Modeling Meat Consumption and Short-Term Prospects

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Abstract

The prospects for development in the short term of the consumption of four main types of meat (beef, pork, poultry and lamb) are presented. The results are based on the developed partially equilibrium dynamic model „Meat". The aim of the present study is to substantiate the reliability of the approaches used to model consumption in these types of meat, revealing the substitution relationships between them. The trends in the levels of individual consumption as well as the annual variations are considered. The main independent variables that are included in the consumption equation for the different types of meat are distinguished. The elasticities, which determine the changes in the consumed quantities as a result from substitution dependencies between resultative value and independent variables are indicated. The applied approach for calibration of the model, by means of subjectively determined coefficients, allowing to derive a forecast for the individual level of consumption in the short term is demonstrated.

The most pronounced is the inverse correlation between retail price and consumption of poultry and pork, where the price elasticity is -0.8. In these two types of meat, the substitution effect is more noticeable, as the increase in the price of pork provokes an increase in the consumption of chicken meat with an elasticity of 0.6. The consumption of pork and lamb changes symmetrically with the increase in economic welfare, expressed in terms of GDP per capita, while the increase of beef consumption is the weakest. In the short term, the most serious increase is expected in the consumption of pork.

Key words: econometric modeling; meat; consumption; elasticity

Моделиране потреблението на месо и перспективи в краткосрочен план

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Резюме

Изведени са перспективите за развитие в краткосрочен план на потреблението на четири основни за страната ни видове месо – свинско, пилешко, говеждо, телешко и агнешко, на основата на иконометричен частично равновесен модел „Месо".

Целта на настоящото изследване е да се обоснове надеждността на използваните подходи за моделиране на потреблението при посочените видове месо, разкривайки субституционните зависимости между тях. Разгледани са тенденциите в равнищата на индивидуалното потребление, както и годишните вариации. Разграничени са основните независими променливи, съставящи потребителското уравнение при четирите вида месо. Определени са коефициентите на еластичност, които детерминират измененията в потребяваните количества, произтичащи от субституционните зависимости между резултативната величина и независимите променливи. Демонстриран е приложеният подход за калибриране на модела, посредством субективно определени коефициенти, позволяващи извеждането на прогноза за индивидуалното равнище на потреблението в краткосрочен план.

Най-силно изразена е обратнопропорционалната зависимост между цена на дребно и консумация при пилешкото и свинското месо, където ценовата еластичност е 0,8. При тези два вида месо е по-осезаем и ефектът на заместването, като повишението на цената на свинското месо провокира нарастване на потреблението на пилешко месо и обратно, с еластичност 0,6. Симетрично на повишението на икономическото благосъстояние, изразено чрез брутния вътрешен продукт (БВП) на глава от населението, се изменя консумацията на свинско и агнешко месо, докато при говеждото месо увеличението е най-слабо. В краткосрочна перспектива се очертава най-сериозно увеличение при консумацията на свинско месо.

Ключови думи: икометрично моделиране; месо; потребление; еластичност

Introduction

The development of animal husbandry in Bulgaria, including meat production, in recent decades has been marked by a number of problems such as low productivity and efficiency, a predominant share of small and medium-sized farms, limited financial opportunities, weak investment activity and low competitiveness (Mitova, 2016; Ivanov et al., 2017). The contribution of livestock to gross agricultural output decreased from 38.0% in 2007 to 22.3% in 2018 (MAFF, Agricultural report, 2008, 2019). Considered by sectors, during the same period the relative share of gross production of poultry meat in gross output from agriculture decreased from 5.2% to 3.6%, from pig breeding – from 4.7% to 3.6%, and from sheep breeding and goat breeding – from 4.6% to 2.4%. The significant decline in livestock numbers, most pronounced in pigs, sheep and goats, determines the reduction of meat production in the country. Despite the positive growth trends observed in the last few years in the production of pork and poultry meat, the harvested production is not able to meet domestic needs, which provokes a steady increase in imports. Given the importance of consumption as a factor for the development of production, it can be expected that the growing, albeit at a very slow pace, purchasing power of the population in the country will stimulate the growth of production.

Forecasting the dynamics of production and consumption in the short and medium term allows the development and comparison of scenarios for the application of different interventions in the meat sector. With this in mind, and through the tools of econometric modeling, a partially equilibrium model "Meat" was developed within the project "Establishment of Center for Agricultural Policy Analysis" (CAPA). The scope of the model includes four main modules for the production, consumption and trade in beef, pork, poultry and sheep (lamb).

The aim of the present study is to substantiate the reliability of the approaches used to model consumption in these types of meat, revealing the substitution relationships between them.

Methodology

The derivation of the consumer module in CAPA modeling is a part of the overall model specification of meat demand. The econometric modeling works with a system of equations, as the derivation of the purchase prices of the differ-

ent meats is external to the CAPA model. These prices are linked to European wholesale prices of meat, which reflects the high market integration of the Bulgarian meat market with the European and the fact that the country is a net importer of beef, pork and poultry, which is the reason for the high determination of domestic prices. Only in the case of lamb and mutton, Bulgaria is not a net importer and much of the consumption is supplied directly from the farms, but the external prices of lamb in neighboring countries and the EU are in this case an arbiter in fixing national price levels.

According to Listorti and Esposti (2012) the horizontal price transmission is a spatial relationship between the markets, such as between Bulgarian and European prices in most cases. There is also cross-commodity price transmission (Esposti and Listorti, 2011), and in CAPA modeling and especially in modeling the consumption of different meats, cross-commodity transmission between them is included. The model equations for the consumption of different meats and their functions in the CAPA model is as follows:

$$Y_{ACCBV} = \beta_0 + \varepsilon_1\beta_1 X_{PRBV} + \varepsilon_2\beta_2 X_{PRPO} + \varepsilon_3\beta_3 X_{PRPL} + \varepsilon_4\beta_4 X_{HI} + U_{ACCBV} \quad (1)$$

$$Y_{ACCPO} = \beta_0 + \varepsilon_1\beta_1 X_{PRPO} + \varepsilon_2\beta_2 X_{PRBV} + \varepsilon_3\beta_3 X_{PRPL} + \varepsilon_4\beta_4 X_{HI} + U_{ACCPO}\beta_5 Y^I_{ACCPO} \quad (2)$$

$$Y_{ACCPL} = \beta_0 + \varepsilon_1\beta_1 X_{PRPL} + \varepsilon_2\beta_2 X_{PRPO} + \varepsilon_3\beta_3 X_{PRPL} + \varepsilon_4\beta_4 X_{HI} + U_{ACCPL}\beta_5 Y^I_{ACCPL} \quad (3)$$

$$Y_{ACCSH} = \beta_0 + \varepsilon_1\beta_1 X_{PRSH} + \varepsilon_2\beta_2 X_{PRBV} + \varepsilon_3\beta_3 X_{HI} + U_{ACCSH}\beta_4 Y^I_{ACCSH} \quad (4)$$

The design functions for calculating the dependent variables – Y_{ACCBV}, $Y_{ACCPO,}$ $Y_{ACCPL,}$ Y_{ACCSH}, which represent the consumption of meat per capita are functionally dependent on the prices of the respective meats (X_{PRBV}, X_{PRPO}, X_{PRPL}, X_{PRSH}) and the cross-price elasticity between them and the income effect (X_{HI}). At the same time, X_{HI} is an independent proxy variable for income, which is represented by gross domestic product (GDP) per capita, deflated by the inflation rate. This variable is exogenous for the model and is taken as a complex index, taking into account the predictions of different institutions and agencies. Ivanov (2017) gives its derivation in CAPA modeling, as:

$$HI = f(GDP_{BG}), \quad (5)$$

where HI are the incomes of the population, and GDP is the GDP of Bulgaria, at:

$$GDP_{BG} = GDP_{BG}^{t-1} * GDP_{growth},$$

where GDP_{growth}, is exogenous variable taken from synthesizing various international forecasting agencies (IMF, EC, World Bank and Ministry of Finance).

One of the most important elements of the computational functions in CAPA modeling is the obtaining of the adjustment factor, which is respectively (U_{ACCBV}, U_{ACCPO}, U_{ACCPL}, U_{ACCSH}). Following the CAPA modeling, the error or adjustment factor is also subject to modeling using the Error Correction Model (ECM), which is:

$$U_{ACC} = \beta_5 Y^I_{ACC} + U^I_{ACC} \quad (6)$$

The variables Y^I_{ACC} and U^I_{ACC} are the first derivatives of the dependent variables for the individual consumption of beef and veal (Y_{ACCBV}), pork (Y_{ACCPO}), poultry (Y_{ACCPL}) and sheep and lamb (Y_{ACCSH}). From there was obtained:

$$Y^I_{ACC} = Y_{ACCt} - Y_{ACCtavg} \quad (7)$$

The error correction model is one of the most common tools in applied econometric modeling, which attempts to reduce the stochastic error and to fix the adjustment factor. Alogoskoufis and Smith (1991) described the path that this modeling tool takes, as well as the different modalities that are applied by individual researchers. Hendry (1980) set the closest expression to the ECM, where:

$$\Delta Y = \alpha + \beta\Delta X - \gamma\,(Y_{t-1} - X_{t-1}) + \varepsilon_t \quad (8)$$

Where it is stated that the dependent variable (Y) itself is dependent on itself, and not only on the independent variable (X), which serves to include this element, in order to correct the error in a stationary model:

$$Y = \alpha / \gamma + X \quad (9)$$

The elasticities that show the strength of the response of the dependent variable, in this case individual consumption, when changing the individual types of prices (X) are also subject to calculation and are not exogenous or dummy estimates. Martin Sadd (2005) developed and

showed in great detail how large the elasticity application is, far beyond the economy, as it is the ratio between:

$$E = \Delta Y / \Delta X \quad (10)$$

Ivanov (2020) developed and used a different method for calculating the elasticity, and by means of additional calibration of the elasticity coefficient, the final result for the factor elasticity is obtained. According to him, the elasticity is not the difference between the current and its previous value for a given indicator, but the difference with the average:

$$E = \sum_{k=1}^{t} \frac{(Y_t - \overline{Y}) / \overline{Y}}{(X_t - \overline{X}) / \overline{X}} \quad (11)$$

The effect, achieved by changing the elasticity calculation, is to maintain the consistency and stability of the coefficient, which in the case of ΔY and ΔX sometimes undergoes an overreaction and shows large amplitude that is not symmetrical between the two variables.

CAPA modeling understands the importance of solving these two key technical elements of the computational functions (the adjustment factor and the elasticity), which together with the relevance of the included variables and the system of equations predetermine the reliability of the results. By designing the consumption per capita of the four types of meat, we proceed to obtain the gross result for the consumption of meat, where:

Total Meat Consumption =
Y * Population Number (12)

Results

Substitution dependencies, expressed in terms of price elasticity, substitution effect and income effect in poultry, pork, beef and veal and sheep and lamb, are crucial for the projection of the consumption per capita. The value estimates of the inversely proportional relationship between price and quantity consumed for the four types of meat are given in Table 1. The price elasticity of meat, as a food product, is inversely proportional by default, but at the same time it depends on the change in the inflation of consumer goods. If the overall inflation of consumer goods changes in one direction or another to a greater extent than for meat, this leads to a different elasticity for meat. That is why CAPA modeling uses deflated retail prices for meat, which helps to more accurately measure own-price elasticity.

In a study of Lusk and Tonsor (2015) is assert that "own-price elasticities are more inelastic for a price increase (for higher prices) than they are for a price decrease (for lower prices)". This observation was related to consumer reactions in the United States, with higher prices showing relative inelasticity, indicating the role of income elasticity, which intervenes in parallel with price elasticity.

The relatively low and slowly growing incomes of the population in the country determine the behavior of price elasticity of meat, and due to this fact, the price elasticity of demand increases with price increases and decreases with decreasing prices. Price changes have the most significant impact on the demand for pork and poultry, which occupy the largest share in the national diet. The coefficient of elasticity shows that when the price increases with 1 unit, the quantity consumed decreases by 0.8 units. Traditionally, the higher market price of beef and veal in the country determines the smaller quantities consumed by households. For this reason, the price elasticity is lower (-0.6) compared to the coefficient estimate for pork and poultry. If the price of beef becomes cheaper, its price elasticity will also increase. The increase in income will also lead to a change in price elasticity, which may acquire the ratios observed by Lusk and Tonsor (2015).

The seasonality of the consumption of lamb and mutton, which is present mainly in special cases in the consumption of people in the coun-

Table 1. Price elasticity of different types of meat

Indicator	Value
Price elasticity of beef and veal (εX_{PRBV})	-0.6
Price elasticity of pork (εX_{PRPO})	-0.8
Price elasticity of poultry (εX_{PRPL})	-0.8
Price elasticity of mutton and lamb (εX_{PRSH})	-0.3

Source: Meat model, CAPA.

try, determines the lowest value of the coefficient of price elasticity for this type of meat. When the price increases by 1%, the quantity consumed decreases by only 0.3%, which is a typical reaction to goods belonging to a special category, which is not associated with daily and mass consumption.

The substitution effect is most pronounced between pork and poultry. The assessment of cross-price elasticity shows that an increase in the price of pork by 1% leads to an increase in the amount of poultry meat consumed by 0.6% and vice versa (Table 2). The consumption of pork changes in the same ratio with an increase in the price of poultry. The change in the retail price of beef and veal has the most significant effect on the individual consumption of pork at a value of the cross-elasticity coefficient of 0.4. The percentage increase in the price of beef and veal leads to an increase in the consumption of poultry by 0.3%, as well as of sheep and lamb by 0.2%.

The effect of income has the most significant impact on the demand for pork and sheep and lamb, as the amount consumed per capita increases symmetrically with the growth of purchasing power (Table 3). Given the higher retail prices of these two types of meat, the assessment of elasticity demonstrates the presence of consumer preferences, but also opportunities to replace them in lower incomes. Consumption of poultry meat, as the cheapest and most affordable animal protein, reacts less to the change in income. The increase in purchasing power by 1% leads to an increase in the quantity of consumed poultry meat by 0.7%. The income effect is weakest in beef and veal with a demand elasticity coefficient of 0.1. Beef and veal maintains the highest retail price compared to other meats, which is largely due to shrinking production in the country. At the same time, a large part of the quantity produced is from dairy animals, which causes large differences in the quality of meat on the market, while consumers are constantly increasing their requirements.

Annual data on the quantity of pork consumed per capita (including direct consumption and processing) show an upward trend since 2007, reaching 28.3 kg in 2018 (Fig. 1). An exception was observed only in 2012 and 2013, when consumption remained at 22.6 kg due to the more significant increase in retail prices.

The projection of consumption per capita in the period 2019–2022 reflects both the indicated substitution dependencies between the different meats, taking into account the horizontal and cross price transmission, forming the expected price changes, as well as the projected change in income. The forecast estimate of consumer demand, derived as the first derivative of the dependent variable in the CAPA model, was corrected by the negative values of the adjustment factor, determined on the basis of the deviations from the historical data for the previous seven years. Pork consumption is projected to continue

Table 2. Cross-price elasticity between different meats

Indicator	Value
Cross-elasticity of beef and veal from the price of pork (εX_{PRPO})	0.4
Cross-elasticity of beef and veal from the price of poultry ($\varepsilon X_{PRPL)}$	0.3
Cross-elasticity of pork from the price of beef and veal (εX_{PRBV})	0.4
Cross-elasticity of pork from the price of poultry (X_{PRPL})	0.6
Cross-elasticity of poultry meat from the price of beef and veal (εX_{PRBV})	0.3
Cross-elasticity of poultry from the price of pork (εX_{PRPO})	0.6
Cross-elasticity of sheep and lamb from the price of beef and veal (εX_{PRBV})	0.2

Source: Meat model, CAPA.

Table 3. Income effect on the consumption of different types of meat

Indicator	Value
Income effect on demand for beef and veal (εX_{HI})	0.1
Income effect on demand for pork (εX_{HI})	1.0
Income effect on demand for poultry (εX_{HI})	0.7
Income effect on demand for sheep and lamb (X_{HI})	1.0

Source: Meat model, CAPA.

to grow from 32.2 kg in 2019 to 36.9 kg per capita in 2022. The factor changes forming the forecast are mainly reduced to the expected income growth, which will be stronger than the projected increase in the retail price of pork – by about 0.9% on average for 2019–2022 compared to the average for 2015–2018. The impact of the substitution effect on beef and veal was also considered, where a more significant increase in price levels in real terms is expected – by about 6.8% for the two periods compared.

The values of consumption per capita of poultry meat show some fluctuations in the period 2007–2013, while after 2014 the quantity consumed is constantly increasing, under the influence of production growth and cheaper imports (Fig. 2). Retail prices in the short term are projected to be around 4.72–4.86 BGN/kg,

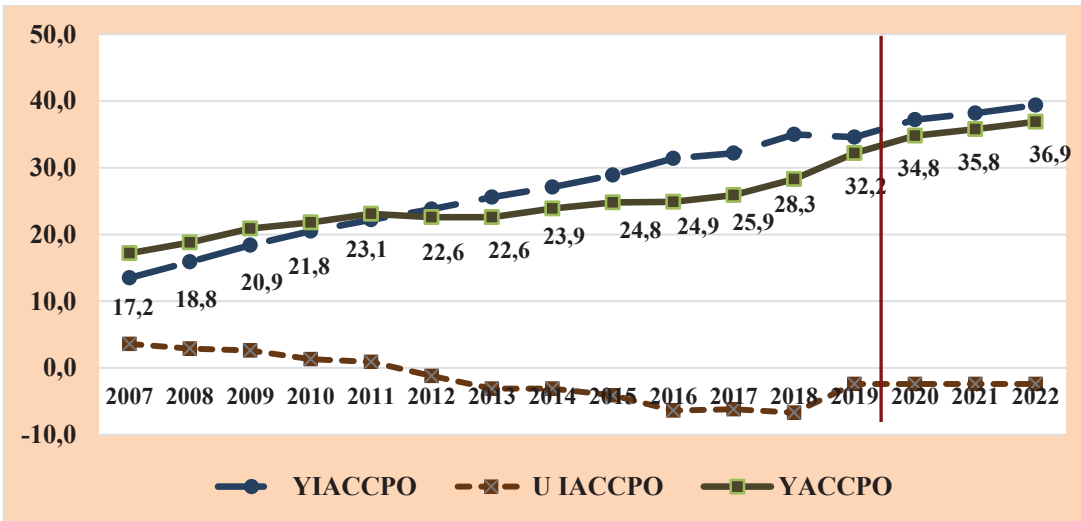

Fig. 1. Modeling the consumption per capita of pork, kg
Source: MAFF, NSI and Meat model, CAPA.

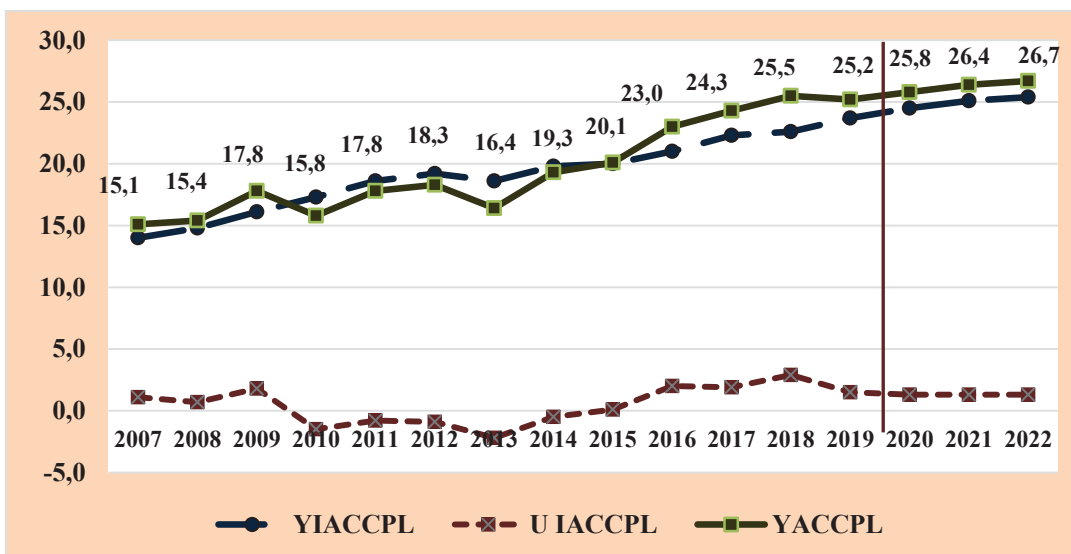

Fig. 2. Modeling the consumption per capita of poultry, kg
Source: MAFF, NSI and Meat model, CAPA.

which is slightly above the average level for the years from 2015 to 2018 – 4.79 BGN/kg and will not be negatively affect the level of consumption.

The expectations are that the positive trend will continue in the next four years, as the quantity consumed per capita will be between 25.2 kg and 26.7 kg. The forecast reflects the substitution dependencies between the quantity of poultry consumed and the expected positive change in the prices of beef and veal and pork. The presence of a positive difference between the historical values of consumption and its projection in most of the studied years determines the positioning of the adjustment factor at the level of 1.3 kg, which corrects the initially determined forecast values.

The higher selling price of beef and veal compared to the prices of pork and poultry, against the background of the relatively low purchasing power of the population, is the main factor holding back the growth of consumption.

The emerging trend in the period 2007–2018 shows a decrease in consumption from 4.8 kg to 3.7 kg per capita. The forecast for the development of retail prices in the next four years indicates an increase to a level of about 12.70 BGN/kg, which will have a negative impact on the level of consumption. The correction of the initially forecast is positive and raises the estimate of consumption to a level of 4.2 kg per capita in 2019, and this level is expected to decrease over the next four years.

The consumption per capita of sheep and lamb is at the lowest level compared to other types of meat. Besides the seasonality of consumer demand, the high market price as a result of the reduced production in the country also has an impact. The annual values of consumption in the last twelve years are relatively stable, most often at the level of 1.3 kg per capita with small fluctuations (Fig. 4). The differences between the projection of the first derivative of the dependent variable and the historical levels in the previous six years are negative values, which determines a correction in decrease of 0.39 kg. The forecast based on the horizontal price transmission outlines an increase in retail prices by about 1.6% on average for the period 2019–2022 compared to the average for 2015–2018. The growth in the prices of beef and veal, as the main substitute for lamb, is more significant, which determines the impact of the substitution effect in the direction of increasing consumption. At the same time, with the increase in income, a symmetrical increase in consumption is expected, reflecting the magnitude of the income elasticity of sheep and lamb demand. Taking into account the influence of these factors, in the next four years an increase

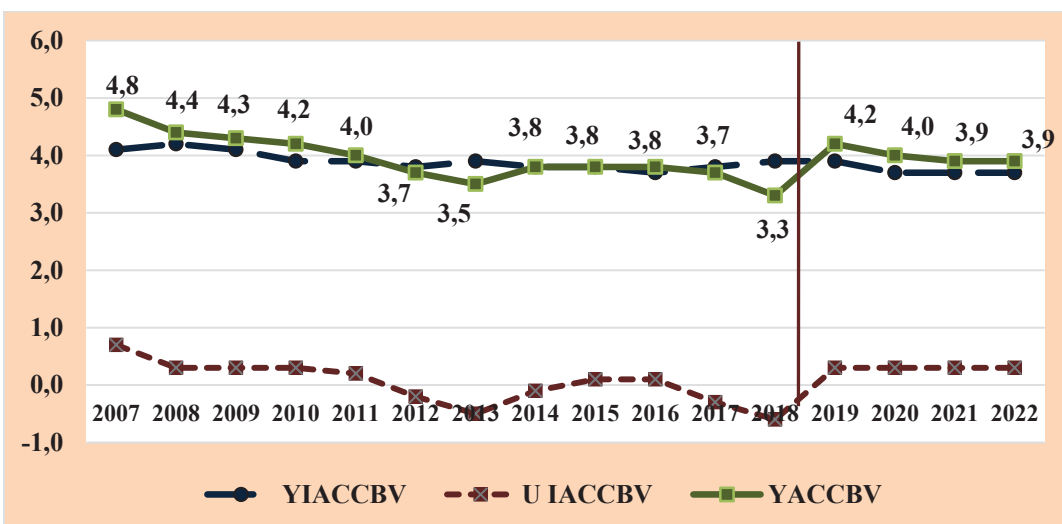

Fig. 3. Modeling the consumption per capita of beef and veal, kg
Source: MAFF, NSI and Meat model, CAPA.

in the level of consumption is forecast from about 1.4 kg to 1.6 kg per capita.

Total domestic consumption, derived as a projection of per capita consumption and the projected number of population, outlines the most serious upward trend in pork (Fig. 5). The quantities of meat used in the country for direct consumption and processing are expected to reach 233.3 thousand tons in 2022. The projected excess of total consumption on average for the period 2019–2022 compared to the average level for 2015–2018 is with 20.9%. Despite the declining population, the driving factor will be the increase in income in conditions of high price levels of beef and veal.

The total domestic consumption of poultry meat in the country will also increase, but at a slower pace than pork. The quantity consumed in the country is projected to reach 181.2 thousand tons by 2022, which is 1.5% above the level of 2018 and 10.4% above the average for the previous four years. The income elasticity of demand

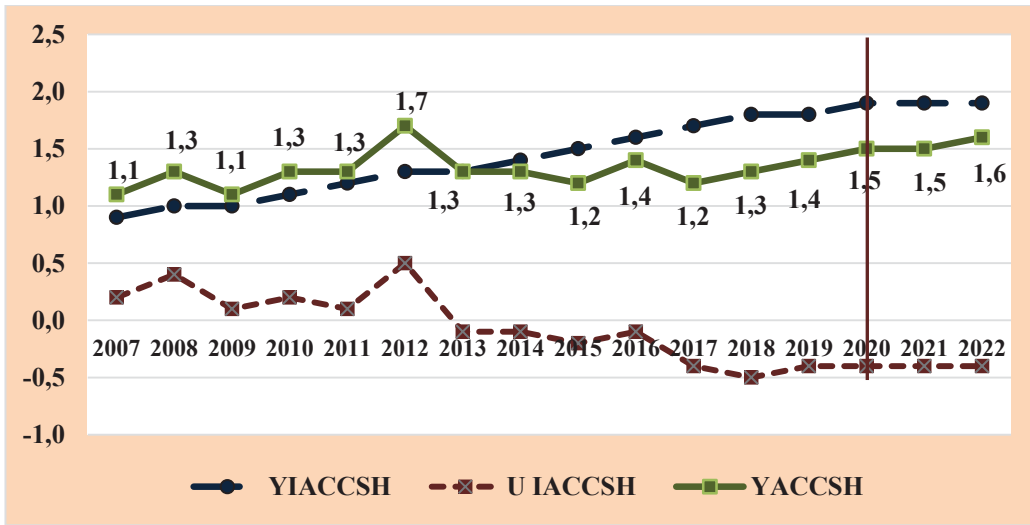

Fig. 4. Modeling the consumption per capita of sheep and lamb, kg
Source: MAFF, NSI and Meat model, CAPA.

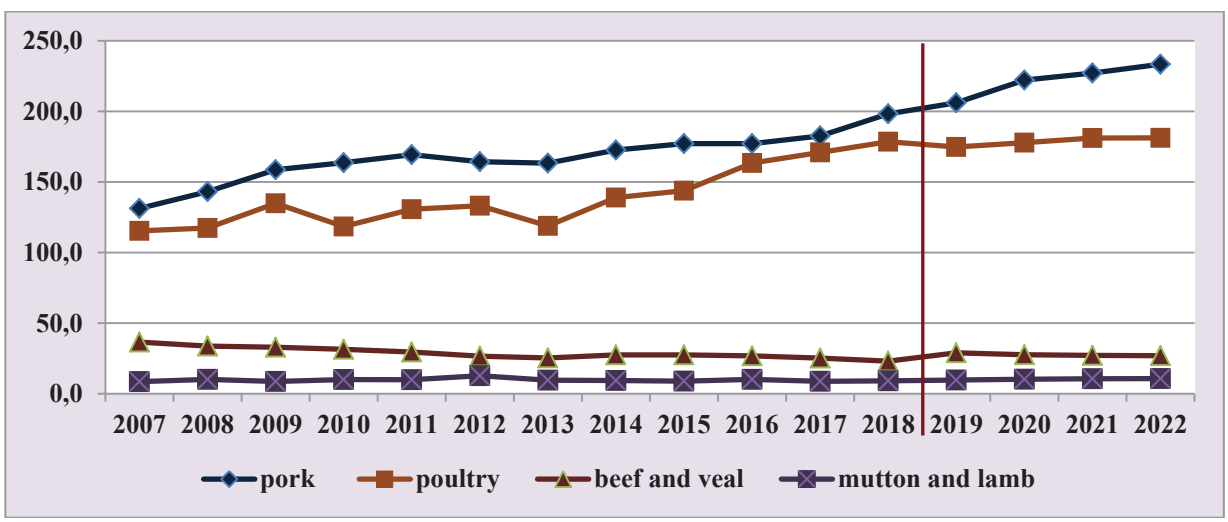

Fig. 5. Total human consumption of pork, poultry, beef and veal, and mutton and lamb, thousand tons
Source: MAFF, NSI and Meat model, CAPA.

for poultry meat is weaker than that of pork, which explains the more moderate growth rate, taking into account the substitution dependencies on the prices of pork and beef and veal.

An increase is also expected in the total consumption of sheep and lamb in the country as the average projected amount for the next four years is 10.3 thousand tons, which is 11.7% above the average level for the period 2015–2018. The symmetrical reaction of the demand quantity to the income growth determines the derived forecast.

The growth rate will be the lowest in the total consumption of beef and veal, as the projected quantity for 2019 is 29.0 thousand tons. Domestic consumption is expected to gradually decrease in the coming years, reaching a level of 26.9 thousand tons in 2022, which is close to the level of 2016. The comparison between the average values of consumption for the two compared periods shows that the expected excess is 7.8% during the forecast period compared to the average for 2015–2018.

Conclusions

The obtained results from the modeling prove the reliability of the applied approach in the projection of the per capita consumption and the total domestic consumption, reflecting the specifics of the influencing factors. The estimation of elasticities, derived on the basis of the differences between the current and average values of the resultant and factor values, provides greater precision in determining the substitution dependencies, based on the consistency and stability of the coefficients. By applying the error correction model, a higher accuracy of the adjusting factor is achieved, which allows the derivation of a more accurate projection for the consumption per capita.

Specifically for the conditions of the Bulgarian meat market, the macroeconomic environment and the forecast for the development of purchasing power of population, the results of the model show the strongest interchangeability between poultry and pork meat, as a reaction to price changes. The increase in income has the greatest effect on the consumption of pork and sheep and lamb. It can be said that the demand for meat is more elastic to prices compared to the income elasticity in beef and less inelastic in lamb. The modeling shows that the income elasticity of meat demand is slightly stronger than the price elasticity, which can be considered the economic reality in the country, characterized by relatively low incomes of people. As incomes rise, price elasticity can be expected to increase, while income elasticity may shrink.

Given the derived dependencies in the short term, the most serious increase in domestic consumption of pork is forecast. The shrinking production in the country and the expected increase in retail prices of beef and veal, taking into account the weak elasticity to income, will restrain the growth of consumption in the next four years.

The forecast derived by the econometric modeling method does not take into account the impact of emergencies, such as the spread of COVID-19 and its impact on economic indicators and especially on income. In view of the expected negative consequences, adjustments in the projected values of meat consumption are possible.

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