | 8.5 | 852 | 923 | 13.9 | 133 | 294 | 8.3 |
| 2003 | 659 | 699 | 10.3 | 0 | 0 | 9.8 | 908 | 1015 | 14.9 | 136 | 366 | 8.6 |
| 2004 | 619 | 661 | 9.5 | 0 | 0 | 11.7 | 863 | 1064 | 15.3 | 204 | 607 | 10.7 |
| 2005 | 637 | 715 | 9.3 | 3 | 12 | 11.6 | 906 | 1075 | 15.2 | 189 | 524 | 10.1 |
| 2006 | 484 | 806 | 11.2 | 11 | 81 | 12.2 | 730 | 1173 | 16.2 | 208 | 600 | 10.4 |
| 2007 | 537 | 888 | 12.1 | 10 | 79 | 14.2 | 757 | 1225 | 16.6 | 221 | 937 | 11.7 |
| 2008 | 503 | 837 | 11.1 | 11 | 119 | 17.5 | 719 | 1151 | 15.3 | 113 | 1470 | 12.6 |
| 2009 | 530 | 902 | 12.4 | 26 | 230 | 19.0 | 743 | 1264 | 16.5 | 154 | 2103 | 15.8 |
| 2010 | 579 | 977 | 8.7 | 35 | 349 | 21.0 | 917 | 1481 | 12.2 | 186 | 2186 | 14.4 |
| 2011 | 613 | 1030 | 8.9 | 35 | 540 | 22.8 | 903 | 1526 | 12.3 | 178 | 2404 | 15.7 |
| 2012 | 660 | 1074 | 9.1 | 61 | 745 | 27.2 | 910 | 1605 | 12.6 | 279 | 3272 | 18.0 |
| 2013 | 1165 | 1261 | 10.4 | 48 | 385 | 29.5 | 839 | 1635 | 12.6 | 237 | 2983 | 20.9 |
| 2014 | 1262 | 1358 | 10.7 | 69 | 870 | 30.5 | 1029 | 1704 | 12.8 | 244 | 4040 | 22.5 |
| 2015 | 1262 | 1391 | 10.7 | 98 | 1329 | 29.4 | 904 | 1707 | 12.5 | 204 | 4306 | 22.9 |
| 2016 | 1263 | 1348 | 10.1 | 71 | 1146 | 33.1 | 1706 | 1894 | 13.5 | 220 | 4803 | 23.3 |
| 2017 | 1276 | 1395 | 10.0 | 115 | 2393 | 34.7 | 1823 | 2130 | 14.5 | 339 | 10087 | 32.6 |
| 2018 | 1595 | 1653 | 11.6 | 68 | 1127 | 40.0 | 1935 | 2436 | 16.3 | 386 | 11632 | 39.4 |
| 2019 | 1929 | 3202 | 13.7 | 73 | 2038 | 42.9 | 2039 | 2563 | 16.8 | 492 | 13176 | 43.2 |

Source:

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