FOOD and HEALTH

FOOD and HEALTH
E-ISSN 2602-2834

Food Health 9(3), 212-229 (2023) • https://doi.org/10.3153/FH23020 *Research Article*

Estimating meat consumption based on economic indicators using linear regression analysis approach: A case study of Türkiye

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Cite this article as:
Öztürk, H.M., Öztürk, H.K. (2023). Estimating meat consumption based on economic indicators using linear regression analysis approach: Case Study of Türkiye. *Food and Health,* 9(3), 212-229. https://doi.org/10.3153/FH23020

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Submitted: 21.11.2022
Revision requested: 01.03.2023
Last revision received: 27.04.2023
Accepted: 07.05.2023
Published online: 25.06.2023

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Available online at
http://jfhs.scientificwebjournals.com

ABSTRACT

The main idea of this study is to investigate Türkiye's meat consumption, projection and supplies by using the structure of the Turkish meat industry and Turkish economic indicators. This present study develops several models for the analysis of meat consumption and makes future estimations based on the **R**egression **A**nalysis **M**eat **C**onsumption **M**odel (RAMCM). Four forms of Regression Analysis models are used to estimate meat consumption. These models are named **Mu**ltiple **Li**near **R**egression **A**nalysis (MULIRA), **Li**near **R**egression **A**nalysis (LIRA), **Po**lynomial **Li**near **R**egression **A**nalysis (POLIRA), and **Lo**garithmic **Li**near **R**egression **A**nalysis. The models developed in the linear and non-linear forms are applied to estimate meat consumption in Türkiye based on social and economic indicators; Population, Gross National Product (GNP) per capita, Imports of goods and services (% of GDP), Exports of goods and services (% of GDP), electricity consumption per capita, unemployment, Gross capital formation (% of GDP) figures. It may be concluded that the Multiple Linear Regression Analysis models can be used as alternative solutions and estimation techniques for any country's future meat consumption values.

Keywords: Multiple Linear Regression; Meat Consumption; Estimation; Türkiye; **Po**lynomial **Li**near **R**egression **A**nalysis; **Lo**garithmic **Li**near **R**egression **A**nalysis; **Li**near **R**egression **A**nalysis

Introduction

Türkiye is considered as a bridge between Europe and Asia countries. Türkiye has undergone a significant transformation in a short time. In 1950, 68.1% of the total population in Türkiye was living in rural, and 31.9% was in urban areas; the proportion of people living in rural areas decreased to 22.7% in 2012 (Yilmaz, 2015). The rural population was reduced to 7.7% in 2017 (TURKSTAT, 2017).

On the other hand, Türkiye's Gross Domestic Product (GDP) was 13.995 billion US dollars in 1960. This value increased to 873.98 billion in 2012 and 950.579 billion dollars in 2013. However, it dropped to 851.55 billion dollars in 2017 (World Bank, 2019). During the same period (1960-2017), the population of Türkiye increased from 28 million to 78 million (TURKSTAT, 2019a). Between 1960 and 2017, Türkiye showed significant population, economic and demographic changes. GDP per capita (with current US$) increased from $509.42 in 1960 to $12530 in 2013 but declined to $10540 in 2017 due to the economic crisis experienced in the last 6 years in Türkiye (World Bank, 2019).

The livestock industry has an important place in the Turkish economy. The developments in this sector are directly related to the degree of development and industrialisation of the country and the level of welfare of society. Today, significant changes are experienced in food production and distribution. In the world and Türkiye, while agricultural enterprises decrease in number, they increase in size and tend to produce more single products. Larger producers replace individual producers. At the same time, the tendency towards safer and certain goods in consumer preferences causes significant changes in food production and distribution. All these and similar changes are called agricultural industrialisation. Technological developments and consumer preferences are the main reasons for the agriculture and food sector changes. New technologies have enabled the creation of different products. Due to Türkiye's social and economic development, industrialisation has changed the structure of traditional agriculture.

To grow, develop and lead a long and healthy life, it is necessary to consume sufficient nutrients in a balance. Animal-based foodstuff has importance among the fundamental nutrients. The energy, proteins, vitamins and minerals required for a good and balanced diet are obtained from animal and vegetable sources (Baysal, 2007; Ásgeirsdóttir et al., 2014), and meat consumption in developing countries remains an important food group for consumers (McAfee et al., 2010)

In recent years, food safety, food security and nutrition have been the main topics of concern for all countries worldwide. The growing world population has become increasingly at risk of reaching adequate, healthy and reliable food sources. The unbalanced distribution of food resources has brought important differences between regions in the world. Access to adequate food sources and reliable and balanced nutrition has become a threat to developed, underdeveloped, and developing countries. In line with these developments, all world countries and international organisations have started to take measures and implement food consumption. Due to population growth, global warming, drought and similar problems, it is important to estimate the food demand in the coming period.

People have the right to buy and consume foods that are reliable, affordable, good quality, and have healthy eating habits. Human health is based on adequate and balanced nutrition. For this reason, food production, processing and trade take place in the policy agenda of all countries. As the concepts of food, nutrition and health are inseparable, it is of utmost importance for the health and agriculture sectors to cooperate with food, nutrition and health. Agricultural policies should include health. For this purpose, food and nutrition policies need to be established. Establishing nutritional and nutritional policies requires a broad perspective and cross-sectoral cooperation. Food and nutrition policies should consider economic, cultural and political trends. While food consumption increases due to population growth, on the other hand, economic and social developments cause to increase in food consumption per capita.

Regardless of the level of development, nutrition is one of the major problems of all countries in every period. The production and quality of meat and meat products are important to ensure the population's healthy and balanced nutrition. The meat in the healthy diet of society, the location of red meat in the total meat is very important, especially for children and young people in the age of development. Proteins are not stored in the body and must be removed from the nutrients. The protein required with foodstuffs is 0.8 g per kg/body weight, although it does not vary according to age and sex. This means about 45-55 g of protein per person. For healthy and balanced nutrition, at least half or 2/3 of the proteins required daily should be from animal-origin food (Mutluer, 2005).

At least 50% of the protein required for the balanced nutrition of the human body and 25% of the amount of calories needed must be obtained from animal foods (Gürlük and Turan, 2008)

Meat consumption per capita per year in Türkiye is very low compared to other countries' consumption. Annual meat consumption per capita per year in Türkiye, with data for 2013, was 35.1 kg. Hong Kong is the world's top country by meat consumption per capita. Meat consumption in Hong Kong was 153.1 kg per capita per year. Meat consumption per capita per year in 2013 was 116.23 kg in Australia, 115.13 kg in the United States of America, 90.25 kg in Canada, 107.24 kg in Argentina, 86.76 kg in France, 85.64 kg in Germany and 76.6 kg in Greece, 53.72 kg in Bulgaria and 32.88 kg in Iran. The world's total meat food supply was estimated at 8,598.7 kilograms per capita per year in 2013. Meat consumption per capita for 1961, an average of 1961-2013 and 2013, was shown in Figure 1 for selected countries. (See Figure 1). As seen in the Figure, meat consumption increased in 2013 compared to 1961 for all the selected countries. For all countries except France, meat consumption in 2013 was higher than the average between 1961 and 2013 (Ritchie and Roser, 2017).

China is the top country for domestic meat supply in the world. As of 2013, the domestic meat supply in China was 87,682 thousand tonnes, accounting for 28.42 % of the world's domestic supply. The top 5 countries (others are the United States of America, Brazil, Russian Federation, and Mexico) account for 52.64 % of it. The world's total domestic meat supply was 308,567 thousand tonnes in 2013. Türkiye ranks 23 with 2607 thousand tonnes of production (Ritchie and Roser, 2017).

Estimation of food consumption or demand is of great importance in terms of supply formation. Several studies have been conducted to estimate food consumption. The main idea of this study is also to estimate meat consumption in Türkiye using the economic indicator.

In their studies, Antelo et al. (2017), Aguiar and Hurst (2005), Carroll et al. (2003), and Türkmen-Ceylan (2019) examined the parameters affecting household food expenditure and showed that the unemployment rate decreased household food expenditure, especially during the crisis periods. A similar study was carried out by Azabagaoglu and Oraman (2011) and showed that during the economic and financial crisis 2008, food expenditure was also reduced in Türkiye. On the other hand, in their study, Ivanova et al. (2006) showed that in the years of economic transformation in Bulgaria, food consumption increased due to economic development. Sepúlveda et al., 2008 used logistic regression to determine the factors affecting beef preferences, which are quality labels in Spain.

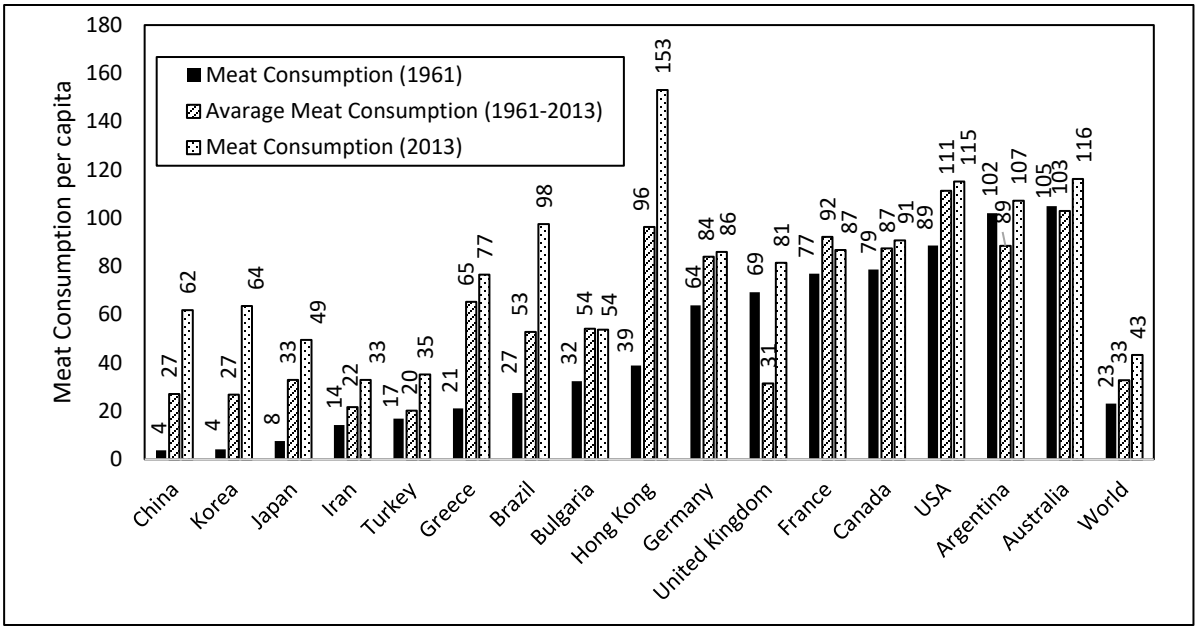

Figure 1. Meat consumption per capita for the selected countries for 1961, an average of 1961-2013 and 2013

On the other hand, Bentolila and Ichino (2008) examined the behaviour of Mediterranean and Northern countries during the crisis period. In the study, it was observed that the decrease in food consumption during the crisis periods was very low in both the Mediterranean and the Northern countries. They concluded that the support of the family in the Mediterranean countries played a role in the government welfare system in Northern countries. However, when economic data and meat consumption are compared for Türkiye, it can be concluded that financial data and meat consumption are related. Meat consumption increases due to increased GDP, and meat consumption decreases due to economic shrinkage and recession (see Figure 2). Yavuz et al. (2013) also reached a similar conclusion, showing that economic meat consumption increases with economic growth. Bilgic and Yen (2013) concluded that there was a decrease in red meat consumption in Türkiye between 2007 and 2009, while there was an increase in the consumption of poultry meat for the same period. They have claimed that the most important factor in this decrease was doubling the red meat prices. Demirtas (2018) showed that the red meat price increase negatively affects meat consumption in Türkiye. Aydogdu and Kucuk (2018) indicated that red meat consumption per capita in Türkiye would be 19.85 kg in 2023, which is 39.5% higher than in 2017 in Türkiye.

Materials and Methods

Model Development

New Meat Consumption Models have been developed in the study to estimate meat demand. Four forms of Regression Analysis Models are used to estimate meat consumption. These models are named Multiple Linear Regression Analysis (MULIRA), Linear Regression Analysis (LIRA), Polynomial Linear Regression Analysis (POLIRA) and Logarithmic Linear Regression Analysis (LOLIRA).

Regression analysis is a mathematical method that examines the relations between a dependent variable and an independent (simple regression) or multiple independent (multiple regression) variables. Regression analysis is a widely used statistical method in social sciences and engineering studies by fitting linear or non-linear equations to observe the relations between one and more independent variables and a dependent variable (Pedhazur, 1997). The linear regression model aims to explain the total change in the dependent variable with independent variables. Regression analysis can provide an inference about how much independent variable(s) predicts the variance of the dependent variable, as well as the extent to which the independent variable(s) predicts the dependent variable (Bagozzi and Yi, 1988; Aiken et al., 2003). When an independent variable is included in the regression model, the analysis is called Simple Linear (Regression) Analysis. In contrast, two or more independent variables are called Multiple Linear Regression Analysis (Dogan and Yilmaz, 2017).

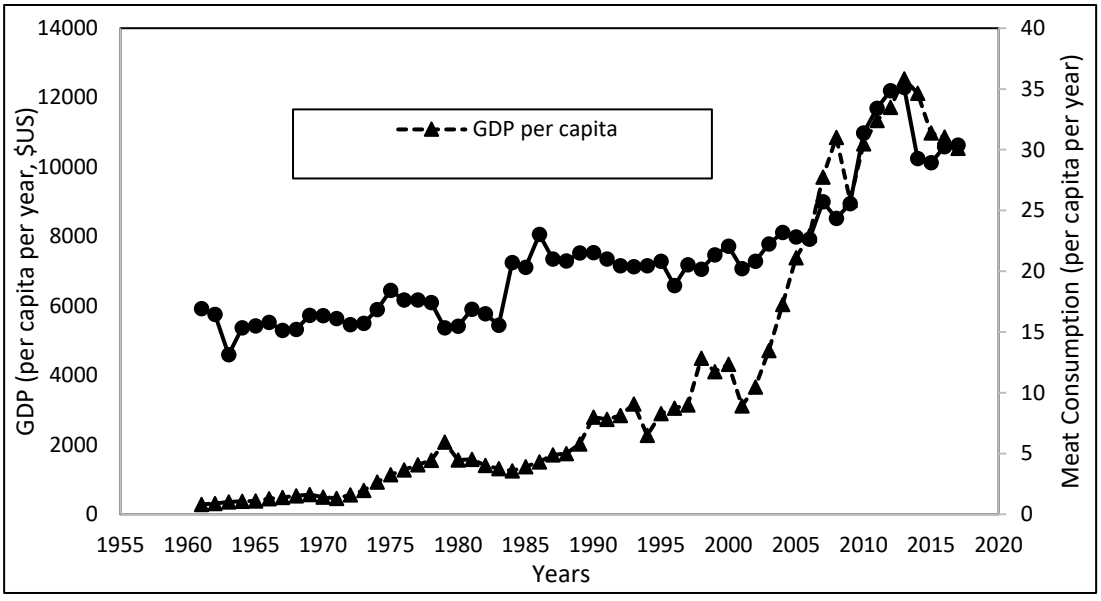

Figure 2. Relation between the GDP per capita and meat consumption per capita

Mathematically, the multiple linear regression equation can be expressed as shown in Equation Multiple Linear Regression Equation

$$Y = \beta_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k \quad (1)$$

In Equation 1, the dependent variables *Y*; x_1, x_2, ..., x_k, are independent variables. k shows the number of independent variables. β_1, β_2, ..., β_k are fixed and unknown parameters for independent variables.

Descriptive statistics were used to describe the basic features of the data set in the study. Correlation analysis was used to examine the relationship between meat consumption and social and economic variables. A linear correlation coefficient was used to determine the degree to which variables were related to covariates. The more the coefficient differed from 1 or -1(close to zero), the weaker the relation.

Linear regression models study the linear relationship between a dependent variable and several independent variables by fitting a linear equation to observed data samples (Coelho-Barros et al., 2008). The fitting is performed by minimising the sum of the squares of the vertical deviations from each data point to the line that best fits the observed data (Agirre-Basurko et al. 2006; Ferraro & Giordani 2012; Kovdienko et al. 2010).

For the MULIRA Model, the following equation, dependent and independent variables, were used to estimate meat consumption.

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 \quad (2)$$

Where

Y: Meat Consumption,

β: Regression Coefficients

x_1: *Population,*

x_2: *Gross Domestic Product (GDP) per capita,*

x_3: *Electricity Consumption per capita*

x_4: *Imports of Goods and Services (% of GDP)*

x_5: *Gross Capital Formation (% of GDP)*

x_6: *Exports of Goods and Services (% of GDP)*

x_7: *Unemployment*

The LIRA, POLIRA and LOLIRA Models are the following equation used in the study.

For the **Li**near **R**egression **A**nalysis (LIRA)

$$Y = \beta_o + \beta_1 x_1 \quad (3)$$

For the **Po**lynomial **Li**near **R**egression **A**nalysis (POLIRA)

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2^2 \quad (4)$$

Logarithmic **Li**near **R**egression **A**nalysis (LOLIRA)

$$Y = \beta_o e^{\beta_1 x_1} \quad (5)$$

For the Eq. 3, 4 and 5

β is Regression Coefficients and x is Years

The following parameter values were obtained when the Regression Analysis Meat Consumption Model (RAMCM) has applied to the meat consumption problem. The coefficients obtained are given below in the form of Multiple Linear Regression Analysis (MULIRA) models. For meat consumption;

For the ***Mu**ltiple **Li**near **R**egression **A**nalysis (MULIRA)*

$$\begin{aligned} Y = 10.01778 &+ 0.147352 x_2 \\ &+ 0.001671 x_3 - 0.00592_4 x_4 \\ &+ 0.040815 x_5 + 0.072768 x_6 \\ &+ 0.129709 x_7 - 0.14217 x_8 \end{aligned} \quad (6)$$

$$Multiple\ R^2 = 0.9113,\ R^2 = 0.8303,$$
$$Adjusted\ R^2 = 0.8034$$

The value of R^2 for the MULIRA model is 0.98303, but since there is multiple regression, the value of Adjusted R^2 and multiple R^2 should also be considered. These values are calculated as 0.9113 for multiple R^2.and 0.8034 for the adjusted R^2. In other words, independent variables can explain 80.34% of the change in the dependent variable (meat consumption). Multiple regression R^2 is 0.9113; then, the model explains 91.13% of the variance in the dependent variable. These values are quite high and satisfactory for social science and engineering studies.

For the LIRA, POLIRA and LOLIRA Models, the following coefficients have been obtained

*For the **Li**near **R**egression **A**nalysis (LIRA)*

$$Y = -539.281691 + 0.281606 x_1 \quad (7)$$

$$R^2 = 0.7615$$

*For the **Po**linomial **Li**near **R**egression **A**nalysis (POLIRA)*

$$Y = 23111.766156 - 23.501869x_1 + 0.005978x_2^2 \quad (8)$$

$$R^2 = 0.8358$$

Fir ***Lo**garitmic **Li**near **R**egression **A**nalysis (LOLIRA)*

$$Y = 1.1959.10^{-10}e^{1.2999.10^{-2}x_1}$$

$$R^2 = 0.8176$$

Data Source

The data related to the design parameters of Türkiye's; Meat Consumption, Population, Gross Domestic Product (GDP) per capita, Electricity Consumption per capita, Imports of Goods and Services (% of GDP), Gross Capital Formation (% of GDP), Exports of Goods and Services (% of GDP) and Unemployment are obtained from different sources such as Turkish Statistical Institute, (TURKSTAT, 2019b), The Food and Agriculture Organization (FAO) (FAO, 2019), World Bank (World Bank, 2019) Organisation for Economic Cooperation and Development (OECD) (OECD, 2019a). The collected data for the variables are given in Table 1.

Correlation analysis was used to examine the relations between meat consumption and social and economic variables, as given in Table 2. The table shows a high correlation between meat consumption and social and economic indicators. Therefore, these social and economic indicators can be applied to the MULIRA model to estimate Türkiye's future meat consumption and demand.

Multicollinearity, serial correlation, and heteroscedasticity tests are important statistical tests has been applied in the study.

Multicollinearity occurs when two or more independent variables in a regression model are highly correlated. This can create problems in the regression model, such as making it difficult to interpret the individual effects of each independent variable on the dependent variable. Multicollinearity can also lead to unstable and unreliable estimates of the regression coefficients. By performing a multicollinearity test, you can identify if this is a problem in your model and take steps to address it, such as by removing one of the correlated variables or using dimensionality reduction techniques like the principal component analysis.

Serial correlation: Serial correlation, also known as autocorrelation, occurs when there is a correlation between the error terms in a regression model. This can create problems in the model, such as biased regression coefficient estimates and incorrect standard errors. The purpose of performing a serial correlation test is to determine whether this is causing a problem in the model.

Heteroscedasticity: Heteroscedasticity occurs when the variance of the errors in a regression model is not constant across all levels of the independent variables. This can lead to biased and inefficient estimates of the regression coefficients and incorrect standard errors. By performing a heteroscedasticity test, it can be identified if this is a problem in the model and take steps to address it, such as by using weighted least squares regression or transforming the variables in the model. Weighted least squares regression is a regression analysis method that gives more weight to observations with more minor errors, which can help account for heteroscedasticity. Transforming the variables in the model, such as by taking the logarithm or square root of a variable, can also help to reduce heteroscedasticity.

Performing these tests can help ensure that the regression analysis is reliable and valid and that the results are interpretable and actionable. In the study, multicollinearity, serial correlation, and heteroskedasticity tests were performed by developing a Python code; the results are given in Table 3. When Table 3 is analysed, it can be seen that the regression analysis is reliable and the model is statistically significant.

R-squared is a statistic that measures the percentage of variation in the dependent variable explained by the independent variables. R-squared value of 0.875 means that the independent variables in the model explain 87.5% of the total variation in the dependent variable. This suggests that the model has a good fit and a strong predictive power, indicating that the independent variables are good predictors of the dependent variable.

Adj. R-squared, on the other hand, is a modified version of R-squared that considers the number of variables in the regression. An Adj. R-squared value of 0.857 means that the model explains approximately 85.7% of the variance in the dependent variable while adjusting for the number of independent variables in the model. This value is slightly lower than the R-squared value, which is expected when changing the number of predictors in the model. This suggests the model is still a good fit and has strong predictive power. However, it is important also to consider other metrics and diagnostic tests, such as residual plots and significance tests, to ensure that the model is appropriate and reliable.

Prob (F-Statistic) is used to assess the overall significance of

the regression, testing the null hypothesis that all the regression coefficients are equal to zero. A low probability value suggests that the regression is meaningful. The Prob (F-statistic) value of 5.46e-20 indicates that the probability of getting such a large F-statistic by chance alone is extremely small. This means that the overall regression model is statistically significant, indicating that at least one of the independent variables is significantly related to the dependent variable. Therefore, we can reject the null hypothesis that all regression coefficients are zero and conclude that the model provides a good fit to the data.

AIC/BIC are model selection criteria that penalise errors in the model when a new variable is added to the regression equation. The AIC (Akaike Information Criterion) value of 249.4 and the BIC (Bayesian Information Criterion) value of 265.8 are both measures of the quality of the model, specifically, its ability to balance between the goodness-of-fit and the number of parameters in the model. The lower the AIC and BIC values, the better the model. In this case, the AIC value of 249.4 measures how well the model fits the data, while the BIC value of 265.8 measures the model's complexity. Overall, a lower AIC or BIC value suggests that the model has a better trade-off between the fit and complexity of the model. Therefore, comparing different models' AIC and BIC values can help select the best model for the dataset.

The Omnibus test with a value of 0.746 and Prob (Omnibus) value of 0.689 tests the normality assumption of the errors. Since the p-value of Prob (Omnibus) is more significant than 0.05, it suggests that the errors are normally distributed, and hence the normality assumption is met.

The Durbin-Watson value of 0.867 tests the independence assumption of errors. A value between 0 and 2 is preferred, and the importance of 0.867 suggests no significant autocorrelation in the errors.

The Jarque-Bera (JB) test with a value of 0.215 and Test Statistic p-value of 0.0117 also tests the normality assumption of the errors. The p-value is less than 0.05, suggesting that the errors are not normally distributed. This contradicts the result of the Omnibus test, and further investigation is needed to reconcile these findings.

The F-statistic of 3.248 with an associated F-Test p-value of 0.0010 tests the overall significance of the regression model. Since the p-value is less than 0.05, the regression model is statistically significant, indicating that at least one independent variable is significantly related to the dependent variable.

Data were made using the Anova test for statistical relationships between a dependent variable (meat consumption in Türkiye) and various economic and social independent variables. While testing, analysis was made for the actual and predicted data. Looking at the analysis results, the following comments can be made about the overall accuracy of the model:

The R-Squared value (0.9811) shows the rate at which the independent variables explain the dependent variable, and in this case, it shows that the model is correct at the rate of 98.1%.

The adjusted R-Squared value (0.965) considers the number of independent variables in the model and indicates that it is 96.5% accurate.

Anova's results show that at least one of the independent variables in the model has a significant contribution to explaining the change in the dependent variable.

A regression analysis was performed by giving t-statistics and p-values along with these coefficients and error terms. The T statistics results show that the relevant coefficient is not zero, while the p-values indicate whether these coefficients are statistically significant. As can be seen in the table, the P-values for all coefficients are very low at the 0.05 significance level (p-value <0.05), so it can be said that all coefficients are statistically significant. Also, 95% confidence intervals are provided for each coefficient. Therefore, a regression model can be constructed using the data, and the effects of coefficients related to this model can be evaluated.

Table 1. Meat Consumption and the corresponding social and economic indicators for Türkiye

Years	Meat Consumption (kg/capita/year)	Population (Million)	GDP per capita (current US$)	Electricity consumption per capita year (kWh)	Imports of goods and services (% of GDP)	Gross capital formation (% of GDP)	Exports of goods and services (% of GDP)	Unemployment
1961	16.93	28.15	285.01	91.85	6.79	9.97	5.12	3.40
1965	15.49	30.97	385.64	136.79	5.40	11.35	4.56	3.70
1970	16.33	34.88	489.93	209.54	6.36	14.71	4.43	6.40
1971	16.11	35.72	455.11	232.05	8.25	13.77	5.32	6.80
1975	18.43	39.28	1136.38	343.51	11.23	18.71	4.42	7.60
1980	15.48	43.98	1564.25	463.84	11.93	18.16	5.16	8.30
1985	20.32	49.13	1368.40	604.65	18.97	16.51	15.86	7.30
1990	21.54	53.92	2794.35	868.30	17.58	24.55	13.37	8.00
1995	20.81	58.49	2897.87	1152.30	24.35	25.47	19.89	7.60
2000	22.05	63.24	4316.55	1554.33	22.55	23.80	19.45	6.50
2001	20.22	64.19	3119.60	1512.19	22.82	18.14	26.58	8.40
2002	20.81	65.14	3660.07	1580.34	23.00	21.24	24.46	10.30
2003	22.24	66.09	4718.46	1691.23	23.36	22.47	22.24	10.50
2004	23.20	67.01	6040.88	1807.88	25.37	25.21	22.75	10.80
2005	22.83	67.90	7384.26	1918.36	24.42	27.03	21.02	10.60
2006	22.63	68.76	8034.61	2080.63	26.50	29.57	21.65	10.20
2007	25.71	69.60	9709.72	2229.04	26.07	28.71	21.22	10.30
2008	24.36	70.44	10850.87	2299.09	27.08	28.94	22.83	11.00
2009	25.55	71.34	9036.27	2199.27	23.36	23.02	22.57	14.00
2010	31.39	72.33	10672.40	2378.80	25.45	26.97	20.45	11.90
2011	33.42	73.41	11340.82	2535.10	30.40	31.27	22.26	9.80
2012	34.85	74.57	11720.31	2613.96	28.58	28.30	23.67	9.20

Results and Discussion

Fifty-two data (1961–2012) (See Table 1) are used to estimate the weighting parameters of the MULIRA, LIRA, POLIRA, and LOLIRA models, and the remaining data (2013–2017) are used to validate the models.

The values of the independent variables between the years 2013-2040 were estimated using the data between 1961 and 2012. Linear Regression Analysis Models have been used for the estimation. Figure 1a-g shows the actual and estimated data for the Population, Gross Domestic Product (GDP) per capita, Electricity Consumption per capita, Imports of Goods and Services (% of GDP), Gross Capital Formation (% of GDP), Exports of Goods and Services (% of GDP) and Unemployment of Türkiye. As can be seen in Figure 1, for each social and economic indicator, the trend lines are fitted to the observed data with the highest R^2 values. Therefore, they may be used for future estimation. The value of meat consumption between 2013 and 2040 was estimated by using the actual values of the independent variables between 1961 and 2012 and the estimated values of independence between 2013 and 2017. Estimated meat consumption between 2013-2017 was used to validate the model and test data compared with the actual meat consumption data for 2013 and 2017.

The polynomial and linear expressions for each social and economic indicator and their actual values and estimation are illustrated in Fig. 1a–g. Fig. 2 shows actual and estimated meat consumption from 1961-2012 in Türkiye. As can be seen in Figure 2, the MULIRA model estimate is in great harmony with the observed data. LIRA, POLIRA and LOLIRA are also compatible with observed data. On the other hand, Figure 3 shows the meat consumption of Türkiye until 2040.

White Test Results testindeki F-Test p-value=0.00105 ve LM-Test p-value= 0.0117, Breusch-Pagan Test Results testindeki F-Test p-value=0.00027 ve LM-Test p-value=0.0013 ve OLS Regression Results testindeki Test Statistic p-value=0.0117 ve F-Test p-value=0.0010 değerleri açısından nasıl değerlendirebiliriz?

Table 2. Correlation analysis results for meat consumption and social and economic indicators

	Meat Consumption (kg/capita/year)	Population (Million)	GDP per capita (current US$)	Electricity consumption per capita year (kWh)	Imports of goods and services (% of GDP)	Gross capital formation (% of GDP)	Exports of goods and services (% of GDP)	Unemployment
Meat Consumption (kg/capita/year)	1.00							
Population (Million)	0.88	1.00						
GDP per capita (current US$)	0.91	0.89	1.00					
Electricity consumption per capita year (kWh)	0.91	0.96	0.97	1.00				
Imports of goods and services (% of GDP)	0.83	0.96	0.82	0.91	1.00			
Gross capital formation (% of GDP)	0.83	0.92	0.83	0.88	0.90	1.00		
Exports of goods and services (% of GDP)	0.80	0.95	0.78	0.90	0.96	0.84	1.00	
Unemployment	0.71	0.82	0.75	0.77	0.71	0.77	0.67	1.00

Table 3. Multicollinearity, serial correlation, and heteroskedasticity tests result

OLS Regression Results

Dep. Variable:	Meat	R-squared:	0.875
Model:	OLS Adj.	R-squared:	0.857
Method:	Least Squares	F-statistic:	49.13
Date:	Thu, 09 Mar 2023	Prob (F-statistic):	5.46e-20
Time:	22:20:50	Log-Likelihood:	-116.71
No. Observations:	57	AIC:	249.4
Df Residuals:	49	BIC:	265.8
Df Model:	7		
Covariance Type:	non robust		

Omnibus:	0.746	Durbin-Watson:	0.867
Prob(Omnibus):	0.689	Jarque-Bera (JB):	0.215
Test Statistic:	35.634	Test Statistic p-value':	0.0117
F-Statistic:	3.248	F-Test p-value:	0.0010
Breusch-Pagan Test Results			
LM Statistic:	23.592	LM-Test p-value:	0.0013
F-Statistic:	4.943	F-Test p-value:	0.00027
White Test Results			
LM Statistic:	35.6344	LM-Test p-value:	0.0117
F-Statistic:	3.248	F-Test p-value:	0.00105

Table 4. Anova result for variables

Regression Statistics	
Multiple R	0.990504
R Square	0.981099
Adjusted R Square	0.965372
Standard Error	3.687425
Observations	80

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	8	4525.02363	565.628	68.72648	2.28878E-30
Residual	71	584.339339	8.230132		
Total	79	5109.362969			

	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0.002739943	0.001202316	2.27888818	0.025640784	0.00034317	0.005136715	0.00034317	0.005136715
Years	-1.18332E-07	2.09611E-08	-5.645324517	3.06406E-07	-1.60117E-07	-7.65469E-08	-1.60117E-07	-7.65469E-08
Population	0.002129779	0.000650369	3.274724551	0.001627646	0.000833292	0.003426266	0.000833292	0.003426266
Actual GDP per capita	-0.012485217	0.003287521	-3.797760975	0.000302198	-0.01903877	-0.005931665	-0.01903877	-0.005931665
Actual Electricity Consumption	-0.540901825	0.2609988	-2.072430312	0.041806705	-1.061193424	-0.020610226	-1.061193424	-0.020610226
Actual Imports of Goods and Services (% of GDP)	0.768984356	0.20158562	3.814678624	0.000285499	0.367130767	1.170837945	0.367130767	1.170837945
Gross capital formation (% of GDP)	1.139232849	0.206576217	5.514830628	5.17122E-07	0.727430686	1.551035011	0.727430686	1.551035011
Exports of goods and services (% of GDP)	0.54719032	0.325607227	1.68052265	0.097189543	-0.101895824	1.196276465	-0.101895824	1.196276465
Unemployment	0.002739943	0.001202316	2.27888818	0.025640784	0.00034317	0.005136715	0.00034317	0.005136715

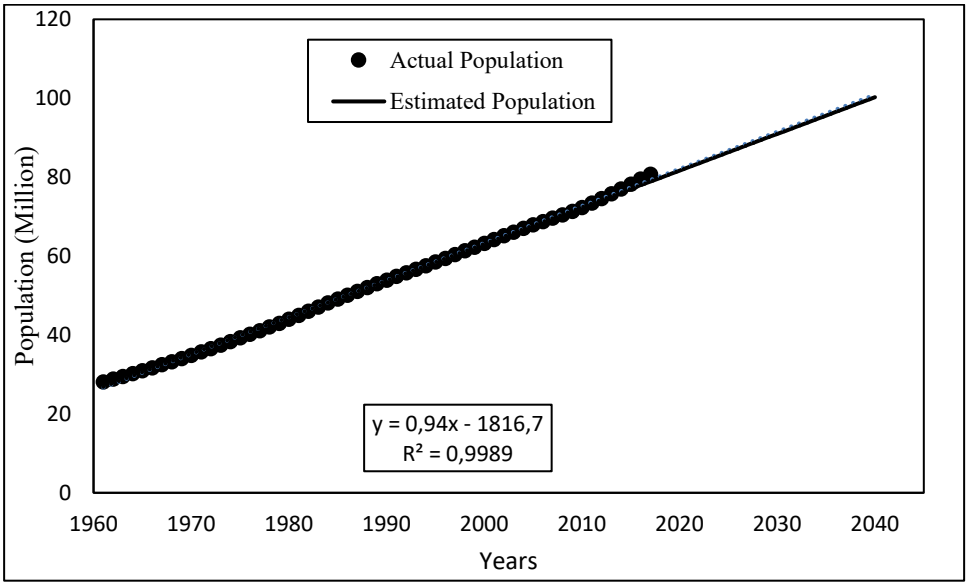

Figure 1a. Trend lines and estimated data of population, figures

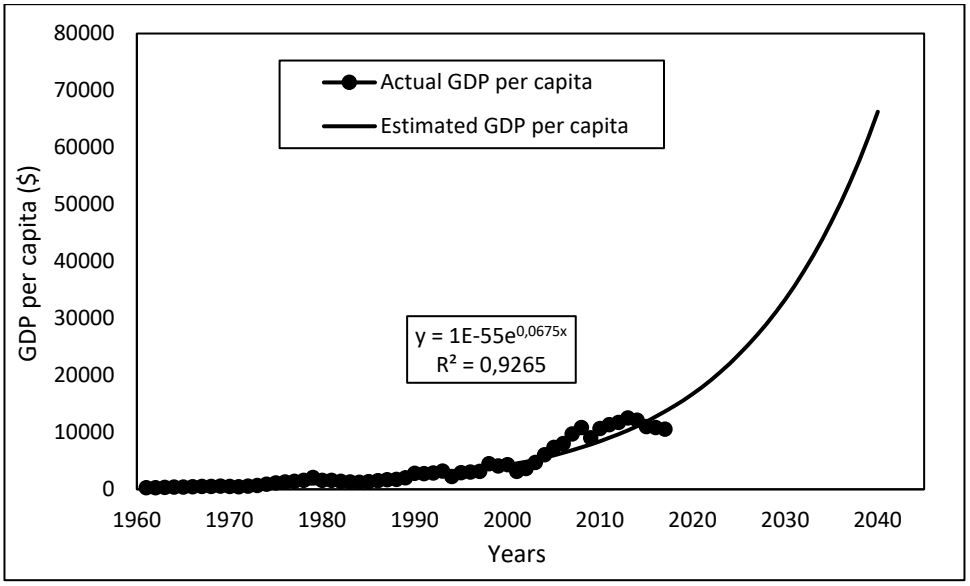

Figure 1b. Trend lines and estimated data of GDP per capita

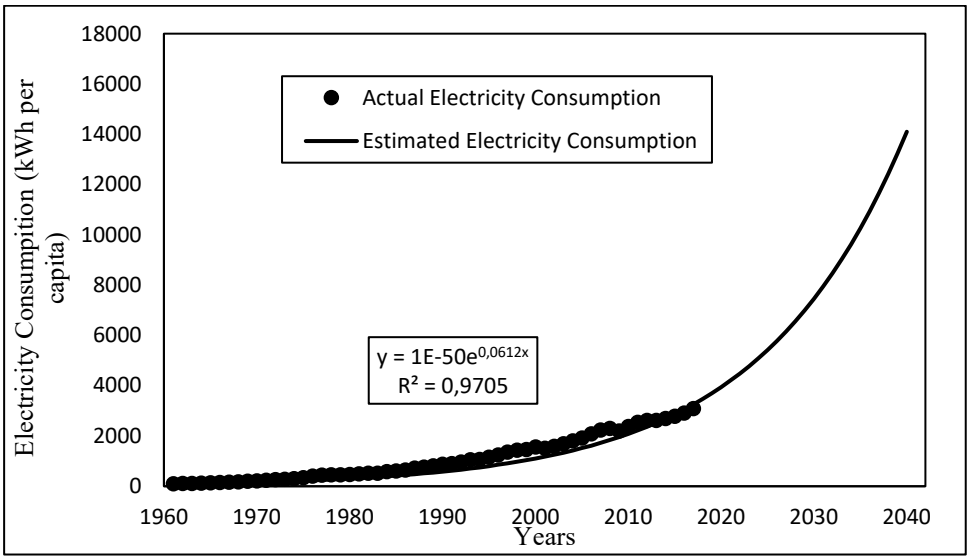

Figure 1c. Trend lines and estimated data of electricity consumption per capita

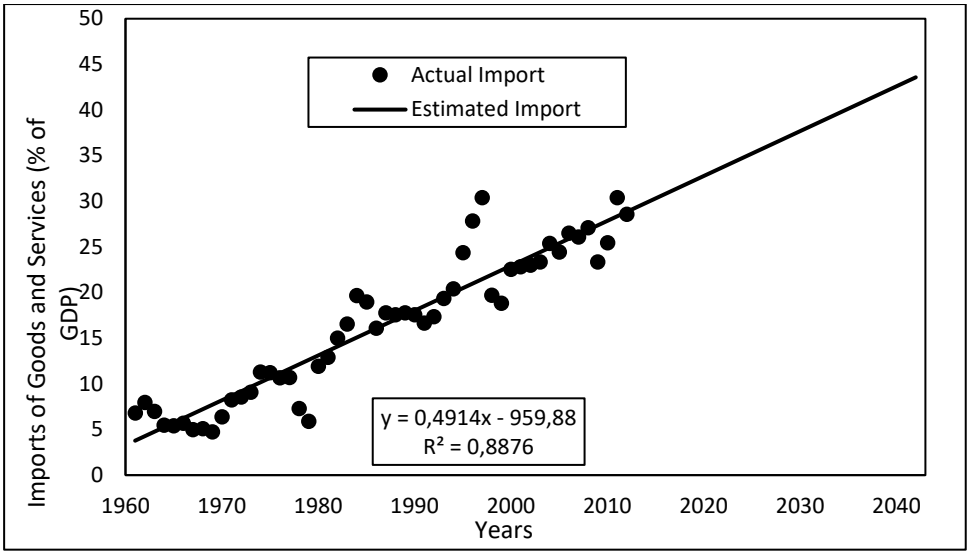

Figure 1d. Trend lines and estimated data of import per capita

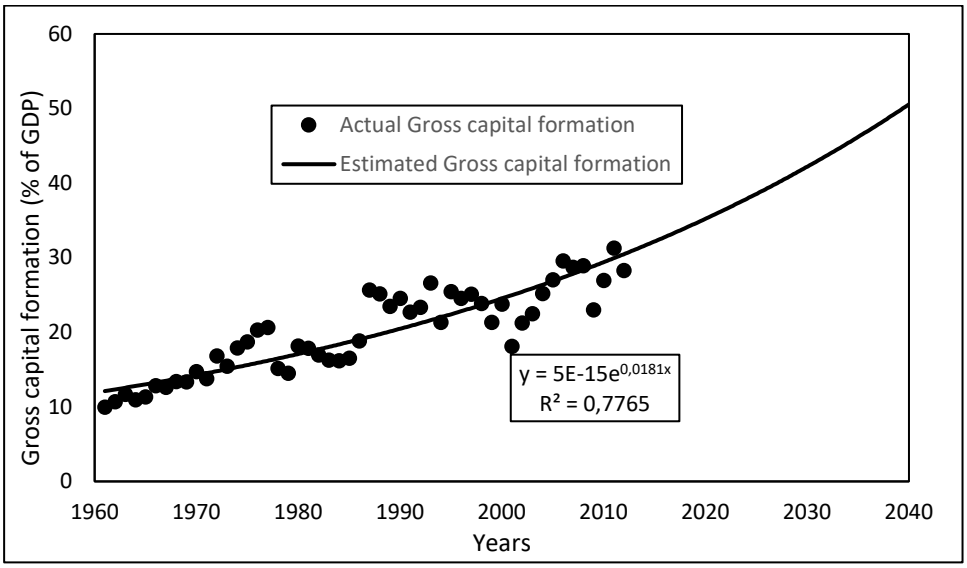

Figure 1e. Trend lines and estimated data of gross capital formation per capita

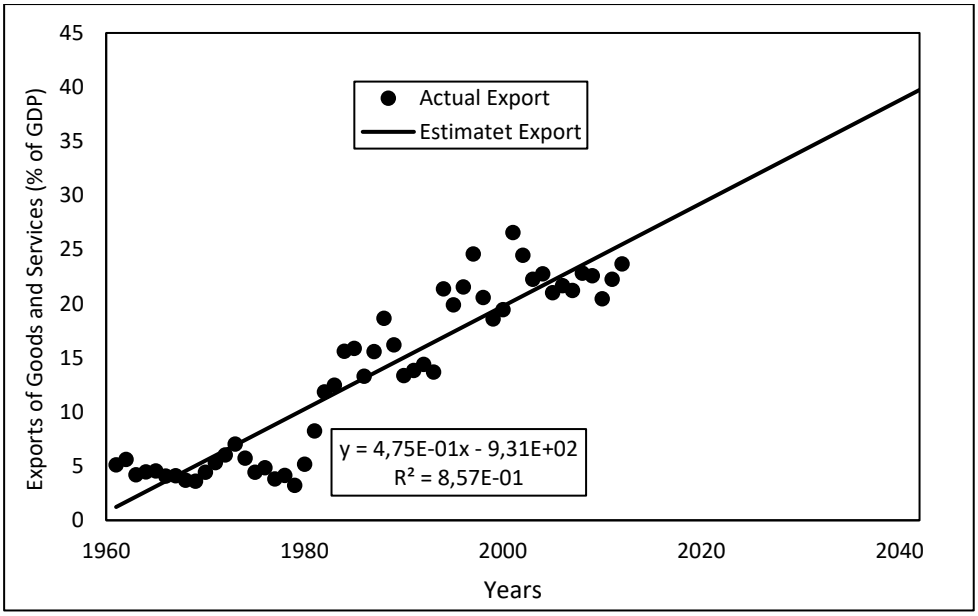

Figure 1f. Trend lines and estimated data of export per capita

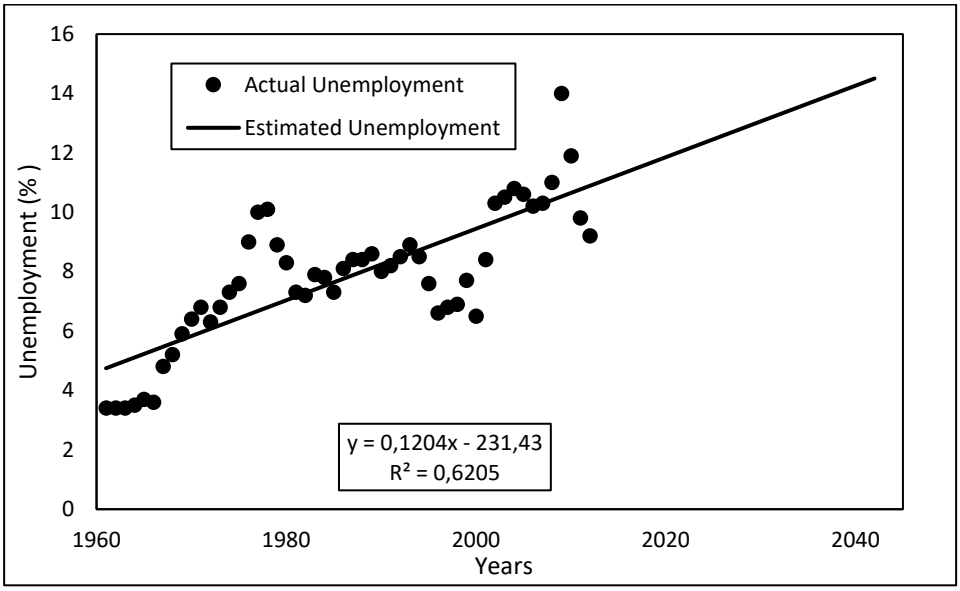

Figure 1g. Unemployment

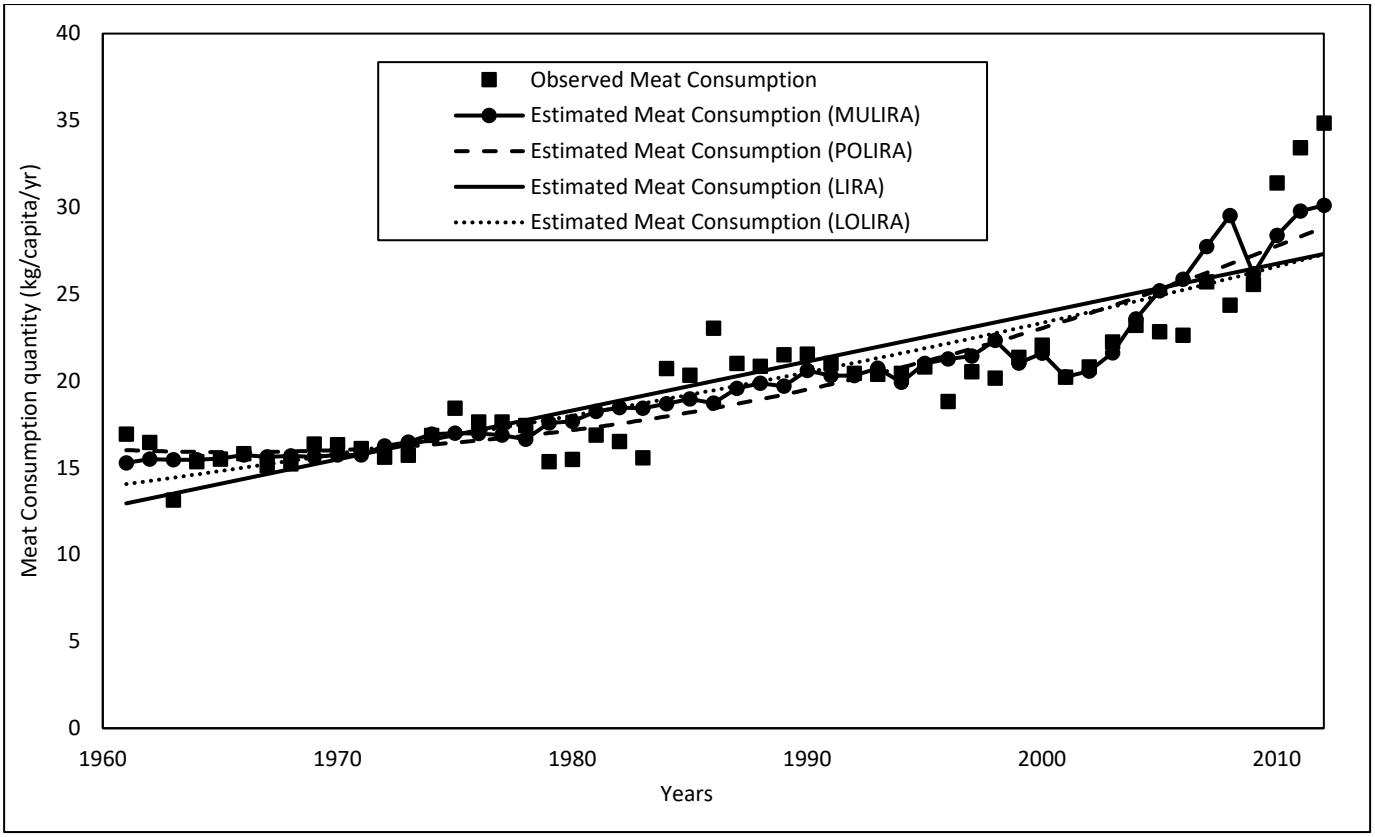

Figure 2. Actual and estimated values of meat consumption for 1961-2012.

Validation is very important for a model before using it for calculation. The model was validated for the five years in the range of 2013-2017. The results obtained from Linear Regression Analysis Models (MULIRA, LIRA, POLIRA, LOLIRA) were validated with observed data (See Table 3). The relative errors between the estimated data of the Minister of Development and observed meat consumption data are reported in Table 4. The MULIRA, LIRA, POLIRA, and LOLIRA model results are also compared with the estimated data of the Minister of Development (2014). As can be seen from Table 3 and Table 4, the MULIRA model provided better results than the Minister of Development (2014). The relative error between the observed and estimated values in the MULIRA model is the maximum for 2013 at -18.97%. For in the remaining years, it is less than 2%. To the Ministry of Development estimates, meat consumption has been predicted to be consistently higher than meat consumption. For example, in 2017, a high estimate of 50% was realised between the actual and estimated values. The estimation errors in 2017 are dramatic when they are compared with each other. The MULIRA model estimation error is 0.84%, while the estimation error of the Ministry of Development is 50.58%. However, the results obtained from other prediction methods (LIRA, POLIRA, LOLIRA) are better than the results of the Ministry of Development but not better than those of the MULIRA (See Tables 5 and 6).

Estimations between 2018 and 2040 using the MULIRA, LIRA, POLIRA and LOLIRA models were compared with the estimation of FAO-OECD (2019a) and FAO-OECD (2019b), and results are shown in Figure 3.

Table 5. Comparison of the linear regression models for meat consumption

	Observed Data FOA (2019)	MULIRA Prediction	Error %	LIRA Prediction	Error %	POLIRA Prediction	Error %	LOLIRA Prediction	Error %
2013	35.12	28.46	-18.97	27.59	-21.44	29.41	-16.26	27.64	-21.30
2014	29.27	28.96	-1.05	27.87	-4.77	29.98	2.44	28.00	-4.33
2015	28.94	29.50	1.92	28.15	-2.71	30.57	5.63	28.37	-1.98
2016	30.25	30.06	-0.64	28.44	-6.00	31.17	3.04	28.74	-5.00
2017	30.39	30.64	0.84	28.72	-5.50	31.78	4.57	29.11	-4.20

, Table 6. Comparison of the Ministry of Development for meat consumption

	Observed Data FOA(2019)	Ministry of Development Prediction (2014)	Error %
2013	35.12	40.52	15.38
2014	29.27	41.78	42.72
2015	28.94	43.08	48.85
2016	30.25	44.40	46.77
2017	30.39	45.76	50.58

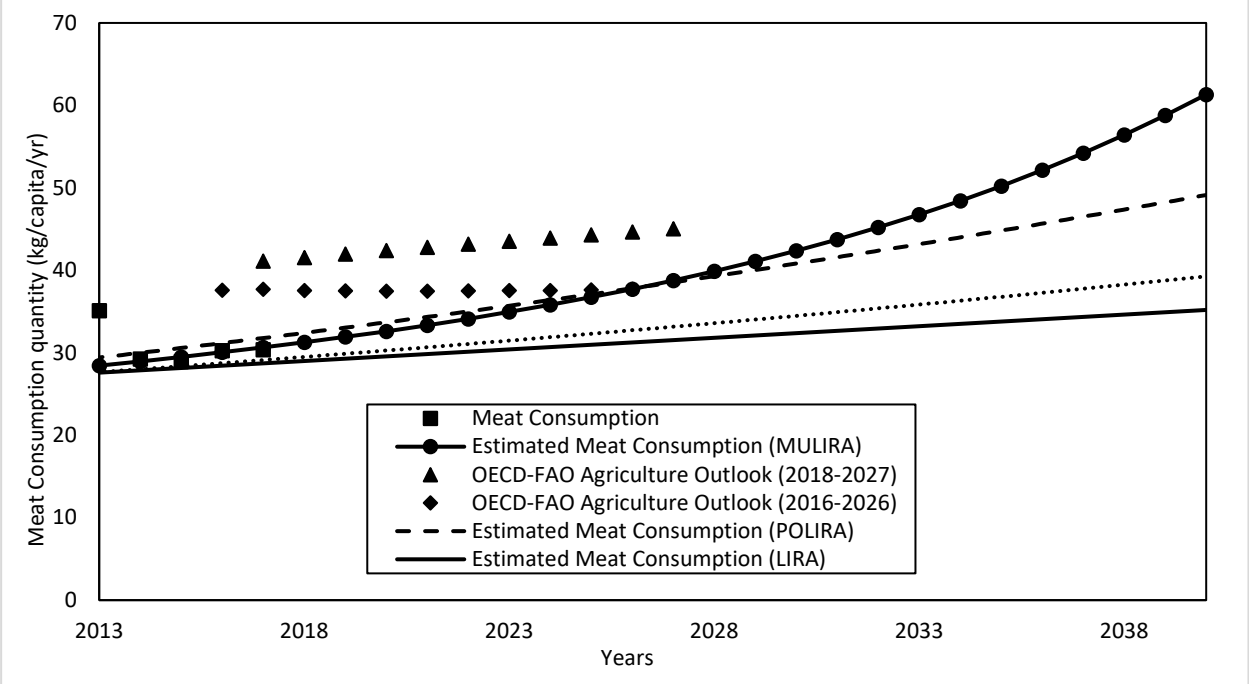

Figure 3. FAO-OECD (2019a) and FAO-OECD (2019b) overestimate than results of the present study.

Conclusion

In this study, the meat consumption of Türkiye is estimated based on Population, Gross Domestic Product (GDP) per capita, Electricity Consumption per capita, Imports of Goods and Services (% of GDP), Gross Capital Formation (% of GDP), Exports of Goods and Services (% of GDP) and Unemployment. The parameters of the Regression Analysis Models developed either in linear or exponential forms were obtained using the observed data. The MULIRA, LIRA, POLIRA and LOLIRA models were validated from 2013 to 2017 with observed data. The four different forms of Regression Analysis Models were performed, while the results obtained were compared projections. The following main conclusions may be drawn from the results of the present study:

(a) All models, Multiple Linear Regression Analysis (MULIRA), Linear Regression Analysis (LIRA), Polynomial Linear Regression Analysis (POLIRA) and Logarithmic Linear Regression Analysis (LOLIRA), can be used as an alternative solution and a prediction of meat consumption of Türkiye.

(b) The linear form of the MULIRA model seems a slightly better-fit solution with the observed data. Therefore, the MULIRA model can be selected for Türkiye's future meat consumption prediction.

(c) Social and economic indicators may be used for meat consumption. Economic development, especially GDP, is the most important factor in meat consumption.

(d) In the test period, the meat consumption estimates made by the Ministry of Development in 2013-2017 are overestimated. Estimates in this study for the same period agree with the actual values.

(e) This study estimates meat consumption in Türkiye using Regression Analysis Meat Consumption Model (RAMCM). The results are compared with the Ministry of Development values. However, an estimation of meat consumption may be investigated with Neural networks, Genetic Algorithms, Fuzzy Logic or other estimation methods. The results of the different techniques could be compared with the result of the present study for the comparison.

Compliance with Ethical Standards

Conflict of interests: The author declares that for this article, they have no actual, potential, or perceived conflict of interest.

Ethics committee approval: Authors declare that this study includes no experiments with human or animal subjects.

Funding disclosure: -

Acknowledgments: -

Disclosure: -

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