Hungarian University of Agriculture and Life Science

Szent István Campus

M.Sc. in Rural Development Engineering

ASSESSING THE SECTORAL AND CROSS-SECTORAL IMPACTS OF NEW EU ANIMAL WELFARE MEASURES IN HUNGARY

An economic analysis on the recent proposal by the European Food Safety Agency and the European Commission on broiler chicken growth rate and stocking density reduction

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1. Introduction

Europe's chicken broiler industry plays a significant role in providing animal protein for global consumption. However, the industry faces challenges such as poor growth, increased mortality, and infectious diseases, such as transmissible viral pro-ventriculitis and necrotic enteritis. To address these challenges, reduced stock density and growth rate strategies have been proposed as a potential solution. The European Food Safety Authority and the European Commission have released an animal welfare measure offering a maximum stock density of 11kg/m² and a 50 grams/day growth rate for conventional broilers. (EFSA, 2022).

The present research was held in the Hungarian chicken broiler market because this sector is, after pork, the second largest in terms of production with 345.1 thousand tonnes produced in 2022 (AKI, 2022) at the same time one of the most controversial in terms of responsible farming technics. Due to the technological progress in terms of feed efficiency, chickens are bred at an accelerated growth rate of more than 60 g/day in a high-density environment to reach maximum cost-efficiency performance. Since animal welfare measures are taking more importance in Europe it`s extremely important to analyze the economic impact on the market to advise policymakers on the possible scenarios to keep in the best way possible the market equilibrium.

The main objective of the present thesis is to identify the combined sectoral and cross-sectoral economic impact of reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary. However, an independent analysis is also presented, which means the sectoral and cross-sectoral impact if only the stock density reduction measure is applied and the economic impact if only the growth rate reduction measure is applied.

To achieve our research objectives, agro-economic modeling technics such as multiple linear regression models are valuable tools utilized for understanding the complex interactions between animal welfare measures and economics in the poultry industry. The poultry industry has a significant effect on the national economy, and it is a popular industry for smallholders with a tremendous contribution to GDP and employment creation (Oladokun & Johnson, 2012).

The software used is called AGMEMOD (AGricultural MEmber states MODelling) which is an econometric, dynamic, partial-equilibrium, multi-country, multi-market model. It was developed for European Union agri-food markets at national levels. Its country-specific models reflect the details of agriculture at the member-state level while allowing their combination in an EU model. It enables the user to model the impact of policy changes across different countries.

Besides this method, the primary Hungarian poultry producers' enterprises were analyzed. A sample of 24 enterprises for 2019 and 23 for 2021 were analyzed to calculate the impact of the growth rate reduction and stock density in their production. These enterprises represent 84% of the total annual production of chicken meat for 2019 and 99% for 2021, the total production of broiler meat taken into account for the comparison is published by the Institute of Agricultural Economics.

Reduced stock density and growth rate strategies have the potential to bring about significant economic benefits for the broiler industry (Lim, Rana, Choi, & Ryu, 2019) These strategies also have the potential to enhance animal welfare, reduce infection rates, and increase feed efficiency. Studies have shown that high stocking densities, such as reduced growth performance, poor feathering, and foot pad dermatitis, can negatively affect bird welfare. By implementing reduced stock density and growth rate strategies, the incidence of these adverse effects on bird welfare could potentially be reduced. (Zhao, et al., 2021).

Implementing reduced stock density and growth rate strategies may not necessarily lead to significant economic benefits for the broiler industry. Firstly, reducing stock density would require more space to house the birds, which could result in additional costs for farmers regarding housing facilities (Hamed, 2020).

Lowering the number of animals in a given area may cause the available space and resources to be underutilized, leading to less efficient use of resources. Additionally, birds that grow more slowly take longer to reach the weight they can be processed, increasing the cost of feeding and labor over time. Moreover, reducing the amount of meat produced per unit of area can further increase production costs due to inefficiencies during the growing stage, which may affect profitability (Kumar, 2016). Finally, several factors beyond stocking density affect bird welfare, such as air quality and lighting conditions, among others.

Therefore simply lowering stocking densities without addressing other welfare issues does not necessarily lead to overall improvements.

In conclusion, while implementing reduced stock density and growth rate strategies could improve animal welfare which is essential consideration; economic benefits become more complex since they depend on many factors beyond just these two parameters. Thus, conducting a rigorous cost-benefit analysis might be necessary before embarking on change towards lower stocking densities or slowing down growth rates.

2. Literature Review: Understanding the European broiler chicken market in and the econometric tools to assess it

2.1. The Poultry sector in Europe

The European Union is among the biggest producers of poultry meat globally and exports exceed imports. It produces about 13.4 million tons of poultry meat per year.

Poultry is included in the standard market organization among EU member states. This organization serves several purposes, including creating a safety net for agricultural markets and setting minimum quality standards. The EU imports valuable poultry products, such as breast meat and poultry preparations, mostly from Brazil, Thailand, and Ukraine, while it exports poultry products with a lower value. Poultry farmers may also receive direct payments as income support (European Commission, n.d.).

The COVID-19 pandemic made 2020 and 2021 difficult, but 2022 has proven to be even more challenging, possibly the most brutal year of the millennium, due to the Ukraine crisis's direct impact on global energy prices, fertilizers, and feed commodities. Feed and energy prices have skyrocketed, and it is still being determined how they will develop in the future. The challenges posed by COVID-19 are still present, and the poultry industry is currently experiencing one of the worst avian influenza seasons on record. This situation could explain the increase in chicken meat prices during the 2021-2022 period (AVEC, 2022).

Despite the ongoing concern about inflation, chicken meat remains a relatively affordable option compared to other animal proteins. In 2022, the European Union saw a 13% increase in chicken meat imports, and this growth is predicted to continue in 2023 due to high demand from the hospitality, restaurant, and institutional sector. The EU's demand for chicken meat from Ukraine specifically saw a significant increase of 60% in 2022, as the temporary EU free-trade measures aimed at supporting Ukraine benefited imports. In contrast, EU chicken meat exports decreased by 6.1% in 2022 and are expected to continue to decline in 2023 due to restrictions related to highly pathogenic avian influenza (HPAI) and the reduced price competitiveness of the EU compared to other global suppliers (The poultry site, 2023).

2.2. The new Common Agricultural Policy

The CAP has evolved throughout the years to consolidate a future for the role of European agriculture. This evolution will be helpful to meet the economic circumstances changes and the needs of the citizens.

In June 2018, the European Commission introduced proposals for legislation for a new CAP. These proposals have outlined a more efficient policy that could incorporate the sustainable goals of the European Green Deal.

Following prolonged discussions among the European Parliament, the Council of the EU, and the European Commission, a consensus was eventually reached on reforming the Common Agricultural Policy (CAP). The revised CAP was officially adopted on December 02nd, 2021. The implementation of the new CAP is scheduled to begin on January 01st, 2023 (European Commission, n.d.).

2.3. The Poultry Industry in Hungary

The poultry sector plays a significant role in Hungary's economy and is a popular industry among smallholders, contributing significantly to GDP and employment. Its economic value is considerable, as it is a fast-growing industry that produces a large quantity of animal food and contributes significantly to the GDP. However, the poultry industry in Hungary has encountered various obstacles, such as the 2016 avian influenza outbreak that affected many European countries. Implementing efficient feed formulation practices is necessary, given that poultry feed accounts for more than 70% of the total cost of producing eggs and broilers to ensure a sustainable poultry industry (Adlhoch, H. Brown, & Angelova, 2016).

In Hungary, the poultry sector has encountered difficulties in disease control. The identification of Fowl Adenovirus serotypes 1, 8b, and 11 in various nations has global implications for the poultry industry, as controlling immunosuppressive agents such as chicken anemia virus and infectious bursal disease virus may not be enough to regulate Infectious Bursal Disease (IBH) entirely (Steer, et al., 2015).

In recent years, the broiler industry in Hungary has been a significant contributor to the country's economy. However, in 2022, the total output of live animals and animal products was lower than the previous year; this episode was influenced by veterinary emergencies such as African swine fever and avian influenza and unfavorable economic conditions resulting from a significant increase in expenditure that impacted livestock production. The number of live animals was reduced by 8.0%, with a decrease in the volume of poultry by 10%, cattle by 8.0%, pigs by 6.0%, and other animals by 5.0% (HCSO, 2023). The Hungarian broiler industry was affected by the COVID-19 pandemic, as were other sectors within the agri-food industry, due to disruptions in supply chains and changes in consumer behavior. Nevertheless, the broiler industry has demonstrated resilience and has adjusted to the new market conditions (Mizik, 2021).

Hungarian SMEs, including those in the broiler industry, need help concerning technological advancement. In order to endure the competitive atmosphere of Industry 4.0 and the COVID-19 era, digitalization and innovation are crucial for these companies. The level of digitalization and participation in e-commerce can be instrumental in their success (Endrődi-Kovács & Stukovszky, 2022). In the most challenging hit sectors, the implementation of Industry 4.0 and digitalization are critical for the survival of Hungarian SMEs.

The conflict between Ukraine and Russia has caused disturbances in food production in Ukraine, resulting in a sharp decline in the projected yield of wheat, soybean, and maize for 2022-2023. In contrast, Russian production of these three food items has shown positive growth during the same period. The global food supply chain and trade have also been adversely impacted, leading to a surge in the worldwide cost of food. From March to May 2022, the average global prices of wheat, soybeans, and maize significantly increased compared to pre-COVID-19. Consequently, this poses a threat to global food security, particularly for low-income nations that heavily rely on food imports from these two countries. Therefore, all nations must prepare themselves for the possibility that Sustainable Development Goals may still need to be accomplished (Nasir, Nugroho, & Lakner, 2022).

2.4. Understanding Agro-economic Modelling

Agriculture faces a significant challenge in climate change, and determining its potential effects necessitates the integration of climate, crop, and economic models (Nelson, Valin, Sands, & Willenbockel, 2013). A combination of global climate, crop, and economic models was utilized to analyze the economic repercussions of climate change-induced decline in agricultural output in Pakistan (Khan, et al., 2020). Coastal Bangladesh is currently facing high levels of poverty and hazards and is expected to become more vulnerable to climate and environmental changes. Simulation models are being utilized to examine various interventions that could help reduce environmental risks and promote development in different plausible socio-economic and environmental scenarios (Lázár, et al., 2015). Over time, the bio-economic approach has developed and has been utilized to comprehend how the agricultural sector will respond physically and socio-economically to potential climate change scenarios (Fernández & Blanco, 2015).

Agro-economic modeling is an effective technique to comprehend the intricate relationships between climate, crops, and economics within the poultry sector, which is a crucial industry for the Hungarian economy. The poultry sector is popular among smallholders and has made significant contributions to both GDP and job creation (Oladokun & Johnson, 2012)

2.5. Agroeconomic Modelling softwares in Europe

CAPRI (Common Agricultural Policy Regional Impact): CAPRI is a comprehensive agro-economic modeling system developed by the Joint Research Centre of the European Commission. It is used to analyze the impact of agricultural and rural policies on the European Union (EU) and its member states and to assess policy scenarios' economic, social, and environmental consequences. Its principal aim is to analyze the impacts of changes in EU (or international) agricultural policies and markets on European agriculture and global agricultural markets, mainly in the medium term (8-10 years ahead). In technical terms, the model is a static, partial equilibrium model made up of four interrelated modules. These modules cover regional agricultural supply for EU-27, Norway, and the Western Balkans, as well as global and EU markets for major primary and secondary agricultural products, bilateral trade, EU markets for young animals, and premium schemes and other policy tools of the Common Agricultural Policy (CAP) (Britz, 2008).

AGLINK-COSIMO: Aglink-Cosimo is a recursive-dynamic partial equilibrium model developed and maintained by the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO) Secretariats as a collaborative effort. The model is primarily used to prepare the OECD-FAO Agricultural Outlook, a yearly publication aiming to provide baseline projections for the main global agricultural commodities over the medium term. In order to improve the accuracy of the forecasts, a partial stochastic analysis tool is used to examine specific market uncertainties. This analysis involves creating counterfactual scenarios based on stochastic variations in yields and macroeconomic variables, which supplement the deterministic projections (Araujo-Enciso, Pieralli, & Pérez-Domínguez, 2017).

GLOBIOM (Global Biosphere Management Model): The International Institute for Applied Systems Analysis (IIASA) in Austria has developed GLOBIOM, a global economic model specifically designed to examine a range of land use-related issues, such as the impacts of bioenergy policies, deforestation patterns, the potential for climate change adaptation and mitigation within the agriculture sector, and long-term agricultural prospects (Valin, et al., 2013).

FSSIM (Farm System Simulator): The Farm System Simulator (FSSIM) is a flexible framework that facilitates using BEFMs in diverse situations and for different objectives, such as generating supply response functions or conducting detailed regional or farm-type assessments. FSSIM is structured as a modular framework that comprises distinct components that represent various aspects, such as farmer objectives, risk, calibration, policies, current activities, alternative activities, and different types of farming activities (e.g., annual and perennial cropping and livestock) (Janssen et al., 2010).

AgriPoliS: The University of Bonn in Germany developed AgriPoliS, a model used to evaluate the effects of agricultural and environmental policies on regional land use, production, and income. AgriPoliS views a regional agricultural structure as a complicated and evolving system that transforms over time, which is its core concept (Kellermann et al., 2008). This dynamic spatial partial equilibrium model is often employed to examine the impacts of land use changes, biodiversity conservation, and renewable energy policies on the agricultural sector. (Kellermann, et al., 2008)

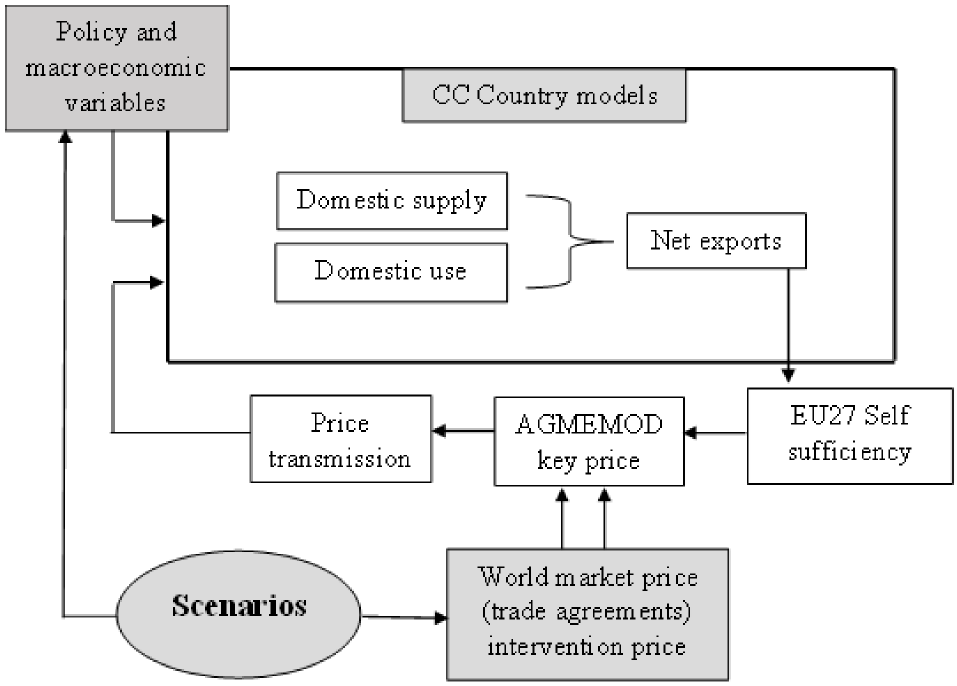
MONICA (Model for Nitrogen and Carbon in Agriculture): MONICA is a crop simulation model created by the Swedish University of Agricultural Sciences to evaluate the effects of climate change on agricultural production and the environment. It is a dynamic, process-based model that accounts for the combined impact of climate variables, which are anticipated to undergo significant changes in the future, on crop growth and development and soil processes in Central Europe. The model focuses on nitrogen and carbon dynamics in agroecosystems (Nendel, et al., 2011).

AGMEMOD (AGricultural MEmber states MODelling): AGMEMOD is a multi-country, multi-market, dynamic and partial equilibrium econometric model. It was developed to analyze agri-food markets within the European Union at the national level. The country-specific model reflects the intricacies of agriculture in each member state while allowing for their combination into an EU-wide model. It is a valuable tool for modeling the effects of policy changes across various countries. The framework of the AGMEMOD is shown in Figure 1.

AGMEMOD software was created in 2001, and since then, it has been continuously improved and updated by a collaboration of research institutes, universities, and government agencies throughout the European Union. Later, it was extended to other countries such as Russia, Ukraine, and Turkey. The model is structured based on the GOLD model (Hanrahan, 2001). The template's standardized approach enables the model to incorporate diverse agricultural systems within the Union while ensuring analytical consistency across the commodity model templates.

The primary objective of the tool is to improve the accuracy of current analytical findings used for decision-making related to agricultural policies (Chantreuil, Hanrahan, & Van Leeuwen, 2012).

Figure 1 AGMEMOD model framework



Source: Own elaboration based on The AGMEMOD Book, Chantreuil, Hanrahan, & Van Leeuwen (2012)

2.6. Animal Welfare in Europe

The livestock sector's technological innovations and structural transformations offer opportunities for poverty reduction and an increase in food security. However, different issues should be addressed to make the systems more sustainable (Alonso, Gonzáles-Montaña, & Lomillos, 2020).

Animal welfare was perceived to be more related to natural and outdoor conditions and to clean and healthy housing environments. These were the issues that were most often raised by consumers in Sweden, Poland, Lithuania, and Romania. However, consumers in Italy and Greece highlighted good feeding as the most important aspect of animal welfare.

Respondents in Spain, Italy, Greece, and Romania exhibited more significant concern regarding animal welfare than those in other countries, particularly pigs for meat, broilers for meat, milk cows, cows for meat, and laying hens. Respondents in Italy, consumers in Spain, and citizens in Sweden showed high levels of concern concerning broiler production.

Our model showed two differentiated behaviors: respondents in southern EU countries (Italy and Spain) exhibited significant reluctance to the implementation of more restrictive regulation, and those in northern EU countries (Poland and Sweden) exhibited the opposite opinions (Pejman, Kallas, Dalmau, & Velarde, 2019).

Respondents from Poland and Sweden were prone to supporting more restrictive regulations. Respondents who exhibited high subjective information levels were more concerned with the welfare of laying hens, broilers, and pigs and were more likely to agree with adopting more restrictive animal welfare legislation. Compared with those from other European countries, respondents from northern European countries showed the most significant concern for animal welfare in farm production systems. (Pejman, Kallas, Dalmau, & Velarde, 2019)

The European animal welfare protocol considers relevant criteria for objectively evaluating poultry farms. In this sense, in principle, it is pertinent to highlight that the welfare of production animals, in the case of broilers, is determined by the management practices (health, feeding, management of the sheds, transfer of the birds to the slaughter plant, slaughtering tasks, and other management activities), carried out by the producer and the personnel in charge of this production.

European Animal Welfare protocol focuses its concern on achieving optimal production; that is, through the implementation and development of these criteria, producers are guaranteed the safety of their products, which are better accepted in their marketing and finally that the producer sees reflected in their economic income (Carrascal Lozano & Batista Bayona, 2021). Implementing the welfare protocol in poultry production (broilers) contributes to economic development. It strengthens production, making them more competitive and sustainable, as society demands, trying to achieve harmony between the animal (broilers) and the environment.

Each of the parameters considered in the framework of the Welfare Quality protocol is important and must be implemented. Among the criteria considered is one that allows productions (broilers) to own their space, free from overcrowding. For example, various investigations have shown that the qualification and provision of a space that each bird requires avoids stress, improves and increases production, and dramatically reduces the bird's susceptibility to contracting various diseases. On the other hand, another critical parameter is the thermal condition under which it is used in the sheds; when the shed has a good environment (required temperature), its performance improves in its first stage of life (Vera, 2010) Which leads to an increase in its feed conversion, in addition to regulating its feed intake by decreasing the amount of feed that consume; a positive result is achieved by reducing mortality in the house.

In all this context, an important advance in farms or poultry production recognizes the dangers associated with breaking chickens' welfare. Nineteen consequences have been identified (19 identified highly relevant welfare consequences in broilers) which affect them (Broiler welfare on the farm). Among some of these described, the consequences over time are highlighted, as a result of genetic selection (genetics selection), identified for presenting some consequences: high growth rate and deterioration in locomotion health (High growth rate, impaired locomotor health), for the welfare of birds (Panel, et al., 2023). In this regard, it should be noted that, at present, it is important to analyze the objectives under which genetic selection in production is designed and implemented and its contribution to animal welfare. Thus, thanks to the advancement of genetics through molecular biology tools, progress has been made in the most significant commercial productions (poultry, pigs, cattle), improving productivity. However, this improvement will undoubtedly have to be accompanied as far as possible by minimizing future risks to production regarding animal welfare that all production demands (Dottavio & Di Masso, 2010).

In the EU environment, the raising of broiler chickens needs to improve their production systems concerning animal welfare, and this is where the most remarkable public concern is focused (Moyano *et al.*, 2015). It should be noted that it also accompanies the production systems of chickens and pigs.

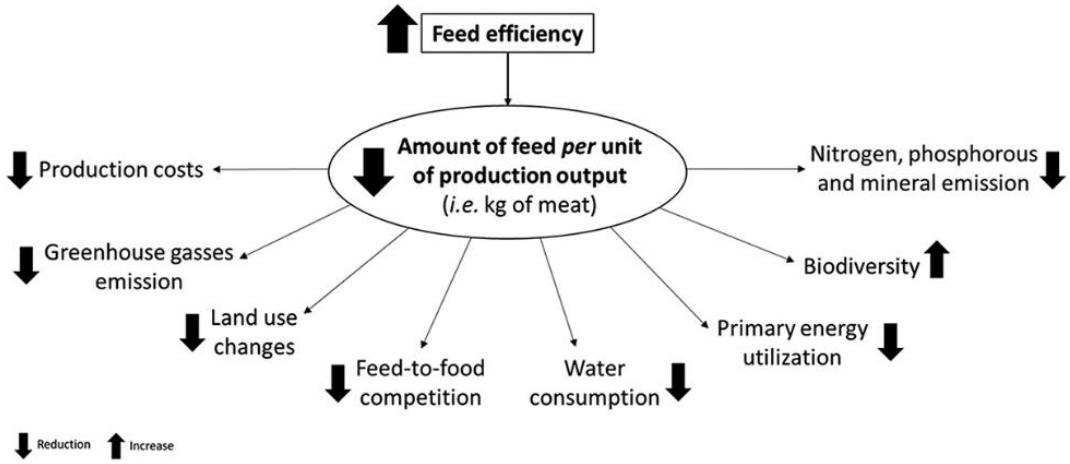
Another important aspect to consider within the framework of animal welfare is to emphasize the registration of mortality and morbidity rates in order to have objective control of the same since these values are expected within the permitted limits since any increase Of these values would be an aspect that could be attributed to deficiencies or mismanagement in the field of animal welfare. Also, in this same sense, the fundamental point is to implement a database in the breeding system that provides information over time and allows comparing the animal welfare situation to validate the breeding system or improve certain conditions that can reflect after this evaluation.

It is then expected that European animal welfare strategies can be implemented on farms to improve the housing conditions, feeding, transport, benefit, or slaughter of the millions of chickens (Moyano Estrada, Castro, & Gomez, 2015). The different links in the production chain, such as producers, veterinarians, and other personnel in charge of production, industry, and marketing, must work in coordination to reach the Animal Welfare standards that the European Union requires and be a tool for support for other regions in the world, despite their particular breeding systems and development policies.

2.7. Previous experiences with reduction of growth rate and stock density in broiler chickens

By implementing these strategies, it is possible to achieve higher feed efficiency by reducing competition for food among the birds. As a result, there could be a decrease in the cost of production, which would be a significant economic advantage for the broiler industry (Zampiga, Calini, & Sirri, 2021).

Figure 2 Feed efficiency and Sustainability



Source: Zampiga (2021)

A research study on poultry density revealed that higher poultry density may lead to animal health issues such as highly pathogenic avian influenza (HPAI). However, the study did not find a strong relationship between poultry density and macro-economic indicators such as gross domestic product (GDP), agricultural gross domestic product (AGDP), the percentage that AGDP contributes to the total GDP, GDP per capita, gross national income (GNI), and the Human Development Index (HDI) (Pavade, Awada, Hamilton, & Swayne, 2011) For this reason, the present research is focused in the evaluation of sectoral economic indicators.

2.8. Sustainabile aspects on broiler chicken breeding

The carbon footprint of the world's most environmentally impactful chicken and pork is 12 and 14 kgCO2eq, respectively. This value is comparable to or slightly higher than the carbon footprint of the most sustainable beef and lamb (Ritchie, 2020) If we talk about sustainability, it is possible to assume that, by reducing the growth rate by up to 50 grams per day and the density, the consumption of chicken will be reduced, and the footprint of other animals with more greenhouse emissions such as beef and pork will possibly increase because those are suplementary products.

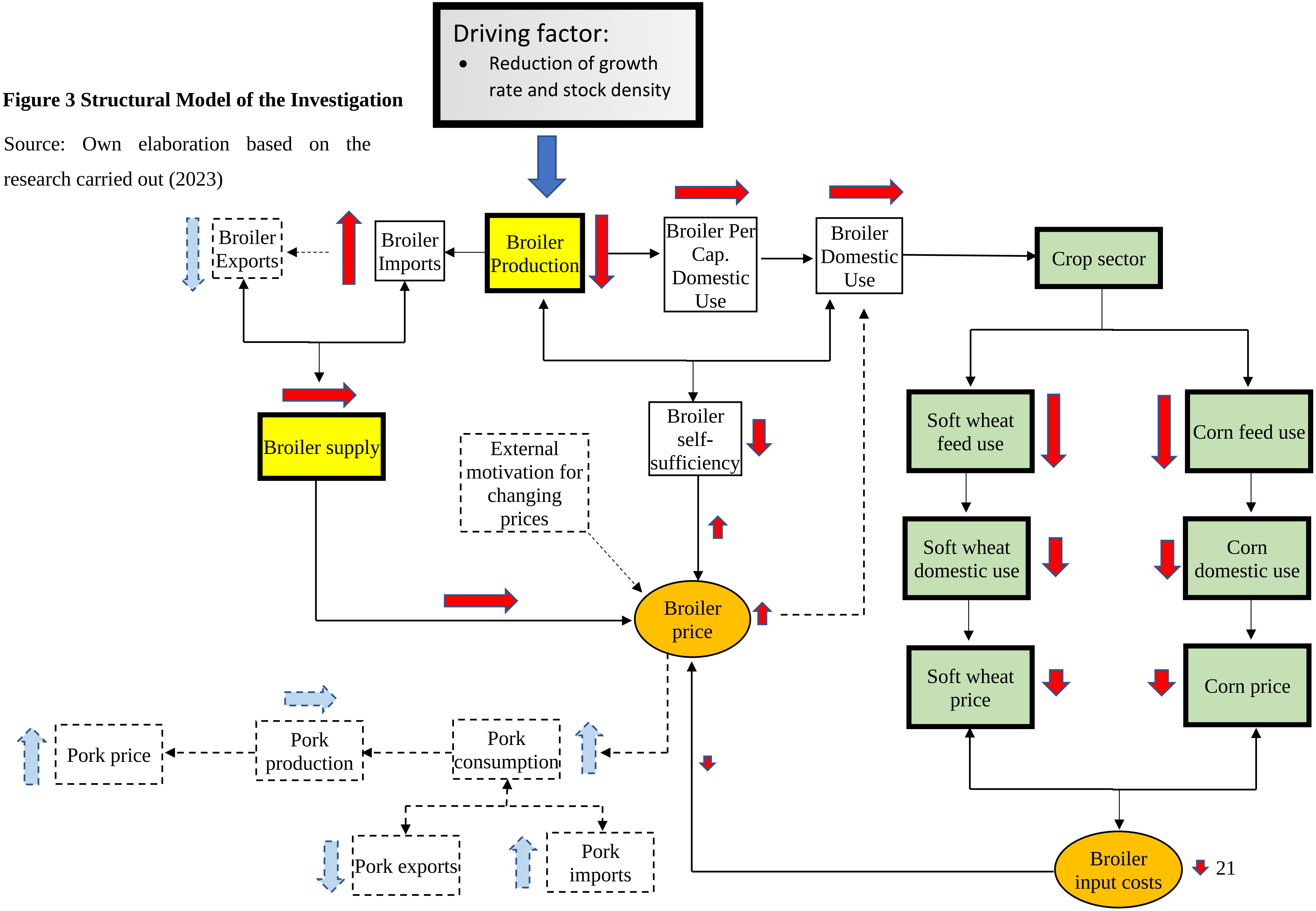
In terms of organic production, the Netherlands example could be taken into account; in the Netherlands, animal welfare is a highly regarded issue, and in the broiler sector, the stocking density in the poultry house and the growth rate of the broilers are increasingly becoming topics of societal discussion. The country's organic broiler production systems adhere to strict animal welfare rules described by EU regulations (EU, 2007b). Organic broiler farmers must use a slow-growing breed (slaughtering at a minimum age of 70 days), a maximum stocking density of 21 kg/m2, and provide free-range areas for the birds. Additionally, the farmer has to provide organic feed to the broilers, and the flock size and farm area are restricted. To produce organic broilers in the Netherlands, a SKAL certificate is necessary. SKAL is a Dutch organization responsible for auditing organic farms (Van Home, 2020).

2.9. Structural model of the thesis

A graphic model is presented in this research work (figure 3). It is possible to see the interactions of the sectors and cross-sectors that can play a role when introducing new policy measures in Hungary. The broiler supply, percapita domestic use, and domestic use are supposed to remain stables. However, the most affected variables will be broiler production, broiler imports, and sectors such as corn and soft wheat. The calculated impact of these measures in the mentioned variables is explained in the results section.

Figure 3 Structural Model of the Investigation

Source: Own elaboration based on the research carried out (2023)



3. Analysis of the economic impact on implementing a broiler chicken growth rate and stocking density reduction

3.1. Research Objectives

Main Objective

MO: To identify the combined sectoral and cross-sectoral economic impact of reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary.

Especific objectives

O1: To find out the sectoral economic impact by 2032 of reducing broilers chicken gowth rate by 50 grams per day in Hungary.

O2: To identify the sectoral economic impact by 2032 of reducing broilers stock density by 11 kilograms per meter square in Hungary.

O3: To discover the cross-sectoral economic impact by 2032 of reducing broilers chicken gowth rate by 50 grams per day in Hungary

O4: To find out the cross-sectoral economic impact by 2032 of reducing broilers stock density by 11 kilograms per meter square in Hungary.

3.2. Research questions

Main research question

MQ: What is expected to be the combined sectoral and cross-sectoral economic impact of reducing the broiler chicken gowth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary?

Especific questions

Q1: What is expected to be the sectoral economic impact by 2032 of reducing broilers chicken gowth rate by 50 grams per day in Hungary?

Q2: What is expected to be the sectoral economic impact by 2032 of reducing broilers stock density by 11 kilograms per meter square in Hungary?

Q3: What is expected to be the cross-sectoral economic impact by 2032 of reducing broilers chicken gowth rate by 50 grams per day in Hungary?

Q4: What is expected to be the cross-sectoral economic impact by 2032 of reducing broilers stock density by 11 kilograms per meter square in Hungary?

3.3. Hypotheses

H1: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the broiler sector in Hungary.

H2: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the soft wheat sector in Hungary.

H3: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the corn sector in Hungary.

3.4. Study setting and location

The present research was held in the Hungarian chicken broiler market using entirelly official and validated data but keeping extrictly the confidenciality of the non-public information. The main sources of information were, Eurostat, the Hungarian Central Statistical Office and the Institute of Agricultural Economics of Hungary databases.

Although AGMEMOD support projections until 2050, the forecasts in the present study are made until 2032 because it correspond to the medium term outlook of the European Union analysis criteria.

This study is carried out under an uncertainity reality due to the global economy situation and the changes of the methodologies from the statistiacal sources of information, which is a serious challenge for economic modelling. In that sense it is assumed that the market will recover the stability in the short term to be able to elaborate more reliable forecasts.

3.5. Research methods and sample presentation

In order to achieve the objectives, two research methods will be used. A multivariable analysis of agricultural products through a software called AGMEMOD to analyze the impacts of the animal welfare measures to build scenarios projected until 2032.

Besides this method, the leading Hungarian poultry producers' enterprises were analyzed. Based on anonymous and non-public AKI farm-level data, a sample of 24 enterprises in 2019 and 23 in 2021 was analyzed to calculate the impact of the growth rate reduction and stocking density on their production. These enterprises represent 84% of the total annual production of chicken meat for 2019 and 99% for 2021 which means that the studied sample is a reliable representation of the total national broiler meat production presented in the public database of the Institute of Agricultural Economics of Hungary.

The losses in production due to the implementation of the animal welfare measures has been callculated following the creiteria in which farmers will be suggested to decrease teir chickens growth rate and the density, since it is not possible and profittable to sell chickens with less weight, a solution could be to extend the breeding days, which will reduce the shifts per year of broilers resulting in a production decreasing. The calculation details are kept confidentially because it belongs to the farm level information provided by Hungarian companies.

In terms of methodology, the current thesis is an experimental, quantitative, longitudinal, correlational study utilizing a ratio scale of measurement.

3.6. Results

This section presents four scenarios of analysis; the first part shows the results of the model without modifications, which means the building and calibration of the equations to get the estimated formula used to build the projections of the variables studied. The present thesis shows a sectoral analysis of broiler chicken production, international trade, and consumption because it represents the essential economic balance. At the same time, soft wheat and corn are included in the analysis because these crops represents the main feed ingredients for chickens.

3.6.1. Current situation without additional animal welfare measures.

Hungarian broiler chicken price econometric model

The econometric equation for Broiler price is:

$$brp_t = f\left(Kbrp_t, brp_{t-1}, ssr_{j,t}, V\right)$$

The broiler chicken price in the year t (brp_t) is determined by key price from Poland ($Kbrp_t$), the self sufficiency ratio ($ssr_{j,t}$) which is the division between the production and consumption of chicken meat, and the vector V, which is an exogenous variable that could have impact on chicken prices, in this case, the Hungarian corn price have been taken into account.

Poland is considered the key price country since it is the leading broiler chicken producer in the European Union. The price in zloty (polish currency) is multiplied by the Hungarian exchange ratio to get Hungarian forints. The broiler key price and corn price positively relate to broiler prices because if those commodities increase their domestic prices, the Hungarian chicken price will increase too.

The statistical parameters of the model are shown in the following tables:

Table 1 Multiple linear regression model for broiler price : estimated coefficients and corresponding statistics

Broiler price	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1362.21	2783.09	0.49	0.63
Poland broiler price (forints)	0.07	0.02	3.92	0.00
One year lagged broiler price	0.46	0.11	4.32	0.00
Broiler self sufficiency ratio	-674.81	3116.21	-0.22	0.83
Hungarian corn price	0.43	0.40	1.08	0.29

Source: Own elaboration based on the research carried out (2023)

Table 2 Broiler price significance tests

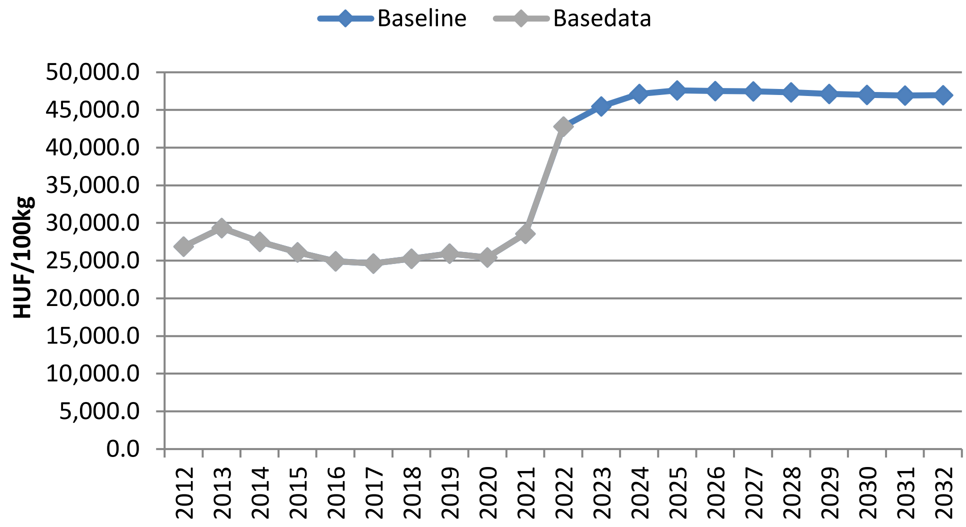
Statisticals	Values
Multiple R-squared	0.96
Adjusted R-squared	0.95
p-value	1.926E-12
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, the broiler price may be significantly affected by the aforementioned independent variables with solid attention to the Polonian broiler price. Moreover, An adjusted R square of 0.95 indicates that the regression model used explains approximately 95% of the total variability in the observed data, taking into account both the number of independent variables included in the model and the number of observations available. The poland price of broilers is one of the most significant variables in the model. Which means that if the polish chicken price increases in 1 monetary unit, the hungarian price will increas in 0.07 forints per 100 kg of chicken meat.

Based on the scenario without modifications, compared to 42791 forints per 100 kg in 2022, the price of broiler may increase by 10% percent to 46959.22 forints per 100 kg by 2032 (Figure 4). This may be due to the market's expected stabilization after an unusual price rise during 2021 and 2022.

Figure 4 Projection of the Hungarian broiler price



Source: Own elaboration based on the research carried out (2023)

Hungarian broiler chicken production econometric model

The econometric equation of Broiler production is:

$$brspr_t = f(brspr_{t-1}, brp_t, brict_t, trend70)$$

The price determines the broiler chicken production in the year $t(brp_t)$, the input costs of broilers $(brict_t)$ and the trend 70 which is an exogenous variable that typically increase by one each year. They are used to explain a (linear) development over time. The price and production have been divided in order to obtain the cost-price relation, so the more price in front of a determined cost level will result in more incentives for the farmers to increase their production.

The statistical parameters of broiler production are shown in the following tables:

Table 3 Multiple linear regression model for broiler production: estimated coefficients and corresponding statistics

Broiler production	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-91.02	97.42	0.93	0.36
One year lagged broiler production	0.51	0.13	4.00	0.00
Broiler price/Broiler input costs	0.04	0.01	4.20	0.00
TREND70	5.27	2.20	2.39	0.03

Source: Own elaboration based on the research carried out (2023)

Table 4 Broiler production significance tests

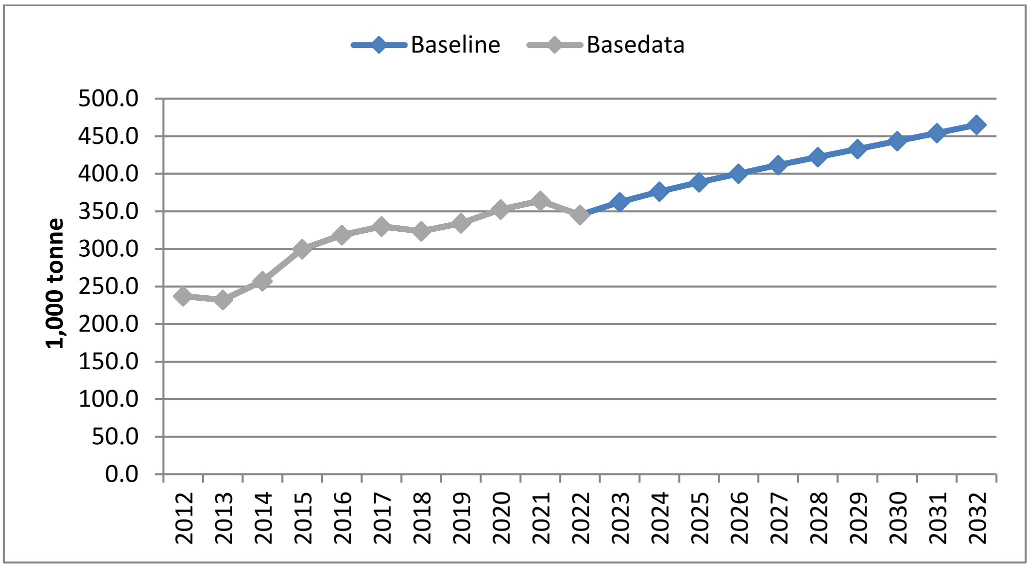
Statisticals	Values
Multiple R-squared	0.85
Adjusted R-squared	0.83
p-value	1.00E-07
Significance α	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.83 indicates that the regression model explains approximately 83% of the total variability in the observed data, considering the number of independent variables included in the model and the number of observations available. The most significant variable is the one that express the relation between broiler price-input costs. Which means that if the relation chicken price-cost increases in one unit, the production of chicken will increase in 0.04 thousands of tonnes.

Based on the scenario without modifications, compared to 345.06 thousand tons in 2022, the production of broilers may increase by 35% percent to 465.11 thousand tons by 2032 (Figure 5). This may be due to the domestic chicken meat production expansion mentioned in the literature review.

Figure 5 Projection of the Hungarian broiler production



Source: Own elaboration based on the research carried out (2023)

Hungarian broiler chicken imports econometric model

The econometric equation of broiler imports is:

$$brsmt_t = f(brspr_t, brudc_t, brp_t, gdpd, trend70)$$

Broiler imports are determinied by broiler domestic production in the year t ($brspr_t$) and the broiler consumption ($brudc_t$) that are suctracted, if the balance is negative, the country will require imports; this is why production negatively relates to imports. Imports also depends on the domestic price (brp_t) because if the hungarian broiler price increases, there will be incentives for the other countries to sell their products in Hungary. The trend70 and the gross domestic product deflator (GDP) ,that is an inflation measure, are also independent variables.

The statistical parameters of broiler imports are shown in the following tables:

Table 5 Multiple linear regression model for broiler imports: estimated coefficients and corresponding statistics

Broiler imports	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-107.90	17.29	-6.24	0.00
Broiler production-Broiler domestic use	-0.34	0.09	-3.65	0.01
Broiler price/Gross domestic product deflator	5.26E-04	3.39E-04	1.55	0.16
TREND70	3.47	0.38	9.05	8.15E-06

Source: Own elaboration based on the research carried out (2023)

Table 6 Broiler imports significance tests

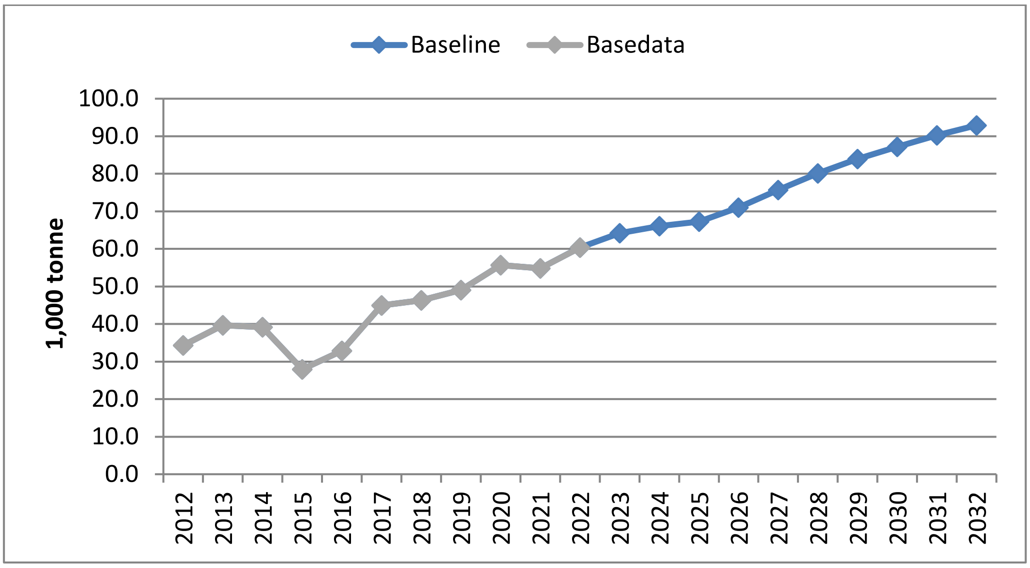
Statisticals	Values
Multiple R-squared	0.92
Adjusted R-squared	0.89
p-value	3.745E-05
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since $\alpha >$ p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.89 indicates that the regression model used explains approximately 89% of the total variability in the observed data, taking into account both the number of independent variables included in the model and the number of observations available. The most significant variable is the one that represents the difference between broiler production and broiler domestic use. Which means, if the difference between broiler production and domestic use increases in one thousand of tonnes, the imports will decrease in 0.34 thousand of tonnes.

Based on the scenario without modifications, compared to 60.03 thousand tons in 2022, the imports of broilers may increase by 54% percent to 92.9 thousand tons by 2032 (Figure 6).

Figure 6 Hungarian broiler imports projection



Source: Own elaboration based on the research carried out (2023)

Hungarian broiler chicken per capita domestic use econometric model

The econometric equation of broiler per capita consumption is:

$$brupc_t = f(brupc_{t-1}, brp_t, pkp_t, rgdpc, gdpd)$$

The broiler percapita consumption is determinied by the domestic chicken meat price (brp_t) with a negative relationship because if the chicken price meat increases, the per capita consumption probably will tend to decrease; on the other hand, domestic pork price (pkp_t) which are also deflated ($gdpd$) to include inflation in the equation, has a positive relationship because it is considered as a supplementary product. Hence, the more expensive the chicken, the more preferred the pork. these variables The per capita real income ($rgdpc$) is also considered in this equation.

The statistical parameters of broiler per capita consumption are shown in the following tables:

Table 7 Multiple linear regression model for broiler per capita domestic use: estimated coefficients and corresponding statistics

Broile per capita consumption	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	9.01	5.59	1.61	0.15
One year lagged broiler per capita consumption	0.26	0.35	0.75	0.48
Broiler price/Gross domestic product deflator	-7.08E-04	0.00	-2.62	0.03
Real GDP per capita	4.70E-06	2.67E-06	1.76	0.12
Pork price/Gross domestic product deflator	0.00	0.00	1.45	0.19

Source: Own elaboration based on the research carried out (2023)

Table 8 Broiler percapita consumption significance tests

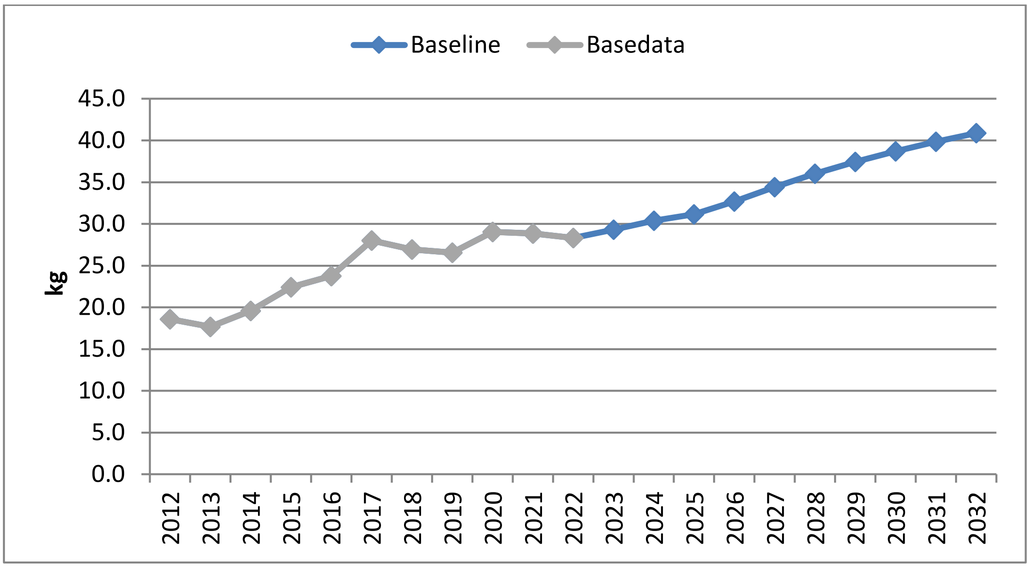
Statisticals	Values
Multiple R-squared	0.93
Adjusted R-squared	0.90
p-value	9.088E-05
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.90 indicates that the regression model explains approximately 90% of the total variability in the observed data, considering the number of independent variables included in the model and the number of observations available. The most significant variable of the model is the broiler price. Which means that, if the broiler price increases in one monetary unit, the per capita consumption will derease in 0.00071 kg. of chicken meat.

Based on the scenario without modifications, compared to 28.3 kilograms in 2022, the production of broilers may increase by 44% percent to 40.9 kilograms by 2032 (Figure 7).

Figure 7 Hungarian broiler percapita domestic use projection



Source: Own elaboration based on the research carried out (2023)

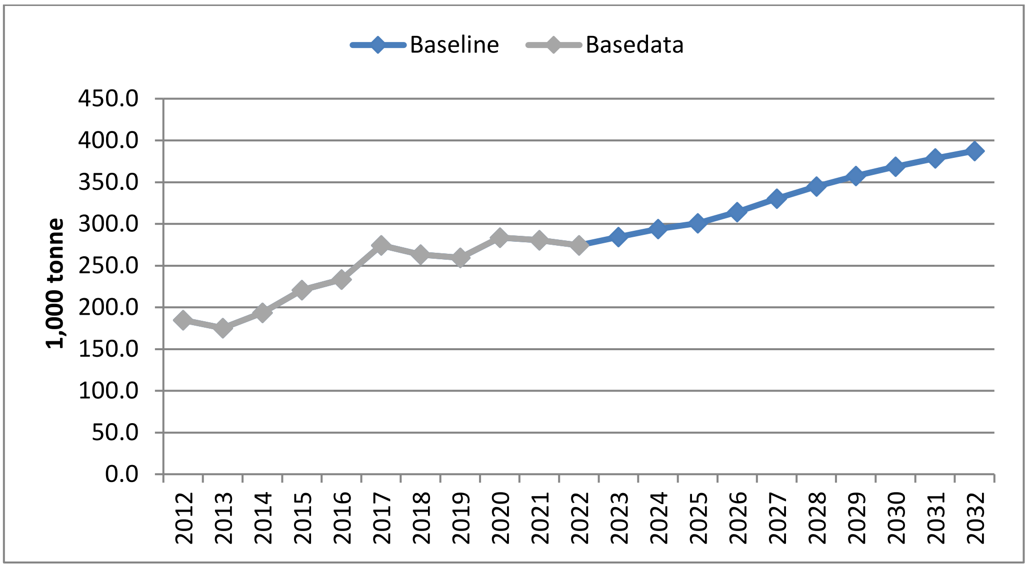
Hungarian broiler chicken domestic use econometric model

The econometric equation of broiler per capita consumption is:

$$brudc_t = f(brupc_t, pop)$$

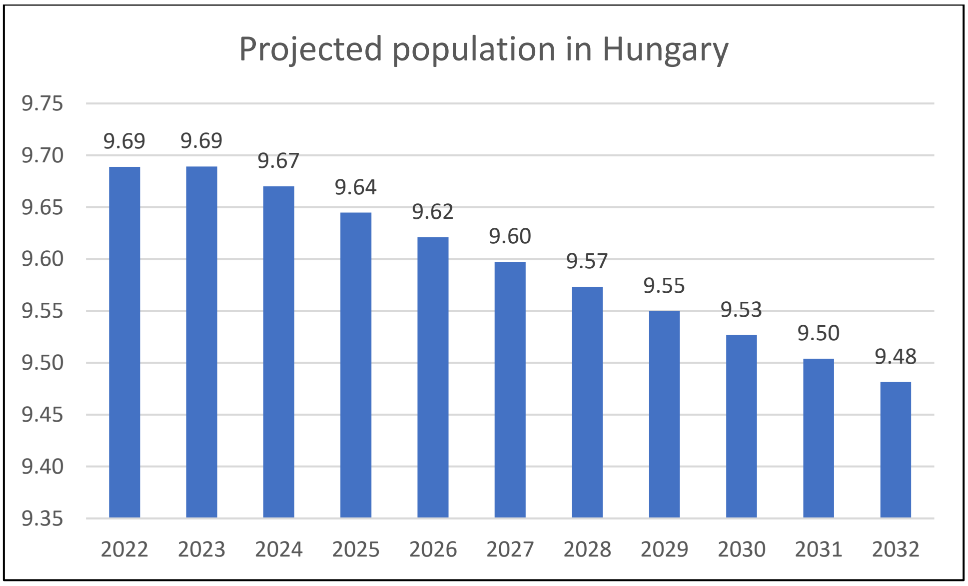
Chicken broiler consumption is an identity equation expressed as the result of the product of broiler per capita consumption ($brupc_t$) and the Hungarian population projection (pop) that can be visualized in figure 9. As it is evident, the population is constantly decreasing, but the consumption of chicken is increasing, this phenomenon could be explained as a change in population eating habits, the tendency to consume meat products is growing over the time. Broiler domestic use is expected to increase in 41% by 2032 compared to 2022 going from 274.4 thousand of tonnes to 387.5 thousand of tonnes (Figure 8)

Figure 8 Projection of broiler domestic use in Hungary



Source: Own elaboration based on the research carried out (2023)

Figure 9 Projected population in Hungary

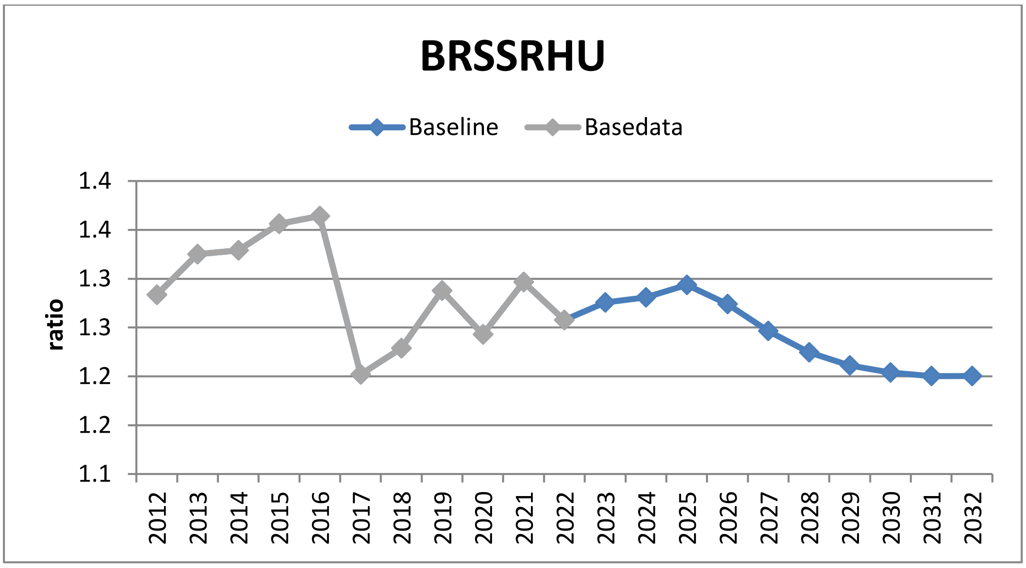


Source: Eurostat (2023), available from: https://ec.europa.eu/eurostat/databrowser/bookmark/5ee5b90f-7614-4883-a811-e9ac47d36443?lang=en

Broiler self-sufficiency ratio in Hungary

The broiler self-sufficiency ratio is the division between the production and the consumption; this variable decreases if the consumption increases in relation to the production; figure 10 shows that the product will be more than the consumption until 2025, but from this year onwards, the production will have a different behavior affected principally by the prices and input costs of chicken broiler. Broiler self-sufficiency ratio is expected to decrease in -5% from 2022 until 2032 going from 1.3 to 1.2 points (Figure 10).

Figure 10 Broiler self-sufficiency ratio in Hungary



Source: Own elaboration based on the research carried out (2023)

Hungarian broiler chicken input costs econometric model

The econometric equations of broiler input costs is:

$$brict_t = f(brict_{t-1}, cop_t, wsp_t, gdpd)$$

Chicken broiler input costs are dependent on the main feed crops prices, such as corn price (cop_t), and soft wheat price (wsp_t),the gross domestic product deflator ($gdpd$) is always present when including a price variable alone in the equation. Crop prices have a positive relationship with broiler input costs. The crops considered for the input costs formula have been considered based on the quantity used for the chicken broiler sector in which corn, wheat, soy, rape meal, and sun meal are the main ingredients. Corn and wheat are the main ingredients that could influence input cost fluctuations from that list.

The statistical parameters of broiler input costs are shown in the following tables:

Table 9 Multiple linear regression model for broiler input costs: estimated coefficients and corresponding statistics

Broiler input costs	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	13570.00	2418.00	5.61	0.00
One year lagged broiler input costs	0.21	0.09	2.29	0.04
Corn price/Gross domestic product deflator	0.32	1.38	0.23	0.82
Soft wheat price/Gross domestic product deflator	1.16	1.56	0.75	0.47

Source: Own elaboration based on the research carried out (2023)

Table 10 Broiler input costs significance tests

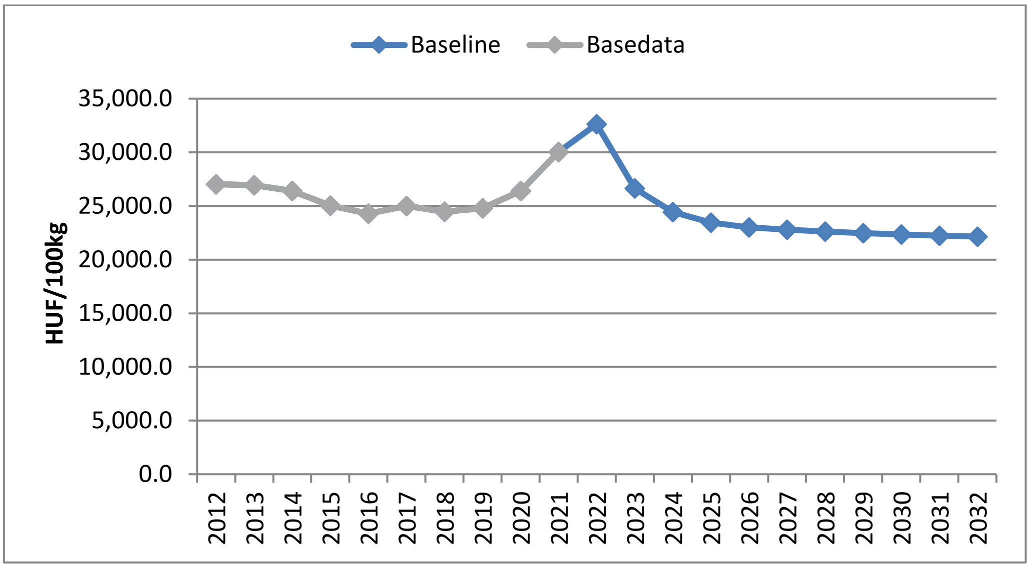
Statisticals	Values
Multiple R-squared	0.63
Adjusted R-squared	0.55
p-value	9.088E-05
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since $\alpha >$ p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.55 indicates that the regression model explains approximately 55% of the total variability in the observed data, considering the number of independent variables included in the model and the number of observations available.

Based on the scenario without modifications, compared to 30044.2 forints per 100 kg in 2021, the input costs of broiler may decrease by 28% percent to 22145.5 thousand tons by 2032 (Figure 11).

Figure 11 Projection of the Hungarian broiler input costs



Source: Own elaboration based on the research carried out (2023)

Econometric models of cross-sectoral crop industries of broiler chicken in Hungary

Hungarian soft wheat price econometric model

$$wsp_t = f(Kp_t, wsufe_t)$$

The national soft wheat price is determined by the key price represented by france (Kp_t) since it is the main wheat producer in in the European Union, the relation is positive. The hungarian soft wheat feed use ($wsufe_t$) is another variable that could explain the price. The relation is positive because an increase in the demand for wheat for feed could explain an increase in the price of this commodity.

The statistical parameters of the hungaria soft wheat are shown in the following tables:

Table 11 Multiple linear regression model for soft wheat price: estimated coefficients and corresponding statistics

Soft wheat price	Estimate	Std. Error	t value	Pr(>|t|)
Soft wheat French price (forints)	0.44	0.13	3.50	0.01
Soft wheat feed use	1.96	0.63	3.10	0.02

Source: Own elaboration based on the research carried out (2023)

Table 12 Soft wheat price significance tests

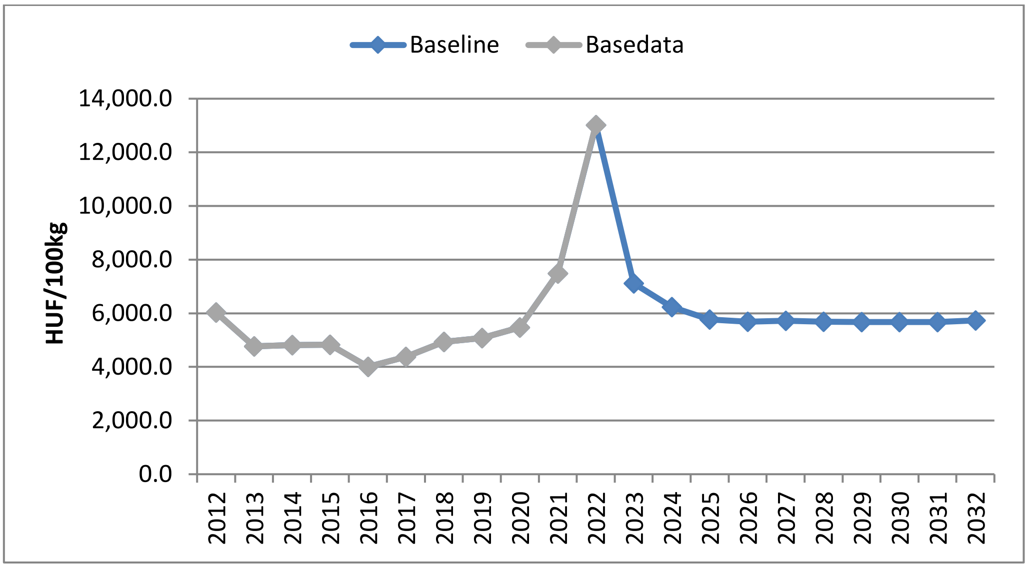
Statisticals	Values
Multiple R-squared	0.997
Adjusted R-squared	0.996
p-value	2.302E-08
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.99 indicates that the regression model used explains approximately 99% of the total variability in the observed data, considering both the number of independent variables included in the model and the number of observations available. It is possible to say, if the french price of soft wheat increases in one monetary unit, the hungarian soft wheat price will increase in 0.44 forints per 100 kg, and if the soft wheat feed use increases in one thousand of tonnes, the hungarian soft wheat price will increases in 1.96 forints per 100 kg of soft wheat.

Based on the scenario without modifications, compared to 13013.8 forints per 100 kilograms in 2022, the price of soft wheat may decrease by 56% percent to 5729.4 forints per 100 kilograms by 2032 (Figure 12). This result is expected due to the normalization of the market after a peak price between 2021 and 2022.

Figure 12 Soft wheat price projections in Hungary



Source: Own elaboration based on the research carried out (2023)

Hungarian soft wheat feed use econometric model

The econometric equation of soft wheat domestic use is:

$$wsufe_t = f(brspr_t, cop_t, gdpd, trend70)$$

Soft wheat feed use positively depends on broiler production ($brspr_t$) and corn price as a supplementary product, which means that if the price of corn (cop_t) increases, the consumers will opt for increasing the use of soft wheat for feed

The statistical parameters of the soft wheat feed use are shown in the following tables:

Table 13 Multiple linear regression model for soft wheat feed use: estimated coefficients and corresponding statistics

Soft wheat feed use	Estimate	Std. Error	t value	Pr(>|t|)
Broiler production	0.75	0.33	2.27	0.07
1/TREND70	4042	3902	10.36	1.4400E-04
Corn price/Gross domestic product deflator	0.04	0.06	0.74	0.49

Source: Own elaboration based on the research carried out (2023)

Table 14 Soft wheat feed use significance tests

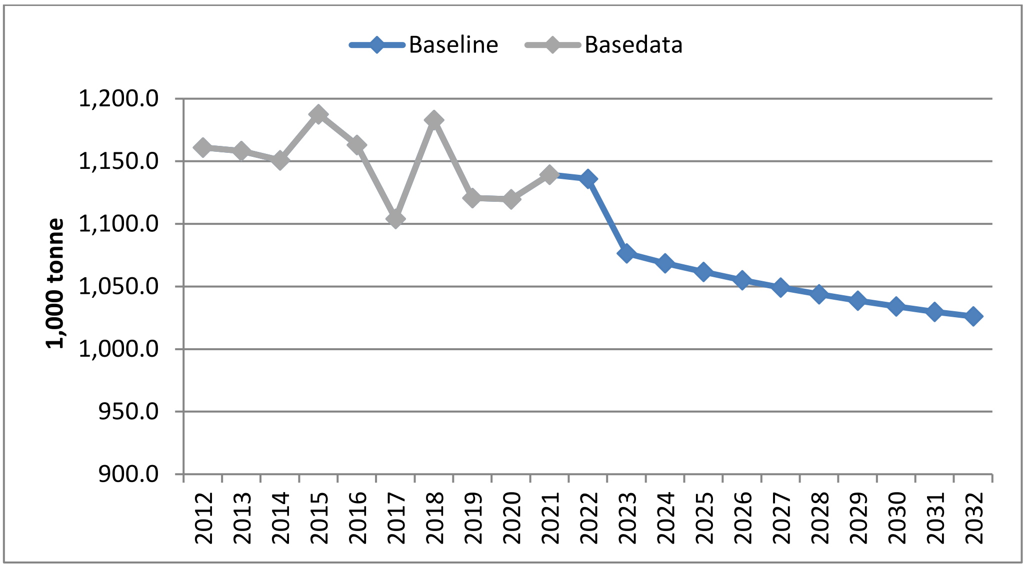
Statisticals	Values
Multiple R-squared	0.9995
Adjusted R-squared	0.999
p-value	1.233E-08
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.99 indicates that the regression model used explains approximately 99% of the total variability in the observed data, taking into account both the number of independent variables included in the model and the number of observations available. This equation needs to be improved adding more variables that could be cattle production or pork production. Pork production has a decreasing tendency, and since Hungary produces mainly pork, this could explain the same behaviour for soft wheat feed use.

Based on the scenario without modifications, compared to 1136 thousand tonnes in 2022, the feed use of soft wheat may decrease by 10% percent to 1026.1 thousand tonnes by 2032 (Figure 13).

Figure 13 Projection of the Hungarian soft wheat feed use



Source: Own elaboration based on the research carried out (2023)

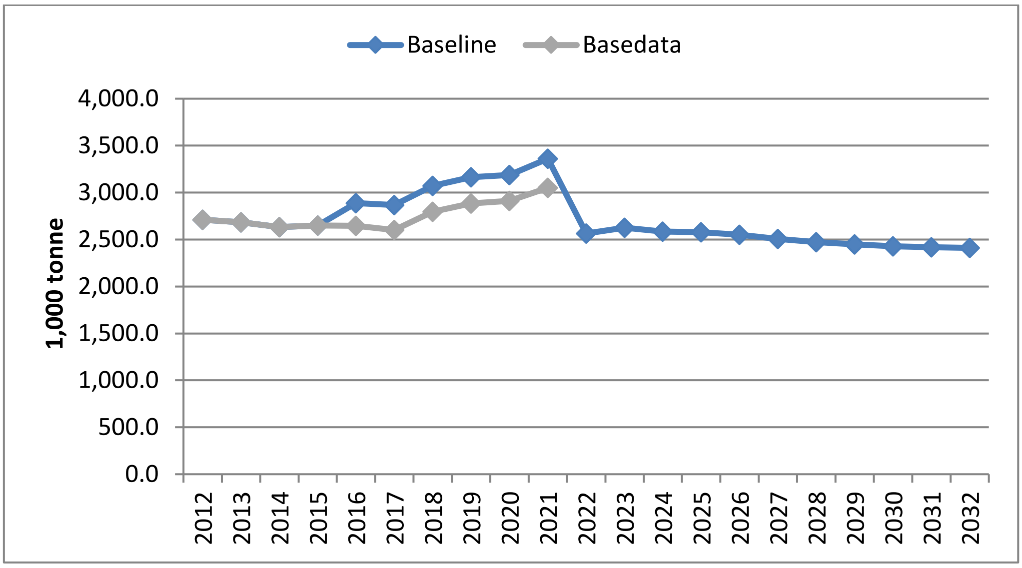
Soft wheat domestic use econometric model in Hungary

The econometric equation of soft wheat domestic use is:

$$wsudc_t = wsufe_t + wsufd_t + wsudl_t + wsufs_t + wsuot_t$$

Soft wheat domestic is expressed as an identity equation to keep the balance of the sector; this variable results from the sum of the feed use *(wsufe)*, food use *(wsufd)*, losses *(wsudl)*, seed use *(wsufs)*, and industrial and processing uses of wheat *(wsuof)*. Variables such as feed use with decreasing tendencies are likely influencing the general domestic use of wheat. Based on the scenario without modifications, compared to 3360.8 thousand tonnes in 2022, the domestic use of soft wheat may decrease by 28% percent to 2411 thousand tonnes by 2032 (Figure 14).

Figure 14 Projection of the Hungarian soft wheat domestic use



Source: Own elaboration based on the research carried out (2023)

ungarian corn price econometric model

The econometric equation of the Hungarian corn price is:

$$cop_t = f(Kp_t, cossr_t, coufe_t)$$

The Hungarian corn price is positively determined by the key price (Kp_t), which is France because it is the main corn producer in European Union; the self-sufficient ratio ($cossr_t$) also explains the variation of the crop prices with a negative relation because, if the production of corn decreases in relation with the consumption, there will be an excess of demand provoking the increasing of the national cor price. The corn feed ($coufe_t$) use affects a minimum quantity of the corn price. Due to the high corn prices, farmers could opt for supplementary products.

The statistical parameters of the Hungarian corn price are shown in the following tables:

Table 15 Multiple linear regression model for corn price: estimated coefficients and corresponding statistics

Corn price	Estimate	Std. Error	t value	Pr(>|t|)
French corn price (forints)	0.32	0.10	3.13	0.052
Corn self-sufficiency ratio	4.197	1271.00	3.30	0.046
Corn feed use	0.02	0.34	0.05	0.96

Source: Own elaboration based on the research carried out (2023)

Table 16 Corn price significance tests

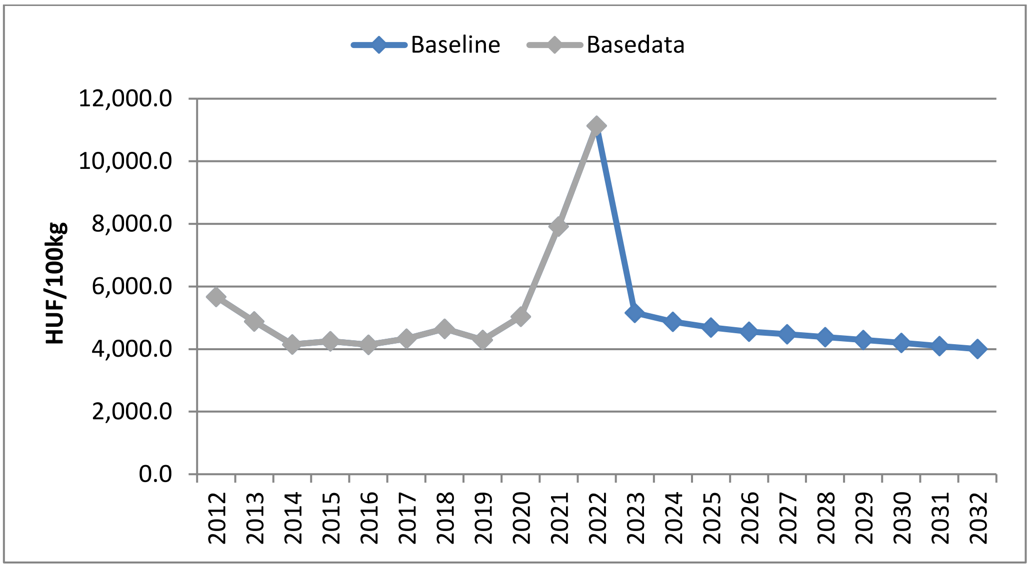
Statisticals	Values
Multiple R-squared	0.9989
Adjusted R-squared	0.998
p-value	5.833E-05
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.99 indicates that the regression model used explains approximately 99% of the total variability in the observed data, taking into account both the number of independent variables included in the model and the number of observations available. The most significant variable of this model is the corn self-sufficiency ratio. Which means, if the corn self-sufficiency ratio increases by one unit, the national corn price will increase in 4.197 forints per 100 kg. of corn.

Based on the scenario without modifications, compared to 11138.9 forints per 100 kilograms in 2022, corn price may decrease by 64% percent to 4002.3 forints per kilograms by 2032 (Figure 15).

Figure 15 Projection of the Hungarian corn price



Source: Own elaboration based on the research carried out (2023)

Hungarian corn feed use econometric model

The econometric equation of the Hungarian corn feed uses is:

$$coufe_t = f(brspr_t, coufe_{t-1}, cop_t, gdpd, trend70)$$

Corn feed use is positively dependent on broiler production ($brspr_t$) and corn price with a negative relation, which means that if the price of corn (cop_t) increases, the consumers will opt for decreasing the feed use of corn.

The statistical parameters of the Hungarian corn feed use are shown in the following tables:

Table 17 Multiple linear regression model for corn feed use: estimated coefficients and corresponding statistics

Corn feed use	**Estimate**	**Std. Error**	**t value**	**Pr(>|t|)**
Broiler production	0.75	4.09	0.18	0.864
One year lagged corn feed use	0.31	0.44	0.70	0.523
COPFNHU/GDPD2010HU	-0.04	0.09	-0.47	0.66
1/TREND70	52710	69760	0.76	0.49

Source: Own elaboration based on the research carried out (2023)

Table 18 Corn feed use significance tests

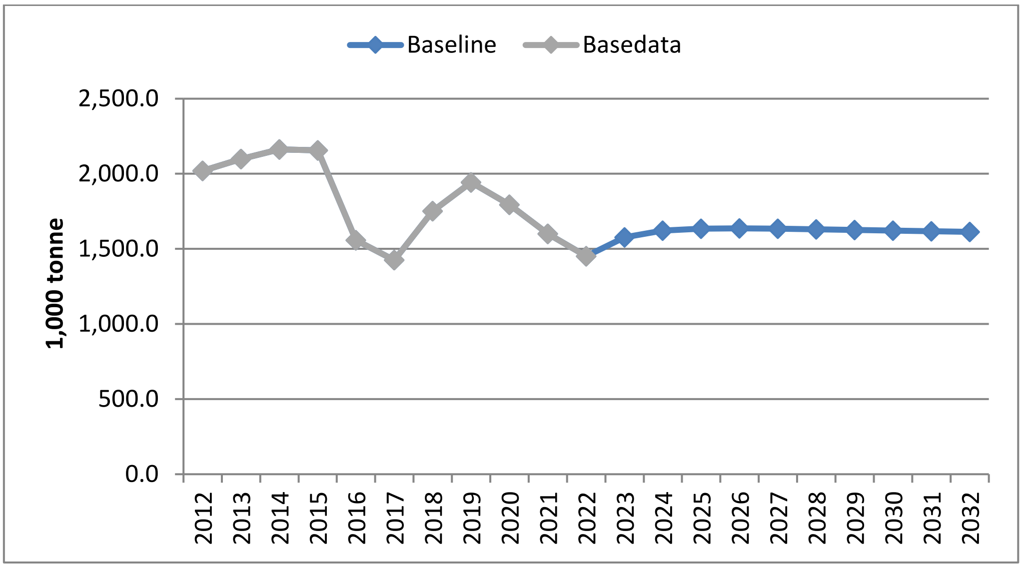
Statisticals	**Values**
Multiple R-squared	0.987
Adjusted R-squared	0.974
p-value	5.221E-04
significance	0.05

Source: Own elaboration based on the research carried out (2023)

Since α > p-value exists enough evidence to refuse the statistical Ho, it is possible to say that broiler production is significantly affected by the aforementioned independent variables. Moreover, an adjusted R square of 0.99 indicates that the regression model used explains approximately 99% of the total variability in the observed data, taking into account both the number of independent variables included in the model and the number of observations available. Similarly to the soft wheat domestic use, this equation needs to be improved adding more variables that could be cattle production or pork production.

Based on the scenario without modifications, compared to 1452.6 thousand tonnes in 2022, the feed use of corn may increase by 11% percent to 1613.1 thousand tonnes by 2032 (Figure 16).

Figure 16 Projection of the Hungarian corn feed use



Source: Own elaboration based on the research carried out (2023)

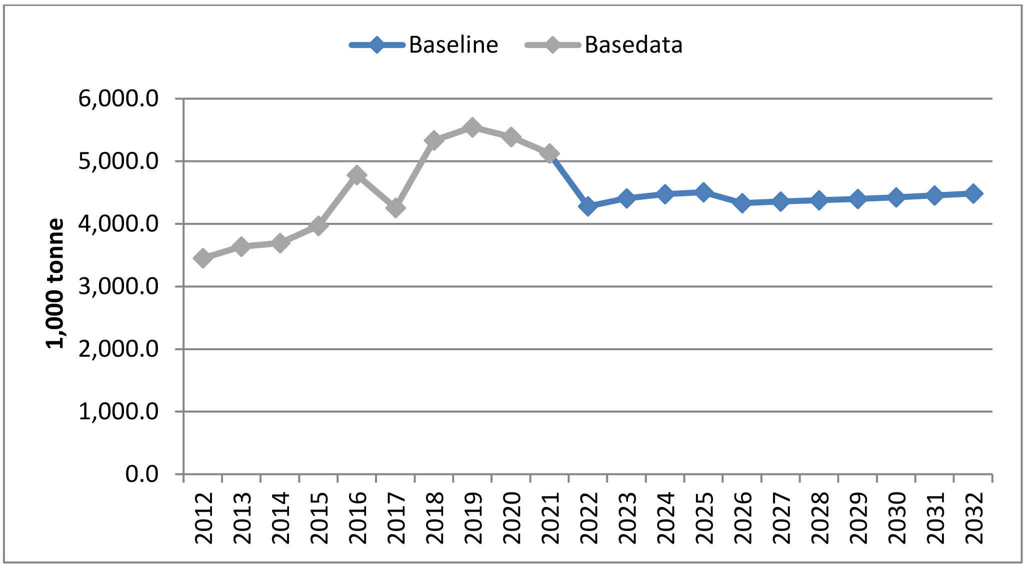
Hungarian corn domestic use econometric equation

The econometric equation of the Hungarian corn domestic uses is:

$$coudc_t = coufe_t + coufd_t + coudl_t + coufs_t + couot_t$$

Similarly to wheat use domestic use, domestic corn use is an identity equation that keeps the sector balanced in the software. That means that it depends on the fluctuation of the other variables, such as feed use *(coufe)*, food use *(coufd)*, losses *(coudl)*, seed use *(coufs)*, and industrial and processing uses of corn *(couof)*. It does not need to be estimated. The market tends to be stable from 2022 due to the expected regulations of the corn prices that affect the whole sector. Based on the scenario without modifications, compared to 5125 thousand tonnes in 2021, the domestic use of corn may decrease by -12% percent to 4486.1 thousand tonnes by 2032 (Figure 17).

Figure 17 Projection of the Hungarian corn domestic use



Source: Own elaboration based on the research carried out (2023)

Scenarios after Implementing the reduction of growth rate and stocking density in broilers chickens in Hungary

Based on anonimus information of the Hungarian poultry companies studied, three scenarios have been developed (table 19), according to the structural model of the present investigation, chickens production will suffer an immediate effect of the animal welfare measures applied. In the first scenario under a stocking density of 11 kg/m2 plus a maximun growth rate of 50g/day, a production loss in -72.32% by 2019 and -72.52% was by 2021 were calculated.

In the second scenario under a maximun growth rate of 50g/day, a production loss in -18.9% by 2019 and -17.57% were by 2021 was calculated. Finally, regarding the third scenario under a stocking density of 11 kg/m2 a production loss in -66.67% for both 2019 and 2021 was estimated. The averge shows the media between both years to get a more precise value that represents the effect of the animal welfare measures applied.

Table 19 Scenarios of the investigation

Scenarios	Animal welfare measures	2019	2021	Average
First scenario	Loss of production after the reduction of both stocking density (11kg/m2) and growth rate (50g/day).	-72.32%	-72.52%	**-72.4%**
Second scenario	Loss of production after the reduction of growth rate (50g/day).	-18.9%	-17.57%	**-18.2%**
Third scenario	Loss of production after the reduction of stocking density (11kg/m2).	-66.7%	-66.7%	**-66.7%**

Source: Own elaboration based on the research carried out (2023)

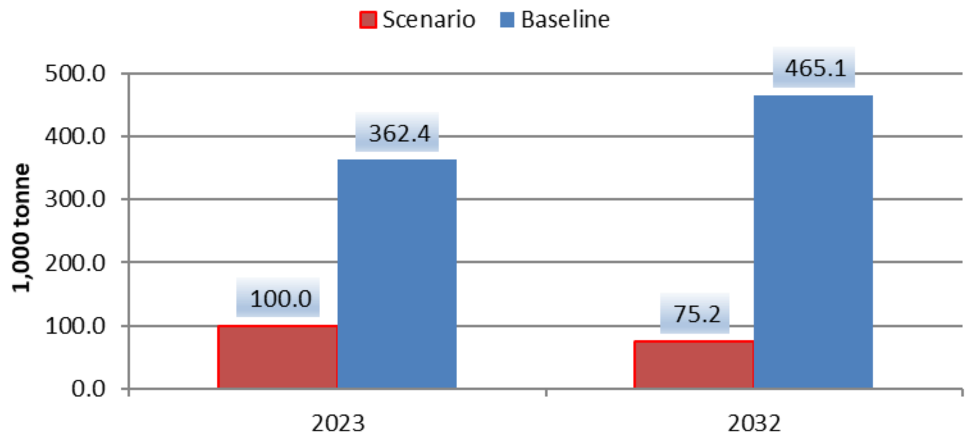
3.6.2. Scenario 1 analysis

Reduction of the growth rate to 50 g/day and the stocking density to 11kg/m2 of chicken broilers in Hungary, a combined measure

Impact of applying a combined measure on broiler chicken production

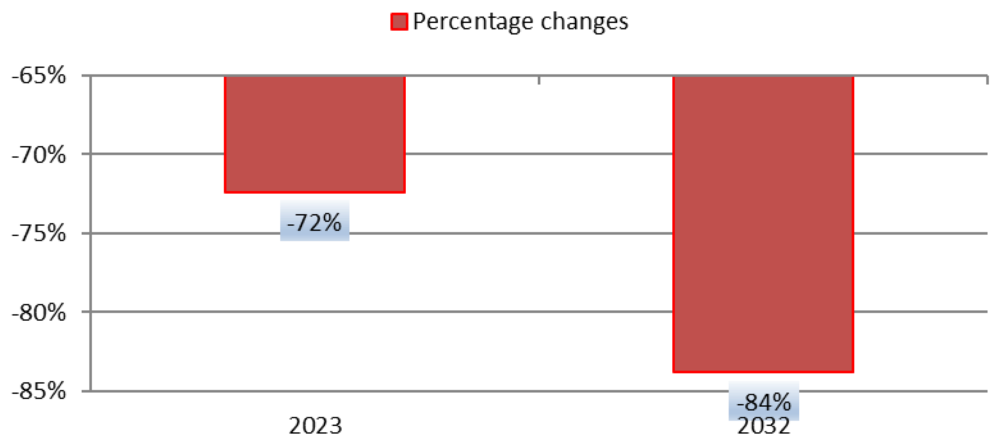
Suppose this measure is kept constant during the following years. Under this scenario, the broiler production is affected directly, reducing the production by 72.4 % considering the average between 2019 and 2021. It is possible to see this inmediate effect if the measure is applied in the present year from 362.4 thousand tonnes to 100 thousand tonnes. In that case, the reduction in production will be intensified even more by 2032 due to the slowdown of the production growth under the new scenario conditions, which means minus 84% of chicken broiler production from 465.1 thousand tonnes up to 75.2 thousand tonnes of chicken meat.

Figure 18 Broiler production comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 19 Scenario and baseline variations of broiler production under a combined measure

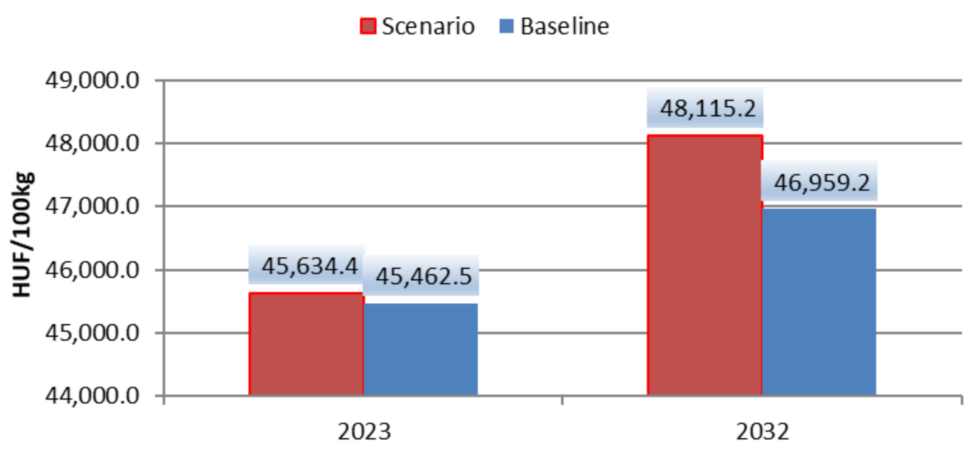


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the broiler chicken price

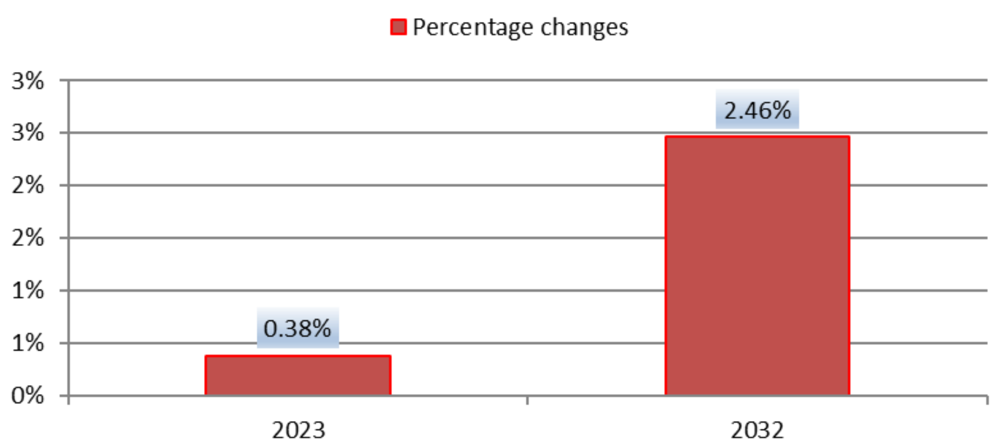
Regarding broiler price, there is not a substantial effect on this variable because the losses on production are compensated by the changes in international trade, which means an increase in broiler imports. However, it is possible to see that by 2032, under this scenario, the price is expected to vary by 2.46% compared with the baseline, explained mainly by the variations in the self-sufficiency ratio, the demand has a constant behavior while the production is reduced resulting in a slight increase of the price. It would be possible to see more price variations if more assumptions are taken into consideration, for instance, a transition period in which the farmers decide to increase the price at the beginning in order to compensate for the loss of production and their financial obligations in the short term. A very low price of the imports could motivate the farmers to look into more attractive international markets affecting the local prices or the fluctuation of Poland prices that would directly influence the domestic broiler prices.

Figure 20 Broiler price comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 21 Scenario and baseline variations of broiler prices under a combined measure

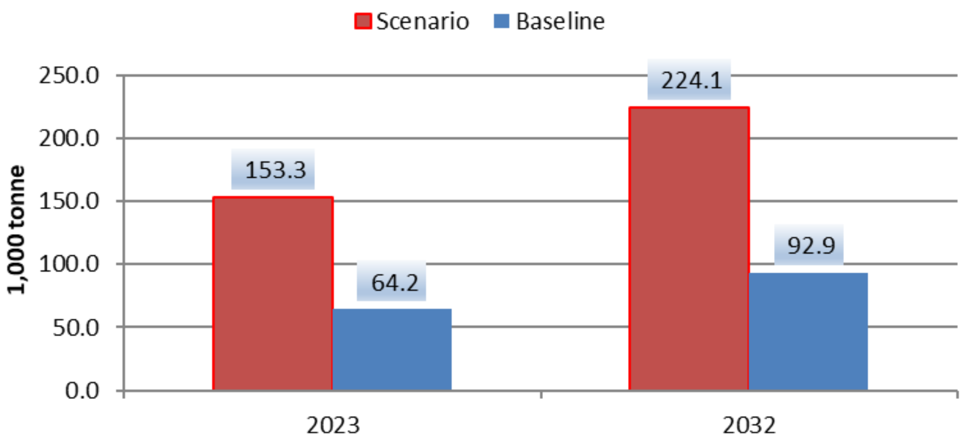


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on broiler chicken imports

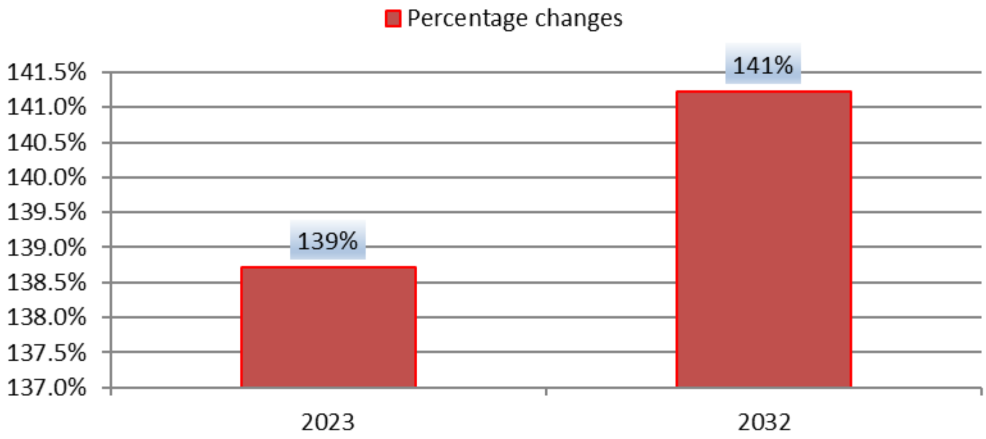
As it is mentioned before, the reduction in production will provide an immediate equilibrium in the broiler sector, which means a substancial increase in imports to cover the demand. By 2023 imports are expected to increase by 139% in relation to the baseline from 64.2 thousand tonnes to 153.3 thousand tonnes, and because of the continous production reduction, by 2032, this amount would increase from 92.9 up to 224.1 thousand tonnes, which means an increase of 141% in relation to the baseline.

Figure 22 Broiler imports comparison under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 23 Scenario and baseline variations of broiler imports under a combined measure

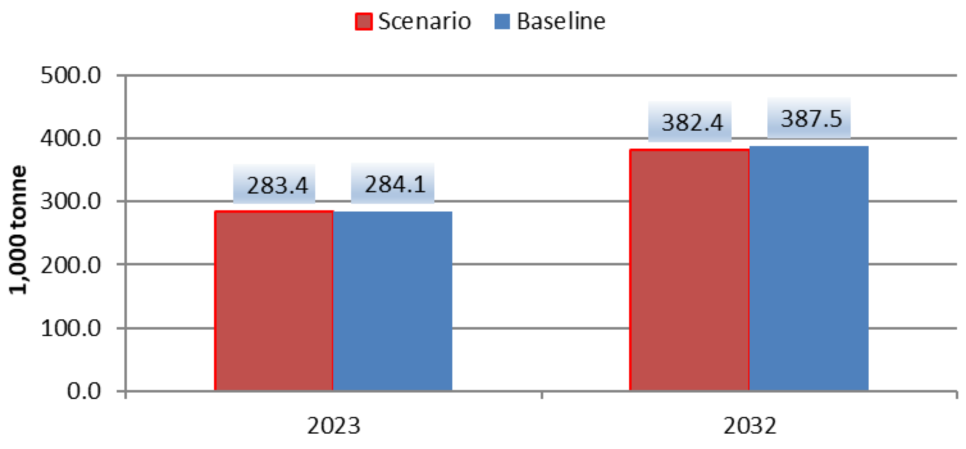


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on broiler domestic use

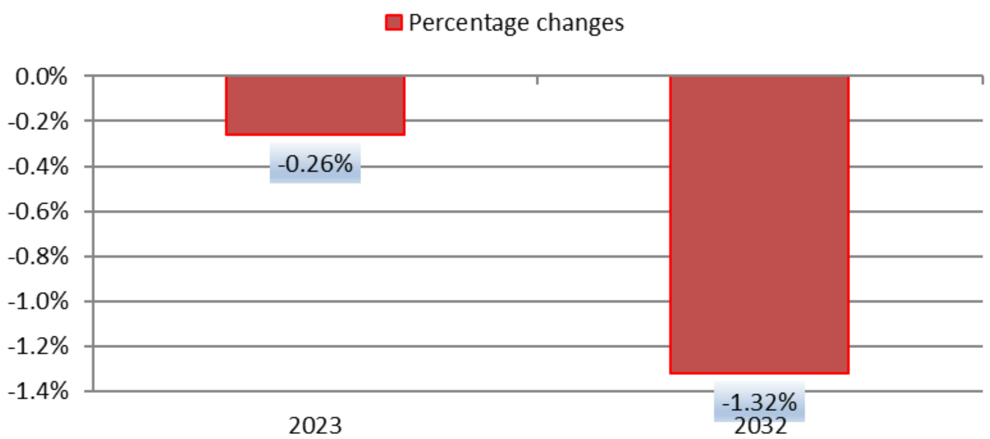
In the present study it is assumed that the consumption will not have significant variations, which means that people won`t change their eating habits of meat in this scenario; the graph shows only a difference of 1.32% between the scenario and the baseline by 2032, going from 387.5 up to 382.4 thousand of tonnes of chicken meat. However it is possible to see changes in consumption if there are changes in broiler prices because, in that case, consumers will opt for the closest suplementary product, which is pork.

Figure 24 Broiler domestic use comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 25 Scenario and baseline variations of broiler domestic use under a combined measure

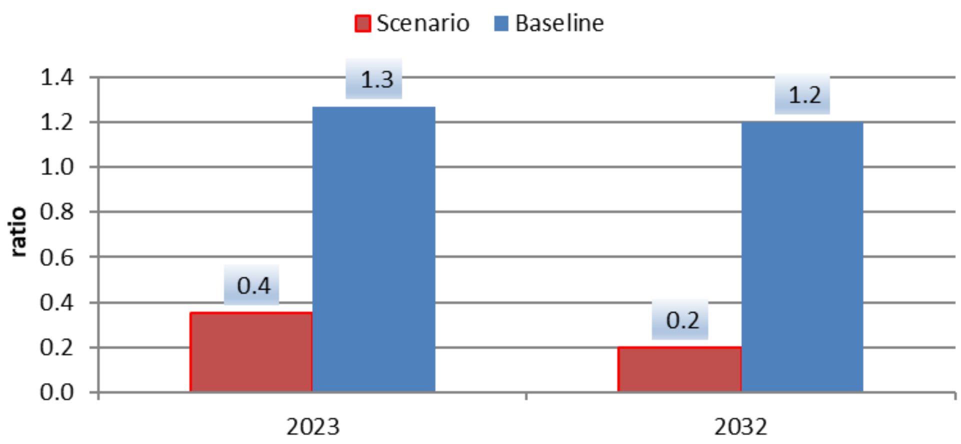


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the broiler self-sufficiency ratio

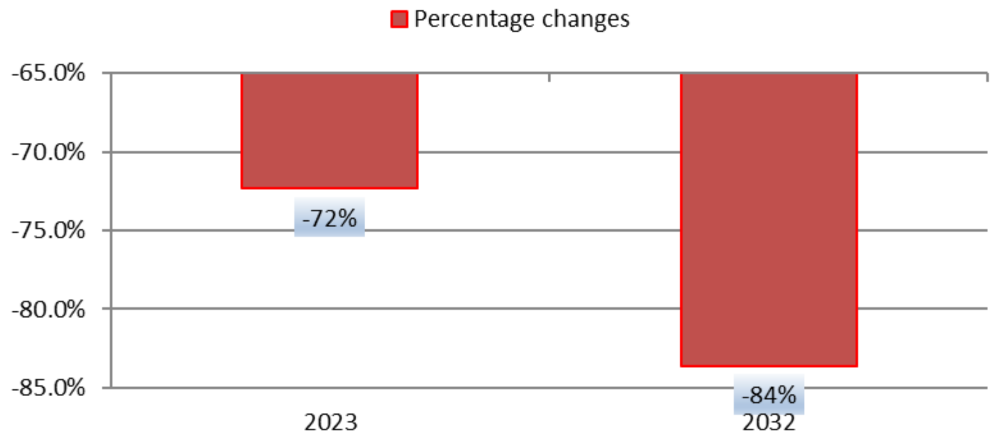
The self-sufficiency ratio is the consequence of the behavior of chicken broiler production and consumption; this indicator will show an index that will be higher if the level of production increases in relation to the consumption, showing, in this case, how self-efficient the domestic economy is at the moment of using their production. In the figure, it is possible to see that this indicator decreases substantially by 72% proportionally with the production in relation to the baseline by 2023 and up to 84% by 2032 this difference will be accentued over the time because of the continous contraction of broiler production while consumption remains in the natural level.

Figure 26 Broiler self-sufficiency ratio comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 27 Scenario and baseline variations of the broiler self-sufficiency ratio under a combined measure

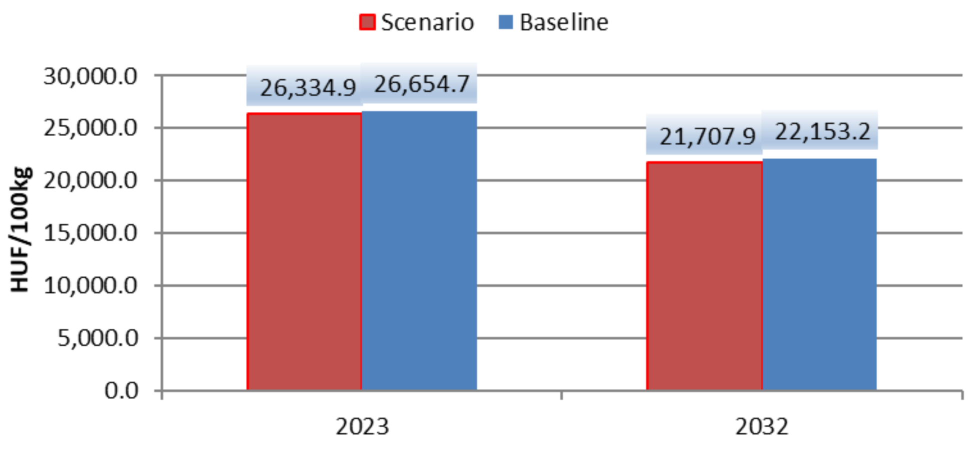


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on broiler chicken input costs

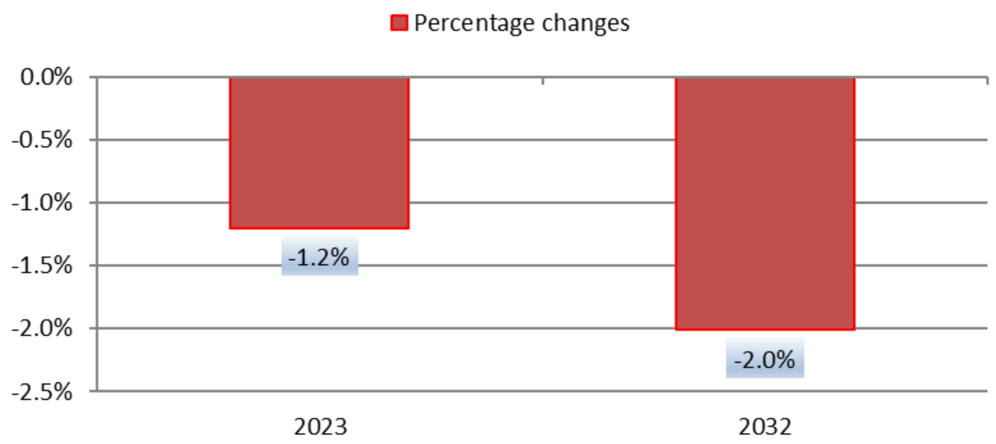
Broiler input costs are not affected in a substantial way by the measure applied due to the stability of other commodities prices such as corn or soft wheat. The graphs show a difference of -1.2% with the baseline by 2023 and -2% by 2032 due to the stabilization of the market. However, it would be possible to see changes if more variables, such as energy or workforce costs, are included. The rigid costs are explained because a reduction in broiler production has an impact on crop feed use, but this is only a part of the total crop domestic use, which is not strongly affected; in consequence, the price (the primary determinant variable of the input cost) is also not substantially affected.

Figure 28 Broiler input cost comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 29 Scenario and baseline variations of broiler input costs under a combined measure



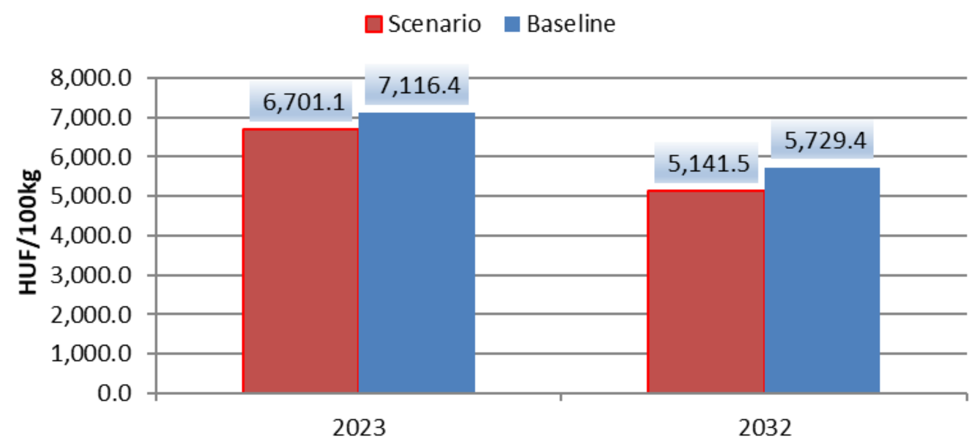
Source: Own elaboration based on the research carried out (2023)

3.6.3. Impact of applying a combined measure on cross-sectoral crop industries of broiler chicken in Hungary

Impact of applying a combined measure on the soft wheat price

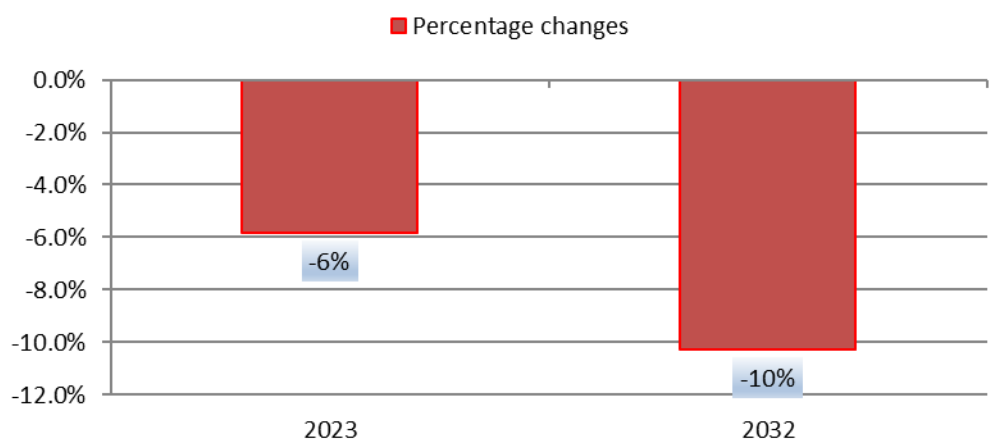
Soft wheat prices are slightly affected by the welfare animal measure in this case because this variable depends on the consumption of soft wheat. This variable has minor or moderate changes. The pictures show a moderate difference of 6% in relation with the baseline from 7116.4 up to 6701.1 forints per one hundred kilograms by 2023 and this percentage increases to 10% by 2032, going from 5729.4 up to 5141.5 forints per one hundred kilograms. Any change in this variable will directly impact broiler input costs.

Figure 30: Soft wheat price comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 31: Scenario and baseline variations of the soft wheat price under a combined measure

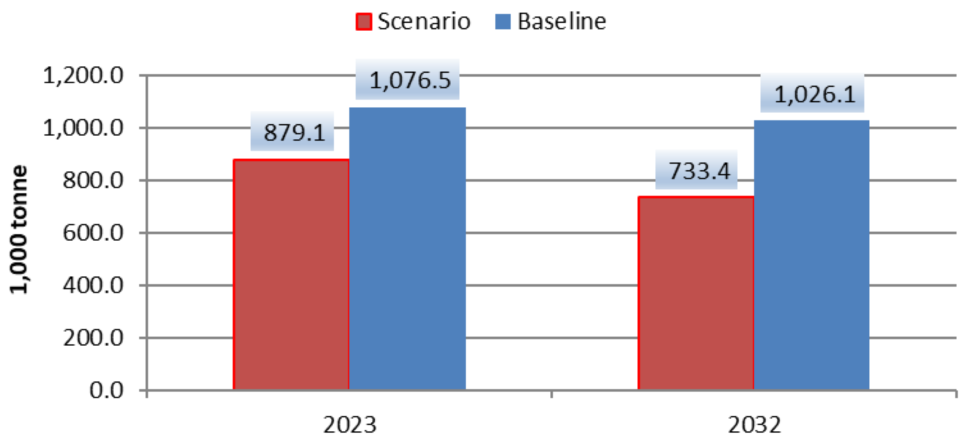


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the soft wheat feed use

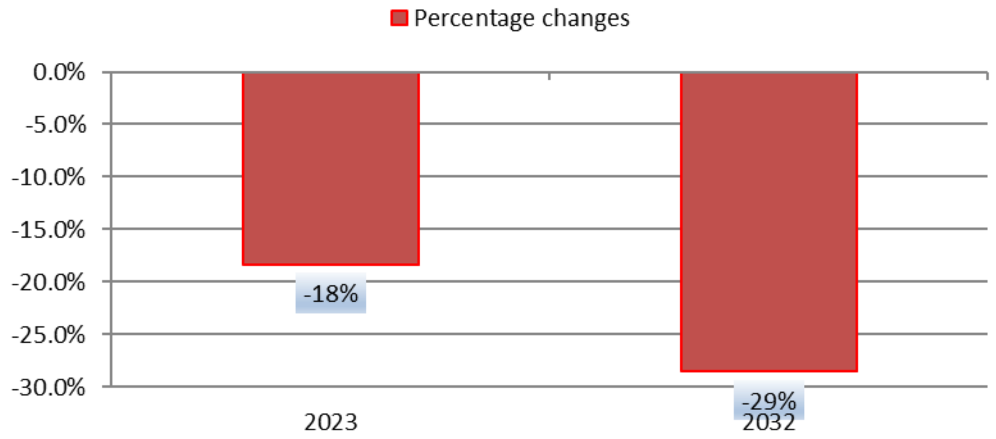
Soft wheat is one of the main crops used to feed chickens. The feed use amount is affected by the animal welfare measure in the following sense; there will be a moderate and immediate reduction of feed use by 18% in relation to the baseline (scenario without modifications) due to less quantity of chicken meat, which result will be intensified reaching the percentage of 29%, from 1026.1 until 733.4 thousand of tonnes by 2032 due to a reduction in the broiler self sufficiency ratio.

Figure 32: Soft wheat feed use comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 33 Scenario and baseline variations of soft wheat feed use under a combined measure

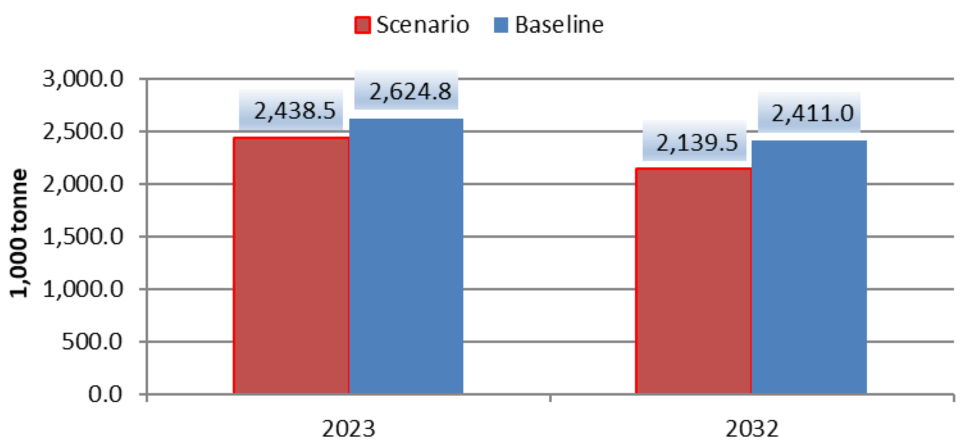


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the soft wheat domestic use

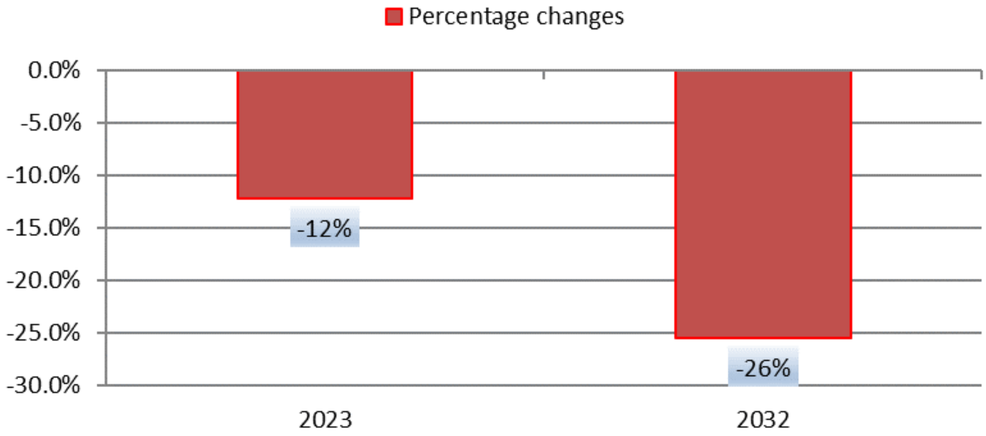
The measure applied affects the soft wheat domestic uses mainly because of the feed use; this variable is part of the general domestic use, so in the following graph, it is shown that the domestic use will moderately decrease by 12% in the first year of applied the measure in relation to the baseline, and by 2032, this percentage will be reduced up to 26% from 2411 to 2139.5 thousand of thones of soft wheat.

Figure 34 Soft wheat domestic use comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 35 Scenario and baseline variations of soft wheat domestic use under a combined measure

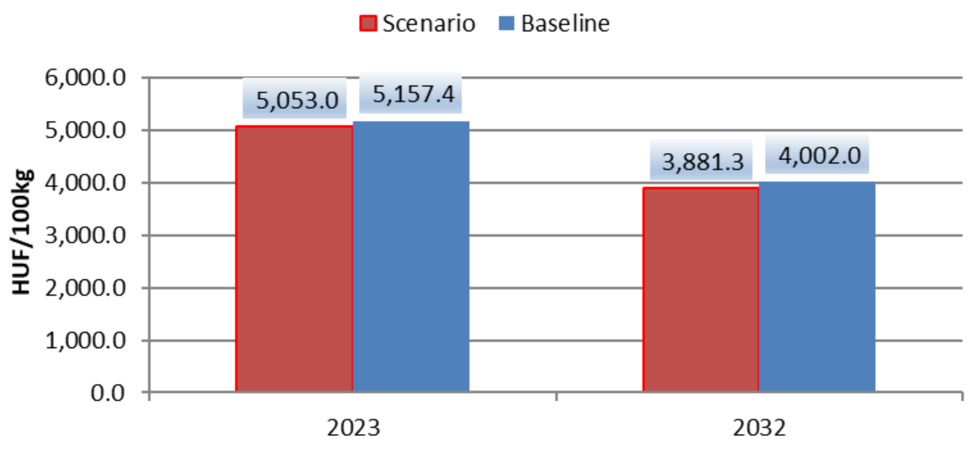


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the corn price

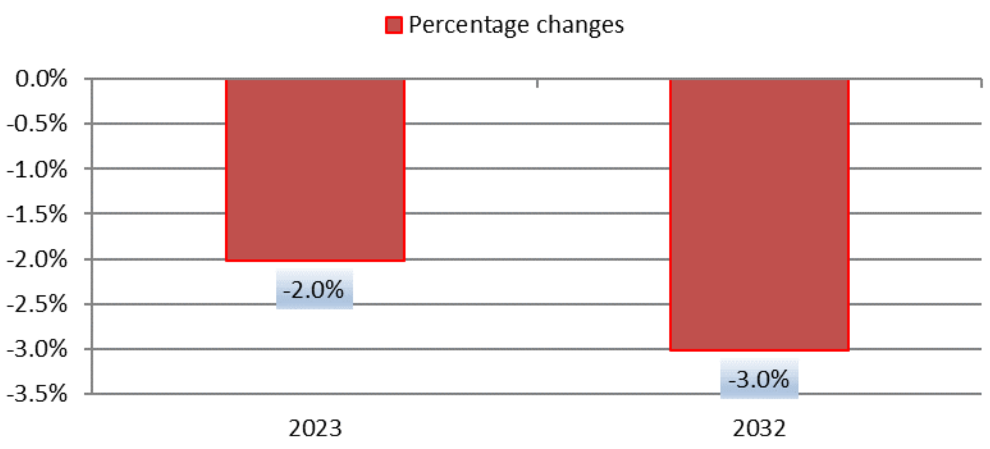
Corn prices are slightly affected by the welfare animal measure in this case because this variable depends on the consumption of soft wheat. This variable has small or moderate changes. The pictures show a difference of 2% in relation with the baseline from 5157.4 up to 5053 forints per one hundred kilograms by 2023 This percentage increases to 3% by 2032, going from 4002 up to 3881.3 forints per one hundred kilograms. Any change in this variable will directly impact broiler input costs.

Figure 36 Corn price comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 37 Scenario and baseline variations of the corn price under a combined measure



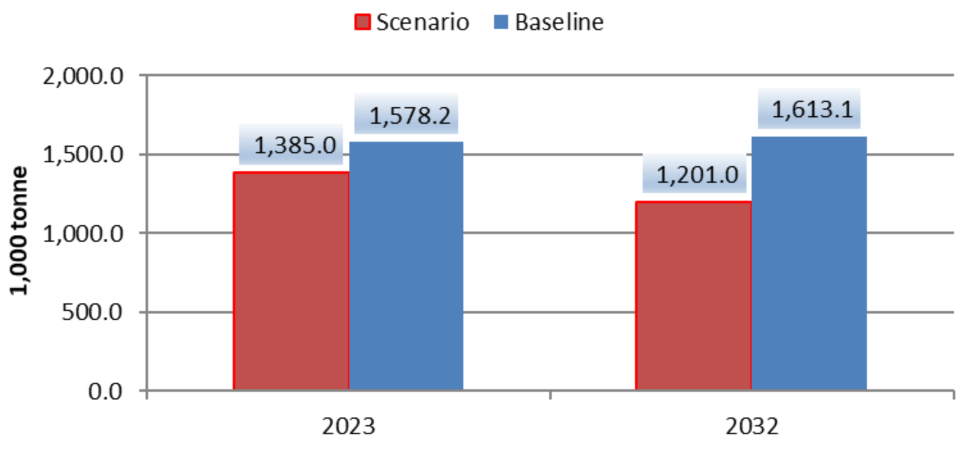
Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the corn feed use

Corn is the main crop used for feeding chickens. The feed use amount is affected by the animal welfare measure in the following sense. There will be an immediate and moderate reduction of feed use by 12% in relation to the baseline (scenario without modifications) due to less quantity of chicken meat, which result will be intensified, reaching the percentage of

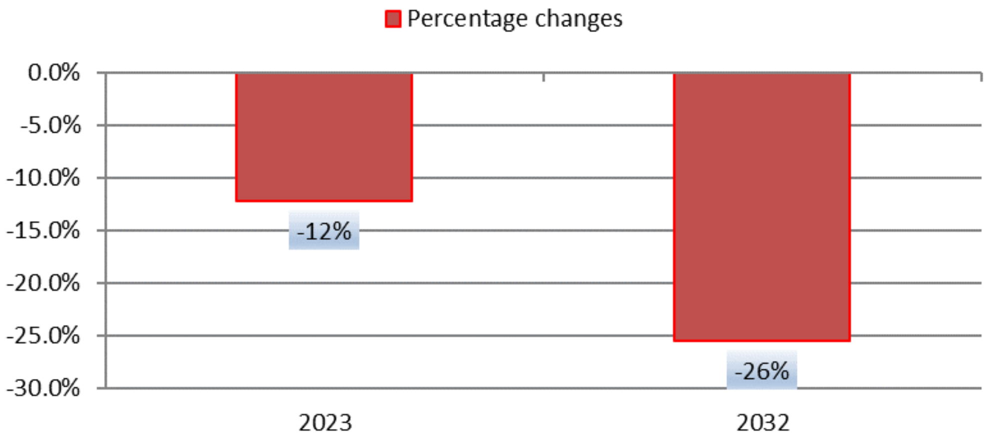
-26%, from 1613.1 until 1201 thousand of tonnes by 2032 due to a reduction in the broiler self sufficiency ratio.

Figure 38 Corn feed use comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 39 Scenario and baseline variations of corn feed use under a combined measure

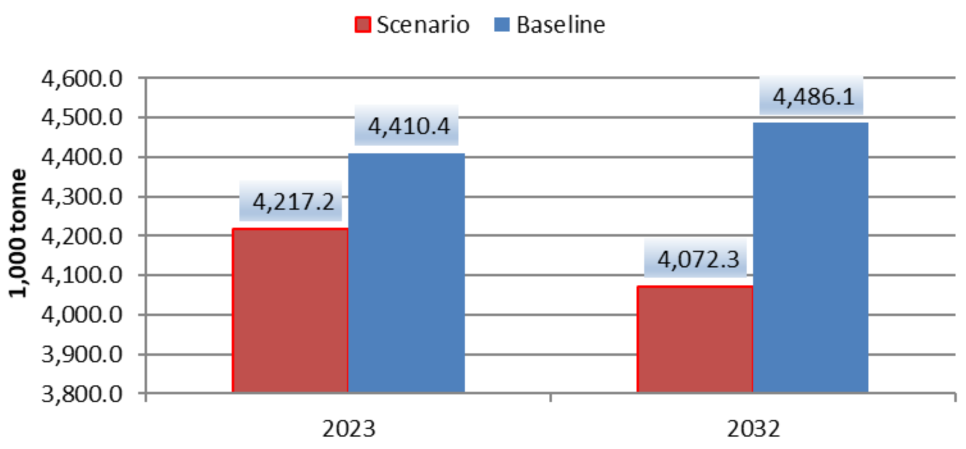


Source: Own elaboration based on the research carried out (2023)

Impact of applying a combined measure on the corn domestic use

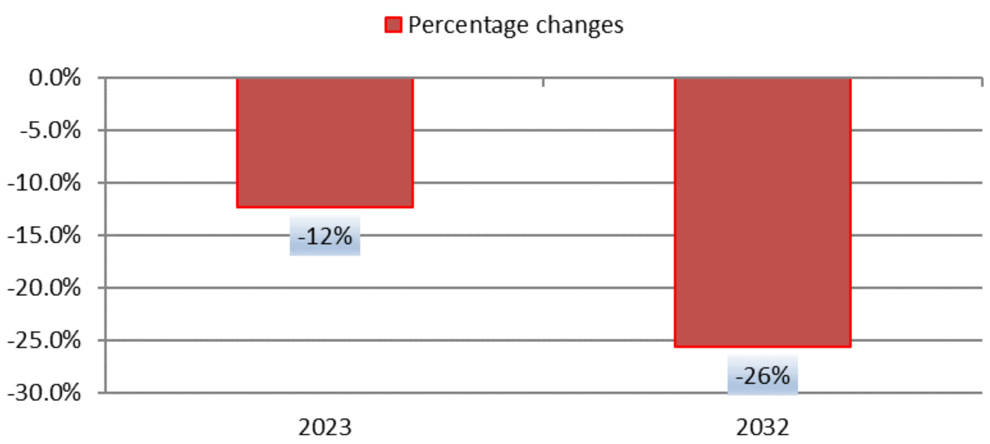
The measure applied affects domestic corn use mainly because of the feed use; this variable is part of the general domestic use, so in the following graph, it is shown that the domestic use will decrease moderately by 12% in the first year of applying the measure in relation to the baseline, and by 2032, this percentage will be reduced up to 26% from 4486.1 to 4072.3 thousand of tonnes of corn.

Figure 40 Corn domestic use comparisons under a combined measure



Source: Own elaboration based on the research carried out (2023)

Figure 41 Scenario and baseline variations of corn domestic use under a combined measure



Source: Own elaboration based on the research carried out (2023)

3.6.3. Analysis of the scenarios 2 and 3

Independet analysis of broiler chickens growth rate reduction to 50 grams/day and stocking density to 11kg/m2 in Hungary

In this section, the analysis has been done separately because every welfare measure results in a different scenario. All results in this section are expressed in the percentage variations between the baseline and the scenario created by 2023 and 2032. The tables and graphs for this sections can be found in the thesis's annexes.

Broiler production independent scenarios analysis

Broiler production in the model is affected directly by the measure released; considering the average between 2019 and 2021 and calculations based on the sample taken from the sampled poultry companies in Hungary, the production would decrease by -18.2% if only the growth rate reduction measure is applied and by -66.7 if only the stock density reduction measure is applied (table 19). It is also possible to see a substantial decrease in the production of the scenario in relation to the baseline between 2023 to 2032 from -18% to -31% of fewer thousand tonnes if only the growth rate reduction measure is applied (Annex 2) and from -67% to -80% of less thousand tonnes if only the stock density reduction measure is applied (Annex 26).

Under the growth rate scenario, the production goes from 362.4 to 296.4 thousand tonnes in 2023 and 465.1 to 323 thousand tonnes in 2032 (Annex 1). Finally, under the stock density reduction scenario, the production goes from 362.4 to 120.8 thousand tonnes in 2023 and from 465.1 to 94 thousand tonnes in 2032 (Annex 25).

Broiler price independent scenarios analysis

Regarding broiler price, there is not a significant effect on this variable because the losses on production are compensated by the changes in international trade, which means an increase in broiler imports. However, It is also possible to see a slight increase in the scenario prices in relation to the baseline between 2023 to 2032 from -0.57% to 0.89% of the amount in forints per one hundred kilograms if only the growth rate reduction measure is applied

(Annex 4) and from 0.28% to 2.34% of the price in forints per one hundred kilograms if only the stock density reduction measure is applied (Annex 28).

Under the growth rate scenario, the broiler price goes from 45462.5 to 45204.9 forints per one hundred kilograms in 2023 and from 46959.2 up to 47376.1 forints per one hundred kilograms in 2032 (Annex 3). Finally, under the stock density reduction scenario, the broiler prices go from 45462.5 to 45588.5 forints per one hundred kilograms in 2023 and from 46959.2 up to 48058.7 forints per one hundred kilograms in 2032 (Annex 27).

Broiler imports independent scenarios analysis

It is possible to see a substantial increase in the imports scenario in relation to the baseline between 2023 to 2032 from 35% to 51% of thousand tonnes if only the growth rate reduction measure is applied (Annex 6) and from 128% to 134% if only the stock density reduction measure is applied (Annex 30).

Under the growth rate scenario, broiler imports go from 64.2 to 87.0 thousand tonnes in 2023. From 92.9 to 140.7 thousand tonnes in 2032 (Annex 5), and under the stock density reduction scenario, broiler prices go from 64.2 to 146.3 thousand tonnes in 2023, and finally, from 92.9 to 217.8 thousand tonnes in 2032 (Annex 29).

Broiler domestic use independent scenarios analysis

It is not possible to see a significant variation in the domestic uses scenario in relation to the baseline between 2023 to 2032; the variation is from 0.38% to -0.48% of thousand tonnes if only the growth rate reduction measure is applied (Annex 8) and from -0.19% to -1.25% if only the stock density reduction measure is applied (Annex 32).

Under the growth rate scenario, broiler domestic uses go from 284.1 up to 285.2 thousand tonnes in 2023 and from 387.5 up to 385.7 thousand tonnes in 2032 (Annex 7), finally, under the stock density reduction scenario, the broiler domestic uses go from 284.1 up to 283.6 thousand tonnes in 2023 and from 387.5 up to 382.7 thousand tonnes in 2032 (Annex 31).

Broiler Self-sufficiency ratio independent scenario analysis

It is possible to see a substantial decrease of the self-sufficiency scenario in relation to the baseline between 2023 to 2032 from -19% to -30% only if the growth rate reduction measure is applied (Annex 10) and from -67% to -80% only if the stock density reduction measure is applied (Annex 34).

Under the growth rate scenario, the broiler self-sufficiency ratio goes from 1.3 to 1 in 2023, and from 1.2 to 0.8 in 2032 (Annex 9), and under the stock density reduction scenario, the broiler self-sufficiency ratio goes from 1.3 up to 0.4 thousand tonnes in 2023 and 1.2 up to 0.2 in 2032 (Annex 33).

Broiler Input costs independent scenarios analysis

It is not possible to see a significant variation in the inputs cost scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -0.4% to -0.8% only if the growth rate reduction measure is applied (Annex 12) and from -1.1% to -1.9% only if the stock density reduction measure is applied (Annex 36).

Under the growth rate scenario, the broiler input costs go from 26654.7 to 26560.3 forints per one hundred kilograms in 2023 and from 22153.2 to 21986.1 forints per one hundred kilograms in 2032 (Annex 11). Finally, the stock density reduction scenario, the broiler input costs go from 26654.7 to 26358.8 forints per one hundred kilograms in 2023 and from 22153.2 up to 21729 forints per one hundred kilograms in 2032 (Annex 35).

Soft wheat price independent scenarios analysis

It is possible to see a small variation of the soft wheat prices scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -2% to -4% only if the growth rate reduction measure is applied (Annex 14) and from -5% to -10% only if the stock density reduction measure is applied (Annex 38).

Under the growth rate scenario, the soft wheat prices go from 7116.4 to 6992.5 forints per one hundred kilograms in 2023. From 5729.4 to 5508.1 forints per one hundred kilograms in 2032 (Annex 13), and under the stock density reduction scenario, the soft wheat prices go from 7116.4 to 6732.1 forints per one hundred kilograms in 2023 and from 5729.4 up to 5169.3 forints per one hundred kilograms in 2032 (Annex 37).

Soft wheat feed use independent scenarios analysis

It is possible to see a moderate decrease in the soft wheat feed use scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -5% to -10% only if the growth rate reduction measure is applied (Annex 16) and from -17% to -27% only if the stock density reduction measure is applied (Annex 40).

Under the growth rate scenario, the soft wheat feed uses goes from 1076.5 to 1026.8 thousand tonnes in 2023 and from 1026.1 to 919.4 thousand tonnes in 2032 (Annex 15), finally under the stock density reduction scenario, the soft wheat feed uses goes from 1076.6 to 894.8 thousand of tonnes in 2023 and from 1026.1 up to 747.5 thousand of tonnes in 2032 (Annex 39).

Soft wheat domestic use independent scenarios analysis

It is possible to see a moderate decrease in the soft wheat domestic uses scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -3% to -9% only if the growth rate reduction measure is applied (Annex 18) and from -11% to -24% only if the stock density reduction measure is applied (Annex 42).

Under the growth rate scenario, the soft wheat domestic uses go from 2624.8 to 2578.4 thousand tonnes in 2023 and from 2418 to 2319.3 thousand tonnes in 2032 (Annex 17), finally under the stock density reduction scenario, the soft wheat domestic uses go from 2624.8 to 2453.4 thousand of tonnes in 2023 and from 2411 up to 2152.6 thousand of tonnes in 2032 (Annex 41).

Corn price independent scenarios analysis

It is not possible to see a significant variation in the corn prices scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -0.5% to -1.1% only if the growth rate reduction measure is applied (Annex 20) and from -1.9% to -2.9% only if the stock density reduction measure is applied (Annex 44).

Under the growth rate scenario, the corn prices will go from 5157.4 to 5130.9 forints per one hundred kilograms in 2023. From 4002.0 to 3958.3 forints per one hundred kilograms in 2032 (Annex 19), and under the stock density reduction scenario, the corn prices go from 5157.4 to 5061.3 forints per one hundred kilograms in 2023 and from 4002 to 3887.2 forints per one hundred kilograms in 2032 (Annex 43).

Corn feed use independent scenarios analysis

It is possible to see a moderate decrease in the corn feed use scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -3% to -9% only if the growth rate reduction measure is applied (Annex 22) and from -11% to -24% only if the stock density reduction measure is applied (Annex 46).

Under the growth rate scenario, the corn feed uses goes from 1578.2 to 1529.6 thousand tonnes in 2023 and from 1613.1 to 1462.9 thousand tonnes in 2032 (Annex 21), finally under the stock density reduction scenario, the corn feed uses goes from 1578.2 to 1400.4 thousand tonnes in 2023 and from 1613.1 up to 1220.9 thousand of tonnes in 2032 (Annex 45).

Corn domestic use independent scenarios analysis

It is possible to see a moderate decrease in the domestic corn use scenario in relation to the baseline between 2023 to 2032. The percentage changes go from -3% to -9% only if the growth rate reduction measure is applied (Annex 24) and from -11% to -24% only if the stock density reduction measure is applied (Annex 48).

Under the growth rate scenario, the corn domestic uses go from 4410.4 to 4361.8 thousand tonnes in 2023 and from 4486.1 to 4335.4 thousand tonnes in 2032 (Annex 23), finally under the stock density reduction scenario, the corn domestic uses go from 4410.4 to 4232.6 thousand of tonnes in 2023 and from 4486.1 up to 4092.3 thousand of tonnes in 2032 (Annex 47).

4. Conclusions and Recomendations

From the main research question, it is concluded that there will be a substantial sectoral economic impact by reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary, identifying a mainly a decrease in 84% of the production and an increasing of 141% of the imports by 2032.

Fulfilling the first specific objective of the present investigation, it is concluded that there will be a substantial sectoral economic impact of reducing broilers' chicken growth rate by 50 grams per day in Hungary, identifying a decrease of 31% the production by 2032 and an increasing of 51% of the imports by 2032.

Fulfilling the second specific objective of the present investigation, it is concluded that there will be a substantial sectoral economic impact of reducing broilers' stock density by 11 kilograms per meter square in Hungary, identifying a decrease in 80% of the production by 2032, and an increase of 134% of the imports by 2032.

Fulfilling the third specific objective of the present investigation, it is concluded that there will be a moderate cross-sectoral economic impact of reducing broilers chicken growth rate by 50 grams per day in Hungary, identifying mainly a decrease in -9% of corn and soft wheat feed use by 2032.

Fulfilling the fourth specific objective of the present investigation, it is concluded that there will be a moderate cross-sectoral economic impact of reducing broilers' stock density by 11 kilograms per meter square in Hungary, identifying mainly a decrease in 27% soft wheat feed use and 24% of corn feed use by 2032.

It is possible to acept the Hypotesis 1 of the investigation because after appling the stocking density and growth rate measures, there is a substantial impact on the broiler sector in Hungary in every scenario. However, the Hypotesis 2 and 3 are rejected because the impact on the soft wheat and corn sectors are moderated.

It is recommended to include more variables in the model, such as other crops, elasticities in demand according to the import chicken prices, and to improve the input costs equation structure. These improvements in the software will be useful to see the effect of the measures studied in this thesis in other sectors, such as pork and cattle.

It is recommended to establish a transition period in the measures suggested by the European Food Safety Agency, so the farmers can make decisions in time that don't affect their monetary benefits and remain competitive in the market. In this sense, the effect of the measure would be relatively moderate in the economy.

Finally it is recommended to compare the results of AGMEMOD with other agri-economic models, such as CAPRI, in order to enrich the scientific and methodological support.

5. Summary

The present thesis shows a sectoral and cross-sectoral economic analysis on the recent animal welfare proposal by the European Food Safety Authority and the European Commission offering a maximum stock density of $11kg/m^2$ and a 50 grams/day growth rate for conventional broilers. A sectoral analysis means a specific analysis of the broiler sector while a cross-sectoral analysis studies the related sectors or industries that could be affected due to changes in the broiler industry.

The hypotheses of the present thesis are:

H1: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the broiler sector in Hungary.

H2: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the soft wheat sector in Hungary.

H3: The new EU animal welfare requirements as proposed by the European Food Safety Agency and the European Commission, in particular the reduction of growth rate and stocking density of broiler chicken, will have a substantial impact on the corn sector in Hungary.

The main objective of the present thesis is to identify the combined sectoral and cross-sectoral economic impact of reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary. However, an independent analysis is also presented, which means the sectoral and cross-sectoral impact if only the stock density reduction measure is applied and the economic impact if only the growth rate reduction measure is applied.

In order to achieve the thesis objectives, two research methods will be used. Firstly a multivariable analysis of agricultural products through a software called AGMEMOD to analyze the impacts of the animal welfare measures and to build scenarios projected until 2032. This software is a multi-country, multi-market, dynamic, and partial equilibrium econometric model. Besides this method, the leading Hungarian poultry producers' enterprises were analyzed. Based on anonymised and non-public AKI farm-level data, a sample of 24 enterprises for 2019 and 23 for 2021 were analyzed to calculate the impact of the growth rate reduction and stock density in their production.

The main conclusion shows that there will be a substantial sectoral economic impact by reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary, identifying a decrease in 84% of the production and an increasing of 141% of the imports by 2032. However, there will be a moderate cross-sectoral impact of the abovementioned animal welfare measures, identifying a decrease in 10% of the soft wheat prices, 26% of soft wheat domestic use, 3% of corn prices, and 26% of corn domestic use by 2032.

The economic effect will be different If the measures are applied independently, for instance, if only a growth rate reduction measure is applied, the effect on the market will be smaller than the scenario in which a stocking density reduction is applied. At the same time, the biggest effect occurs when a combined measure is applied. the details of the independent analysis are explained in detail in the thesis body.

One similar study supports the first impact of the present investigation, Zampiaga, Calini and Sirri, (2021) found that by implementing Growth rate and stocking density reduction strategies, it is possible to achieve higher feed efficiency by reducing competition for food among the birds. As a result, there could be a decrease in the cost of production, which would be a significant economic advantage for the broiler industry. While in the present research, the input costs decrease in the first stage, but possibly they could increase over time due to farmers reactions or market price speculations.

It is recommended to extend this research exploring other variables that could influece the model, for instance, to include other crops in the equations, elasticities in demand according to the import chicken prices, and to improve the input costs equation structure. These improvements in the software will be useful to see the effect of the measures studied in this thesis in other sectors, such as pork and cattle.

Establish a transition period in the measures suggested by the European Food Safety Agency would be important so the farmers can make decisions in time that don't affect their monetary benefits and remain competitive in the market. In this sense, the effect of the measure would be relatively moderate in the economy.

Finally it is recommended to compare the results of AGMEMOD with other agri-economic models, such as CAPRI, in order to enrich the scientific and methodological support.

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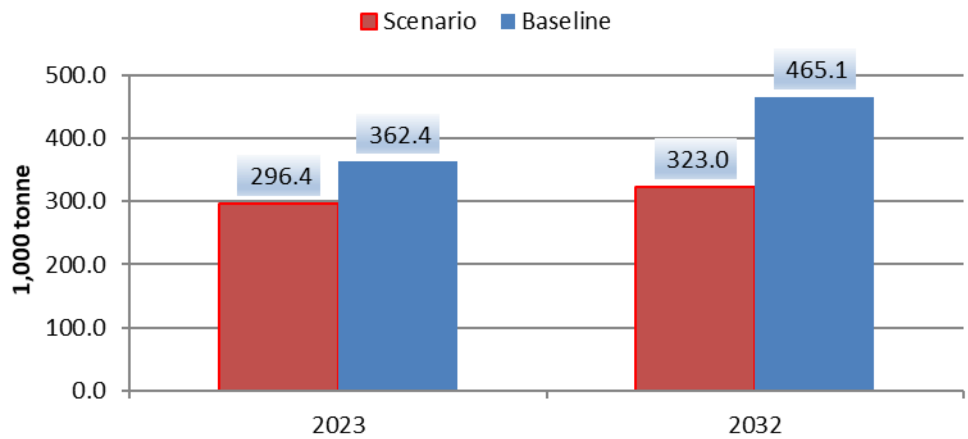
Annexes

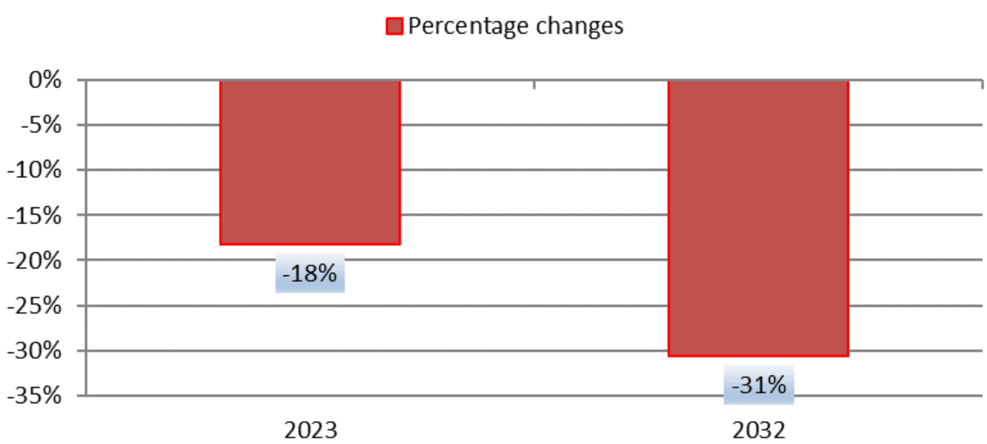
Scenario 2: Reduction of chicken broilers growth rate to 50 grams/day in Hungary

Annex 1 Hungarian broiler production under 50 g/day growth rate



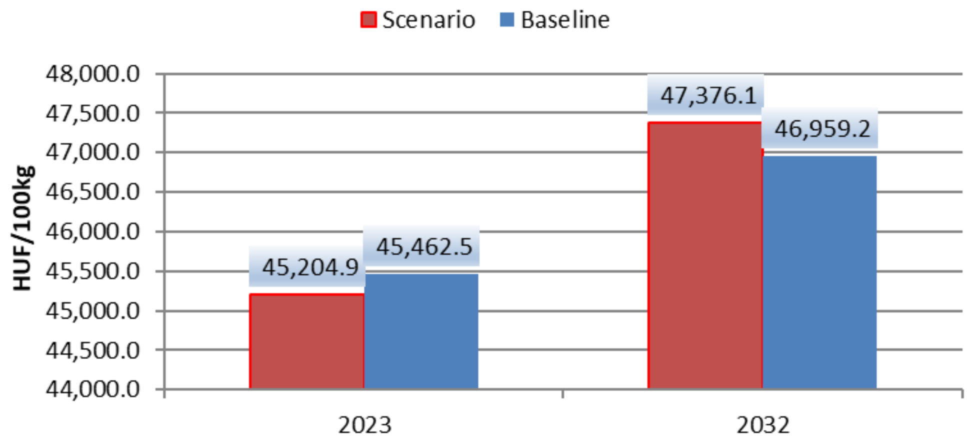
Source: Own elaboration based on the research carried out (2023)

Annex 2 Scenario and baseline variations of broiler production under 50g/day growth rate



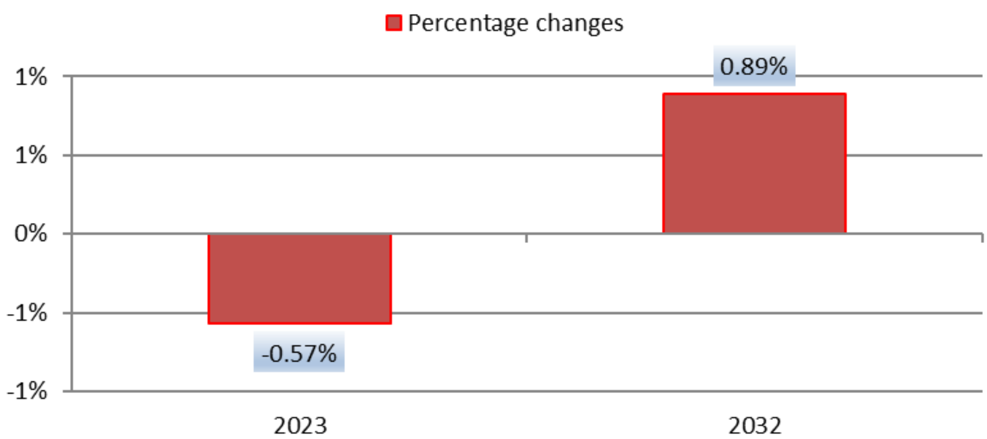
Source: Own elaboration based on the research carried out (2023)

Annex 3 Hungarian broiler prices under 50 g/day growth rate



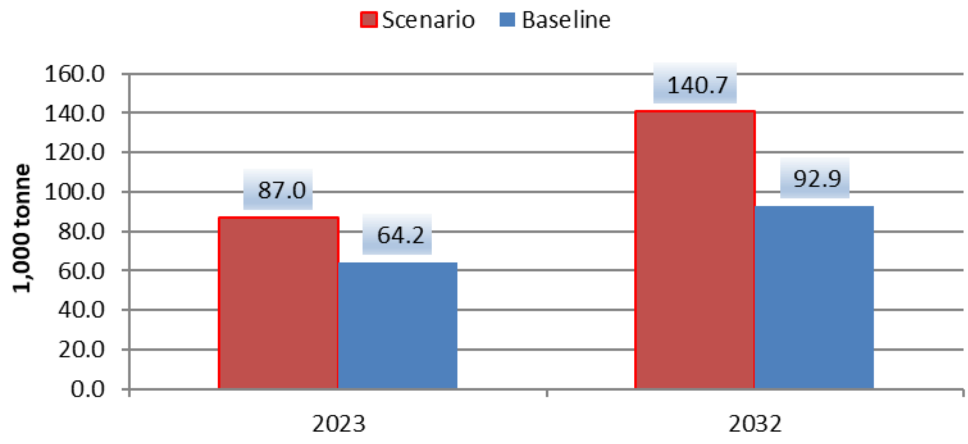
Source: Own elaboration based on the research carried out (2023)

Annex 4 Scenario and baseline variations of broiler prices under 50g/day growth rate



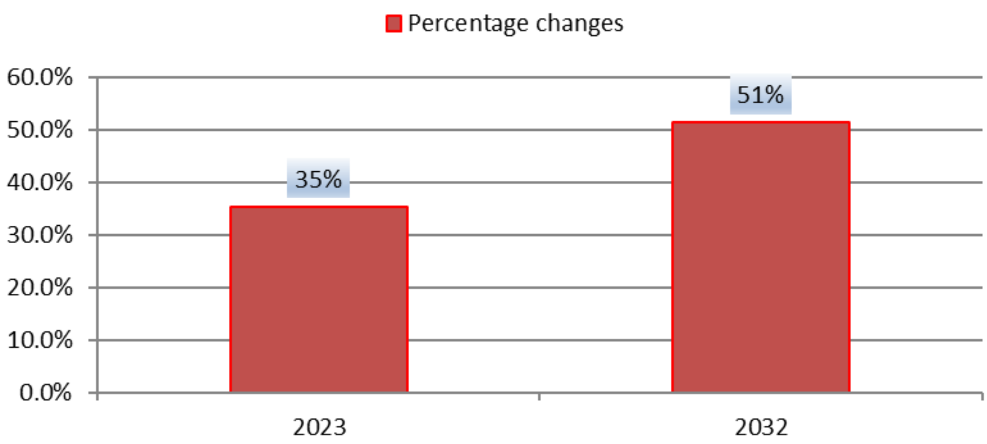
Source: Own elaboration based on the research carried out (2023)

Annex 5 Hungarian broiler imports under 50 g/day growth rate



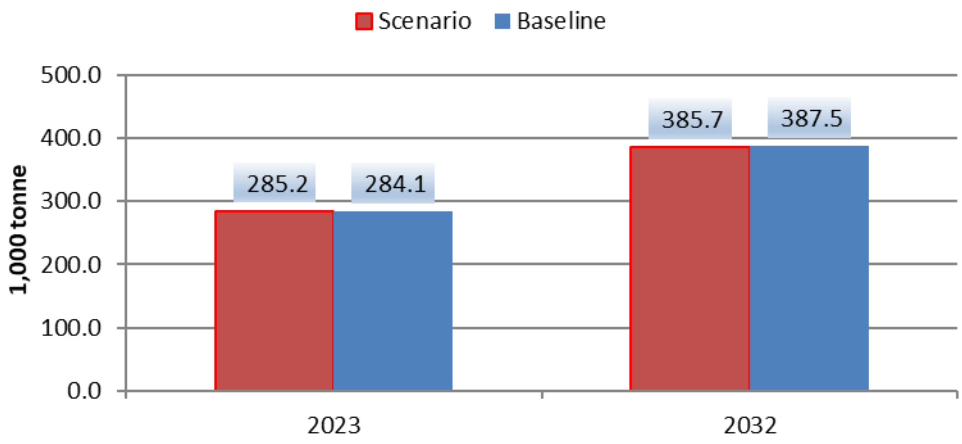
Source: Own elaboration based on the research carried out (2023)

Annex 6 Scenario and baseline variations of broiler imports under 50g/day growth rate



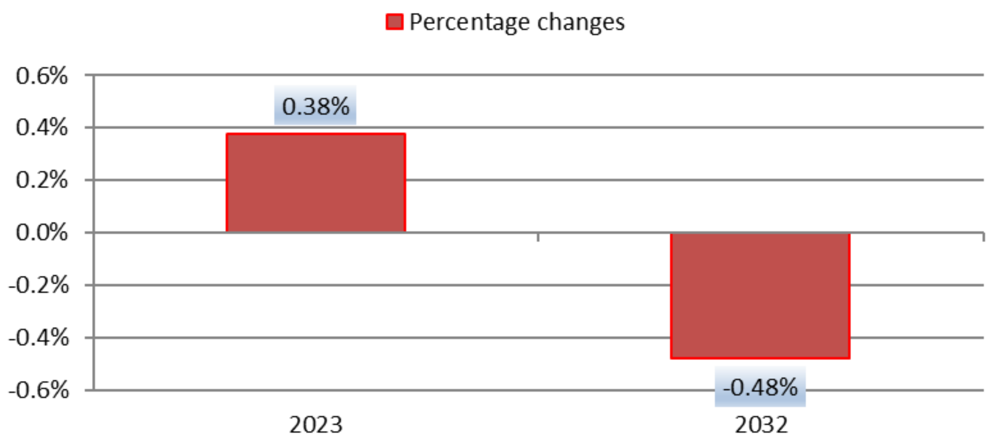
Source: Own elaboration based on the research carried out (2023)

Annex 7 Hungarian broiler domestic use under 50 g/day growth rate



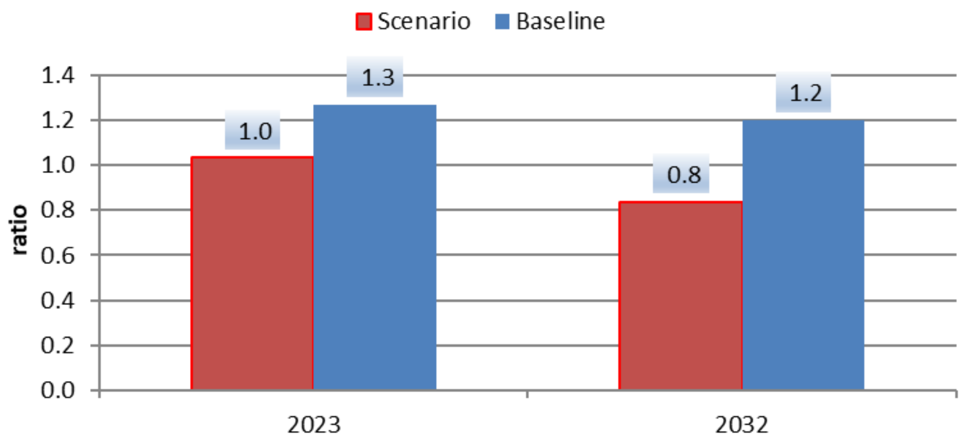
Source: Own elaboration based on the research carried out (2023)

Annex 8 Scenario and baseline variations of broiler domestic use under 50g/day growth rate



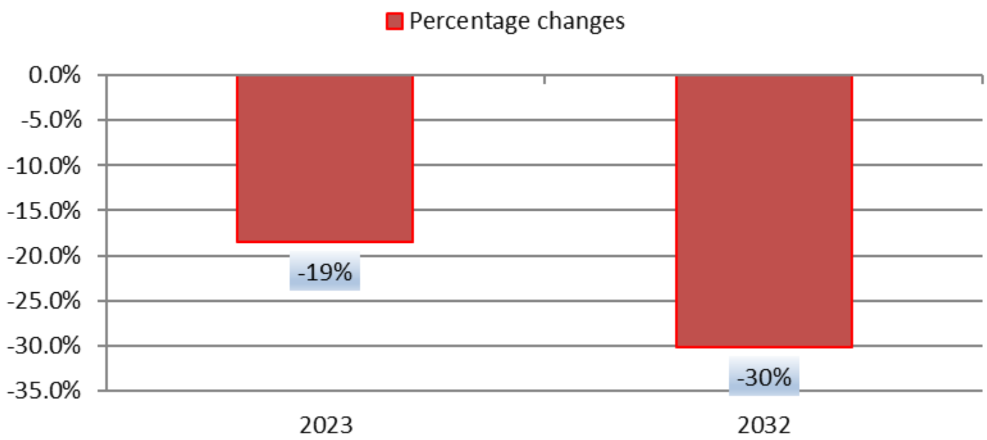
Source: Own elaboration based on the research carried out (2023)

Annex 9Annex 5 Hungarian broiler self-sufficiency ratio under 50 g/day growth rate



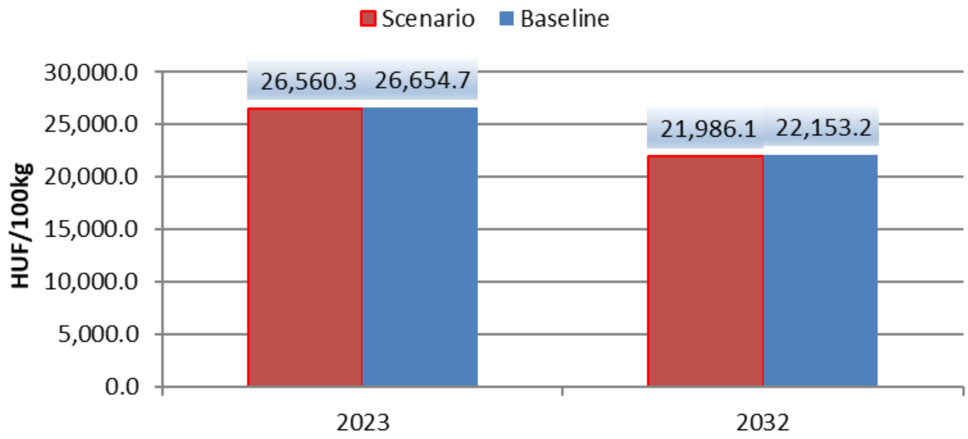
Source: Own elaboration based on the research carried out (2023)

Annex 10 Scenario and baseline variations of the broiler self-sufficiency ratio under 50g/day growth rate



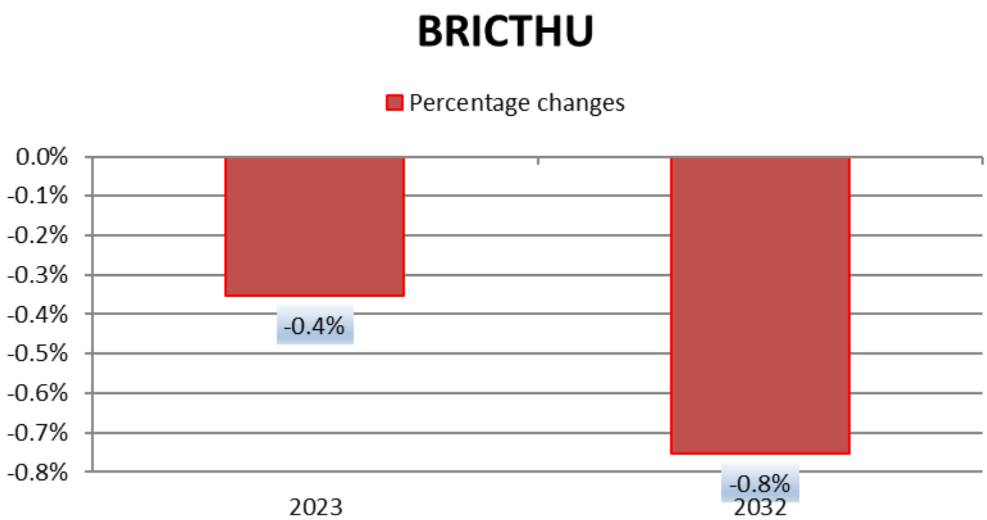
Source: Own elaboration based on the research carried out (2023)

Annex 11 Hungarian broiler input costs under 50 g/day growth rate



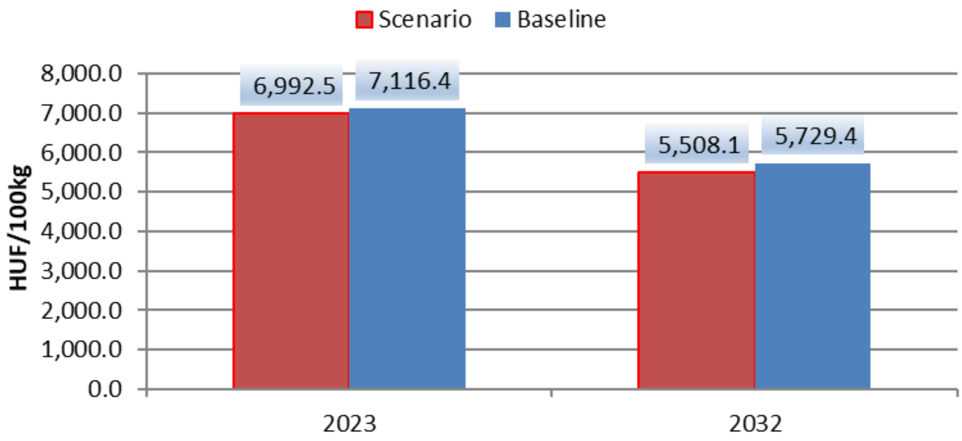
Source: Own elaboration based on the research carried out (2023)

Annex 12 Scenario and baseline variations of broiler input costs under 50g/day growth rate



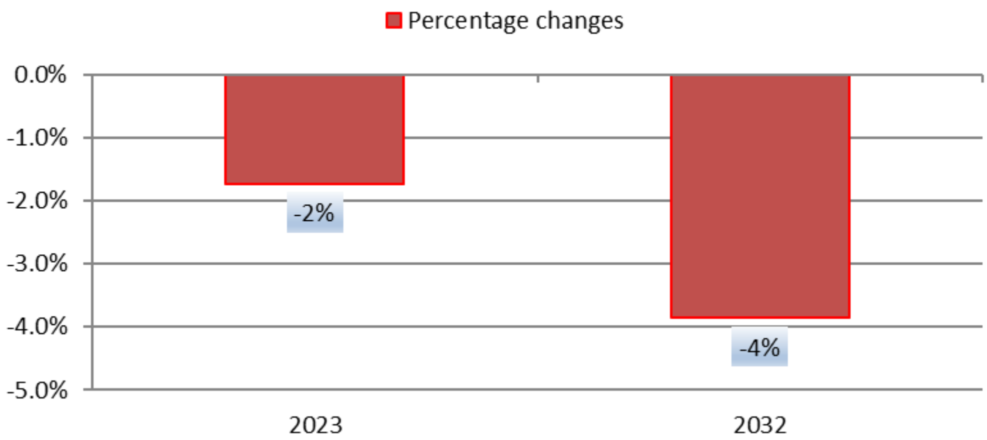
Source: Own elaboration based on the research carried out (2023)

Annex 13 Hungarian soft wheat prices under 50 g/day growth rate of broilers



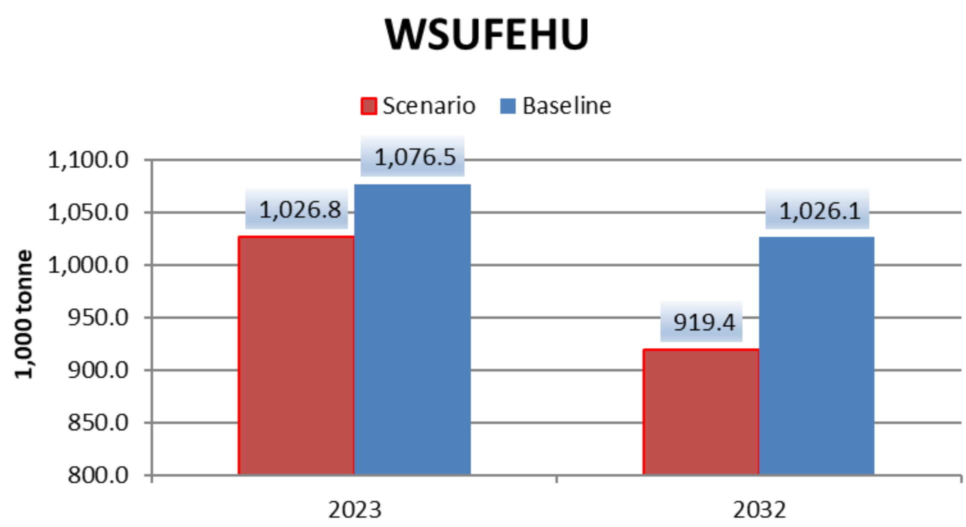
Source: Own elaboration based on the research carried out (2023)

Annex 14 Scenario and baseline variations of soft wheat price under 50g/day growth rate of broilers



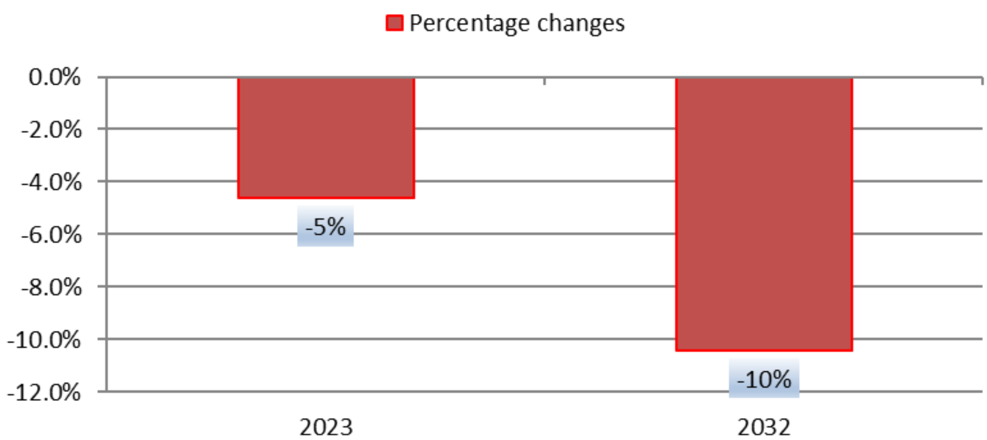
Source: Own elaboration based on the research carried out (2023)

Annex 15 Hungarian soft wheat feed use under 50 g/day growth rate of broilers



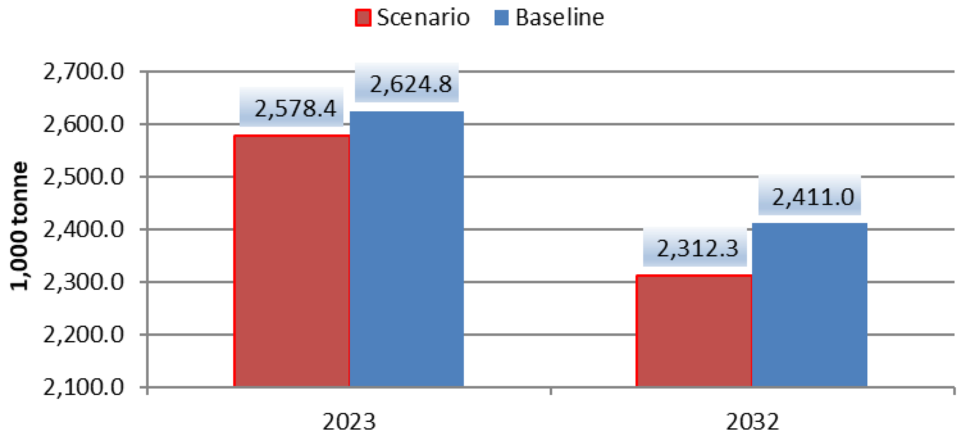
Source: Own elaboration based on the research carried out (2023)

Annex 16 Scenario and baseline variations of soft wheat feed use under 50g/day growth rate of broilers



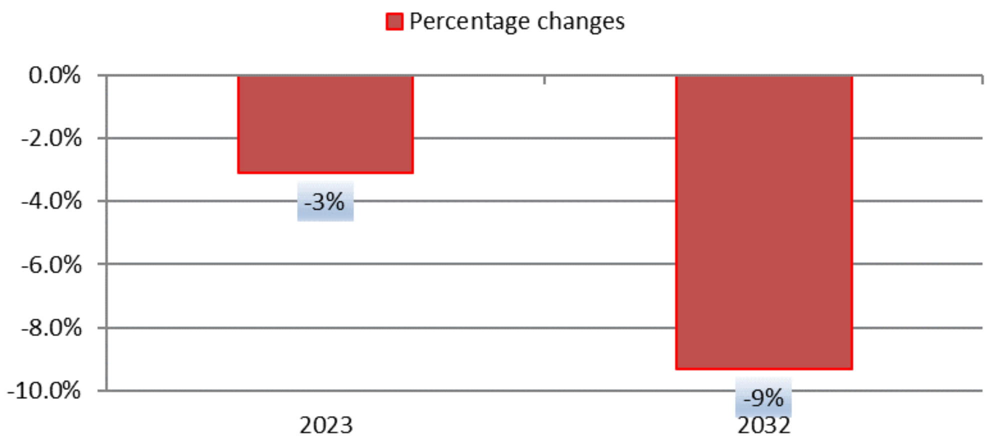
Source: Own elaboration based on the research carried out (2023)

Annex 17 Hungarian soft wheat domestic use under 50 g/day growth rate of broilers



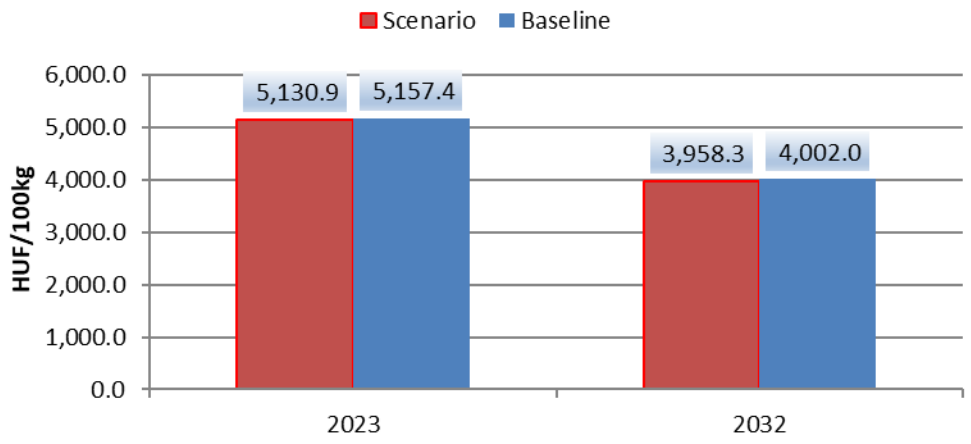
Source: Own elaboration based on the research carried out (2023)

Annex 18 Scenario and baseline variations of soft wheat doemstic use under 50g/day growth rate of broilers



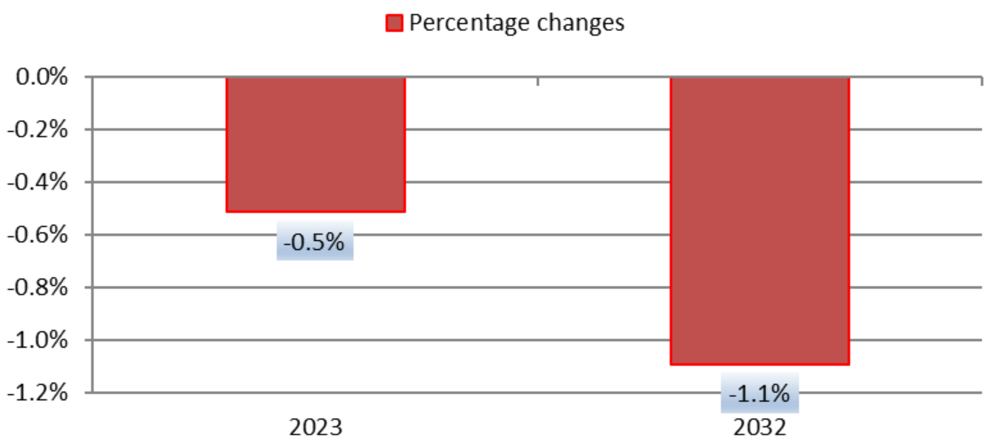
Source: Own elaboration based on the research carried out (2023)

Annex 19 Hungarian corn prices under 50 g/day growth rate of broilers



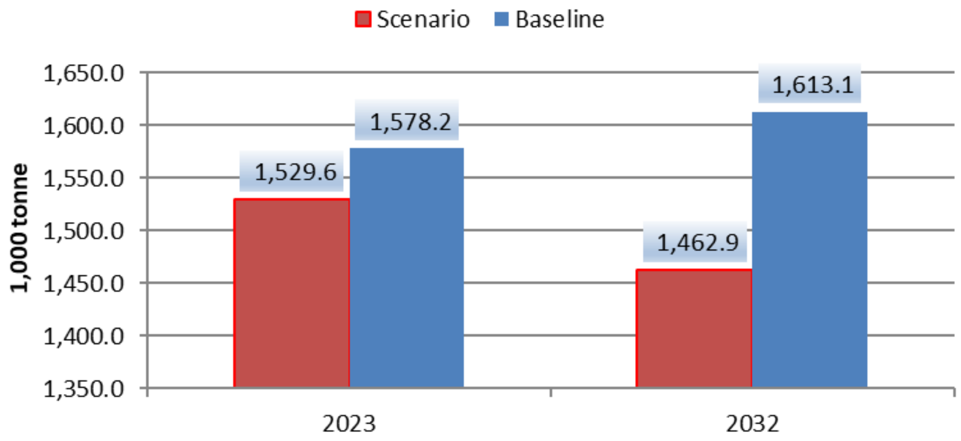
Source: Own elaboration based on the research carried out (2023)

Annex 20 Scenario and baseline variations of corn prices under 50g/day growth rate of broilers



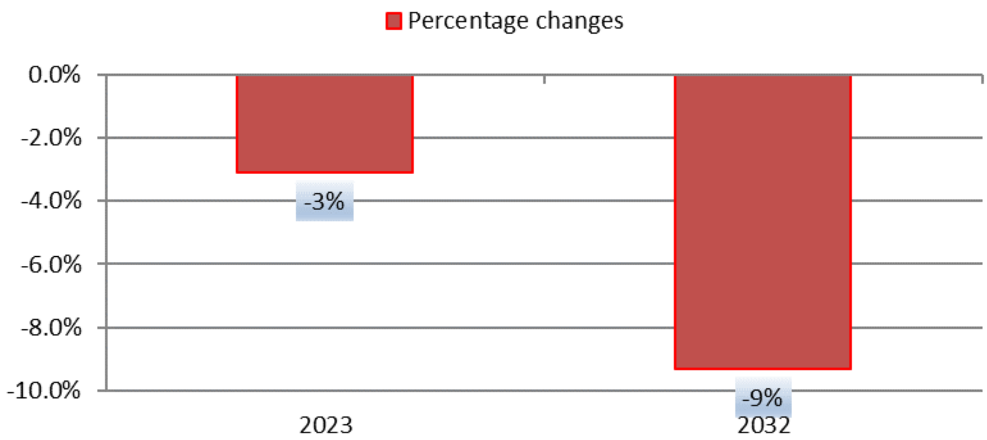
Source: Own elaboration based on the research carried out (2023)

Annex 21 Hungarian corn feed use under 50 g/day growth rate of broilers



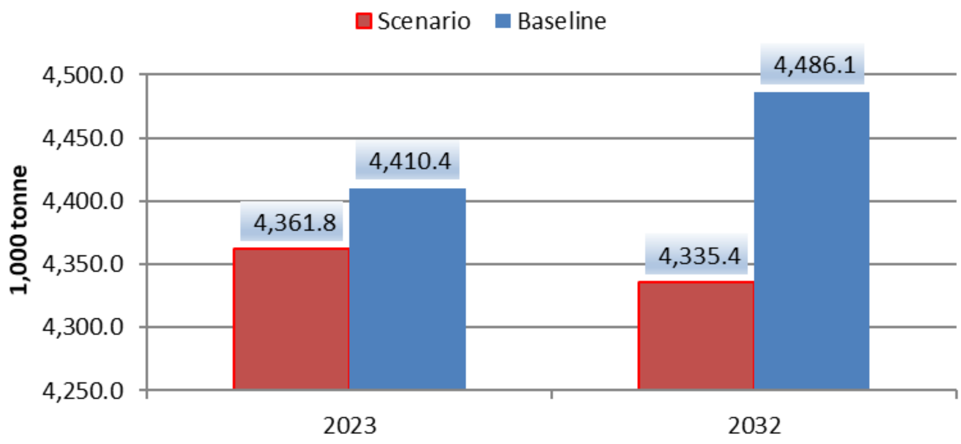
Source: Own elaboration based on the research carried out (2023)

Annex 22 Scenario and baseline variations of corn feed use under 50g/day growth rate of broilers



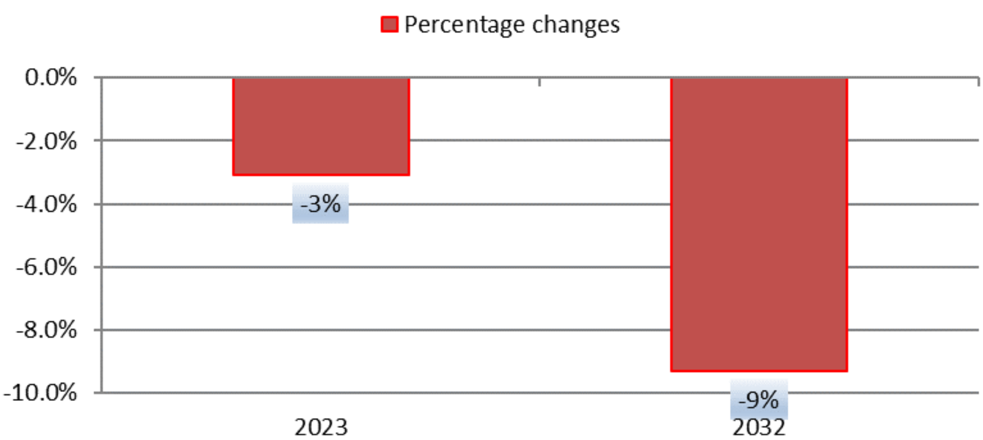
Source: Own elaboration based on the research carried out (2023)

Annex 23 Hungarian corn domestic use under 50 g/day growth rate of broilers



Source: Own elaboration based on the research carried out (2023)

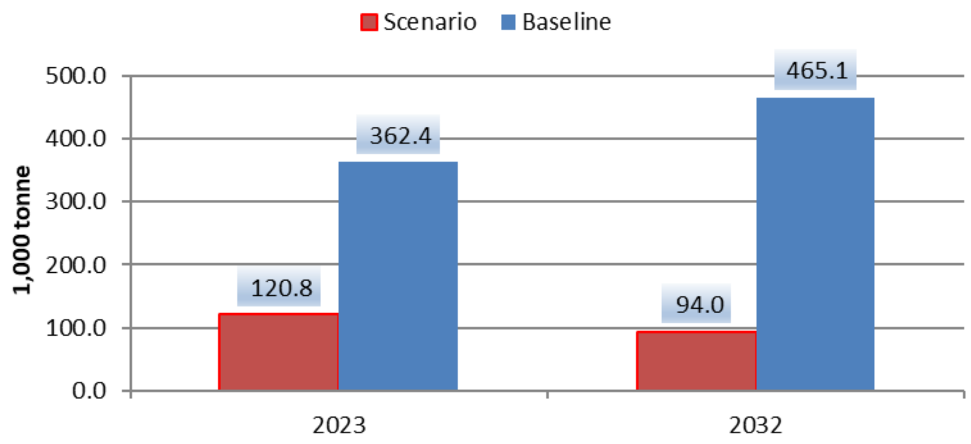
Annex 24 Scenario and baseline variations of corn domestic use under 50g/day growth rate of broilers



Source: Own elaboration based on the research carried out (2023)

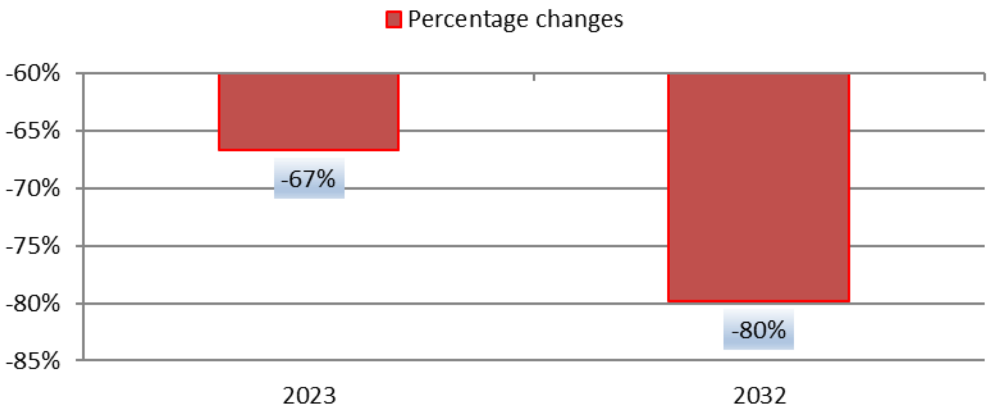
Scenario 3: Reduction of chicken broilers stocking density to 11 kg/m2 in Hungary

Annex 25 Hungarian broiler production under 11 kg/m2 stocking density



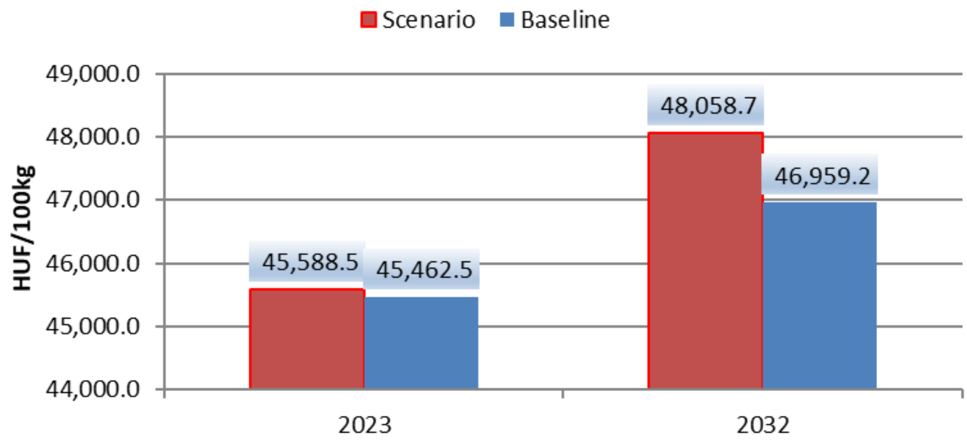
Source: Own elaboration based on the research carried out (2023)

Annex 26 Scenario and baseline variations of broiler production under 11 kg/m2 stocking density



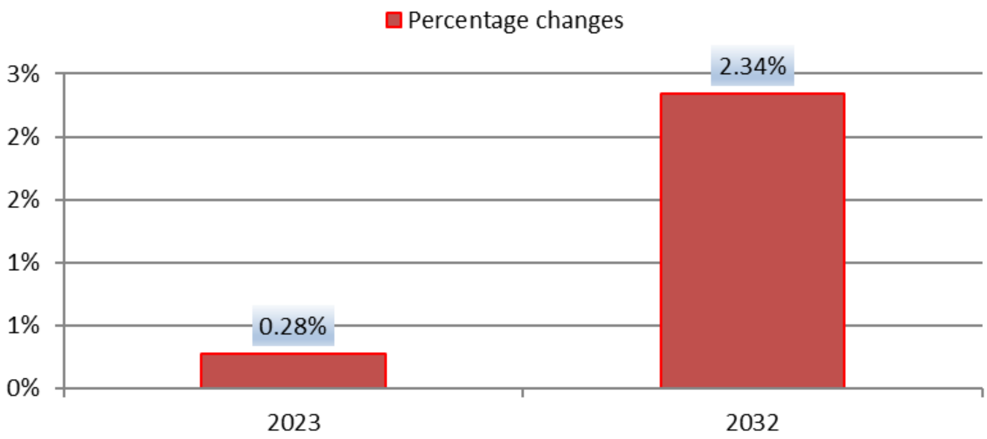
Source: Own elaboration based on the research carried out (2023)

Annex 27 Hungarian broiler prices under 11 kg/m2 stocking density



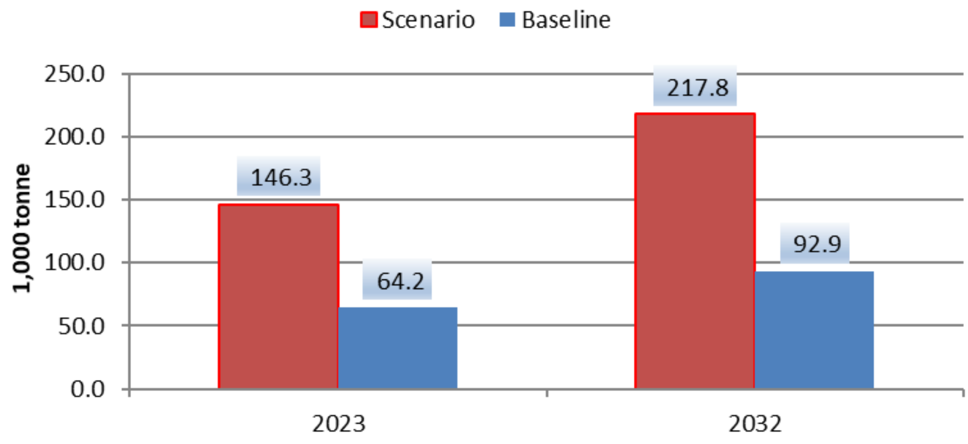
Source: Own elaboration based on the research carried out (2023)

Annex 28 Scenario and baseline variations of broiler prices under 11 kg/m2 stocking density



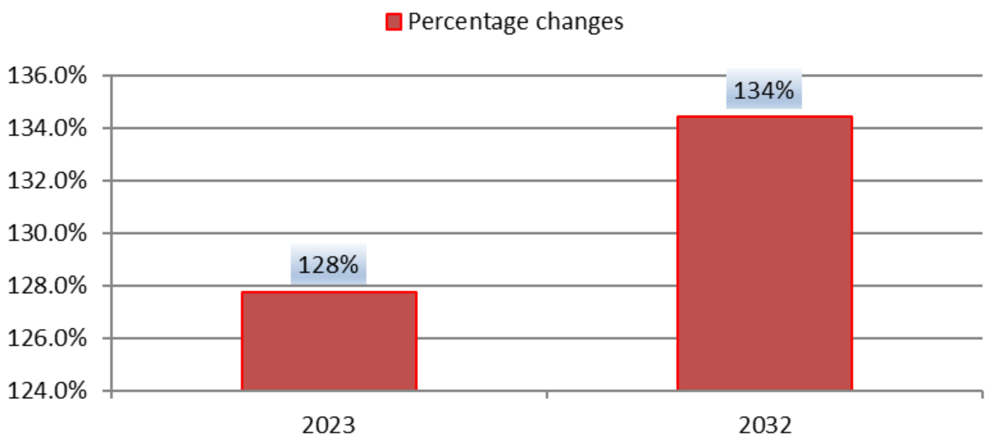
Source: Own elaboration based on the research carried out (2023)

Annex 29 Hungarian broiler imports under 11 kg/m2 stocking density



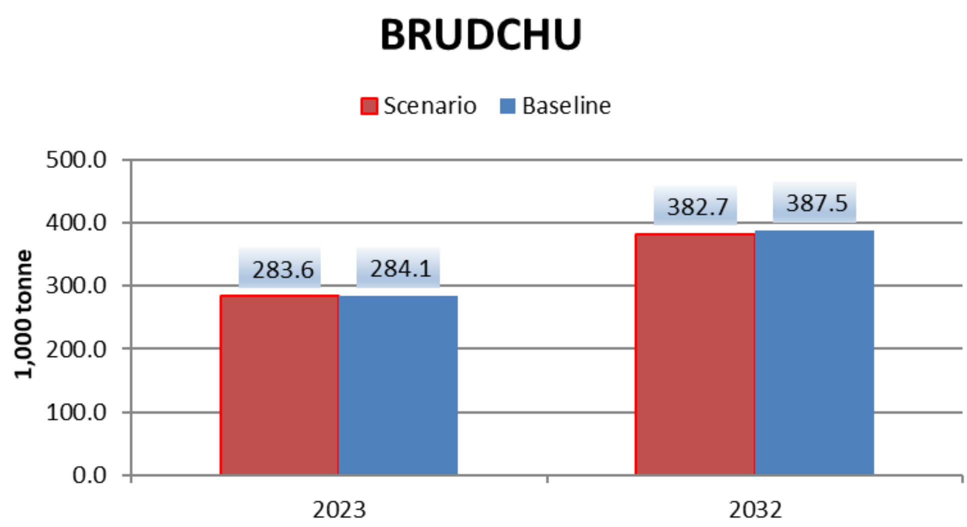
Source: Own elaboration based on the research carried out (2023)

Annex 30 Scenario and baseline variations of broiler imports under 11 kg/m2 stocking density



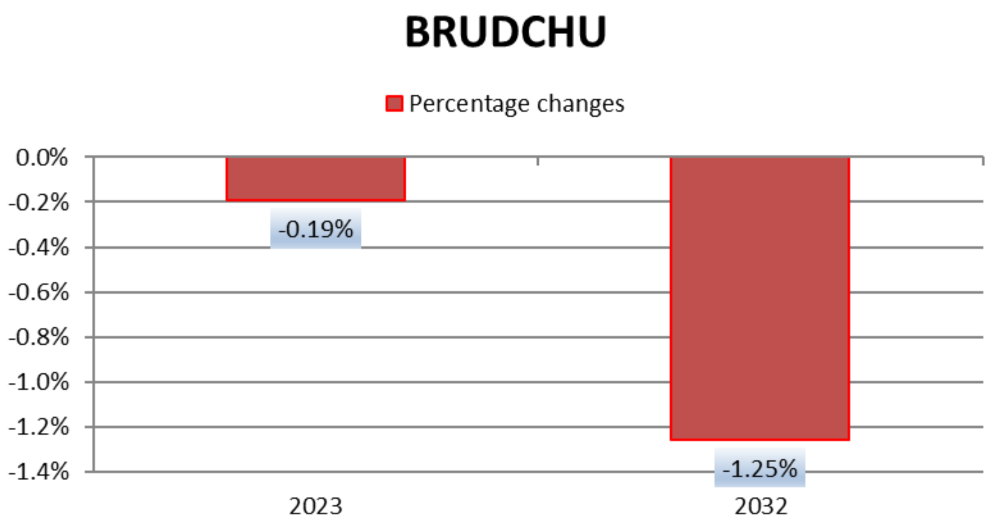
Source: Own elaboration based on the research carried out (2023)

Annex 31 Hungarian broiler domestic use under 11 kg/m2 stocking density



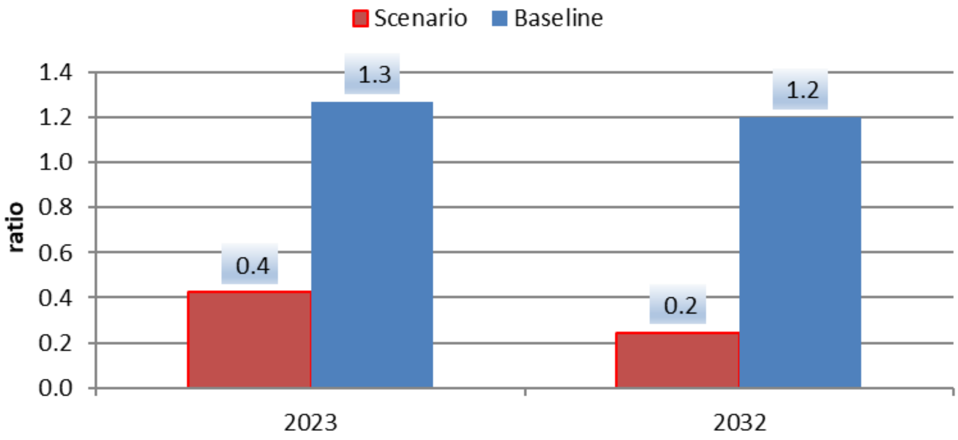
Source: Own elaboration based on the research carried out (2023)

Annex 32 Scenario and baseline variations of broiler domestic use under 11 kg/m2 stocking density



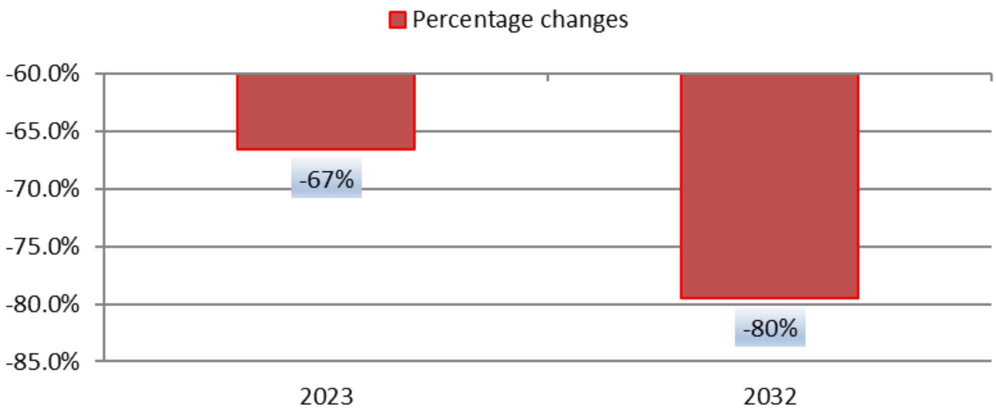
Source: Own elaboration based on the research carried out (2023)

Annex 33 Hungarian broiler self-sufficient ratio under 11 kg/m2 stocking density



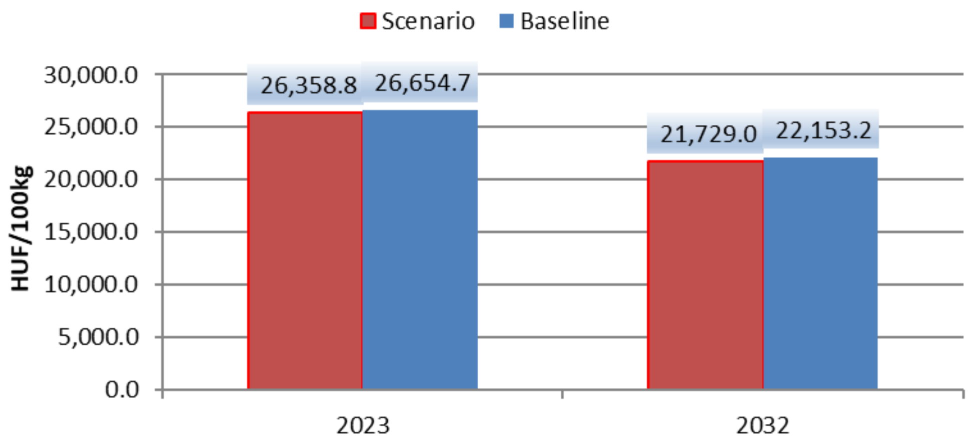
Source: Own elaboration based on the research carried out (2023)

Annex 34 Scenario and baseline variations of the broiler self-sufficiency ratio under 11 kg/m2 stocking density



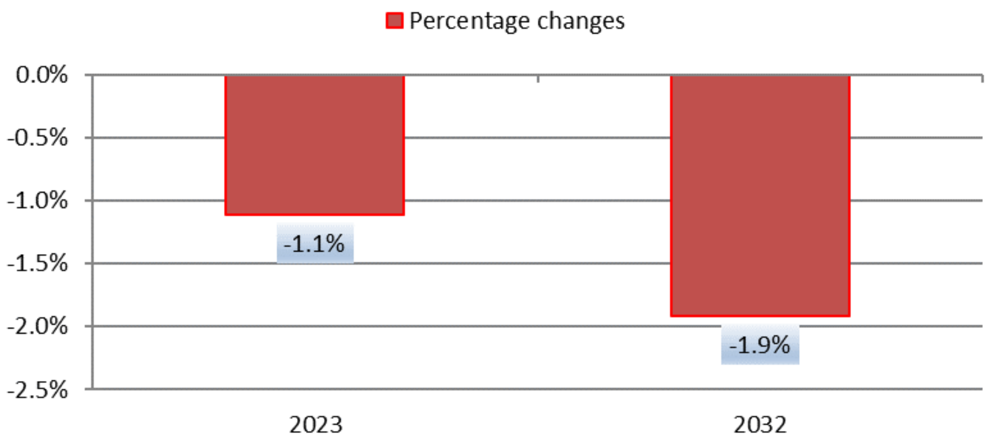
Source: Own elaboration based on the research carried out (2023)

Annex 35 Hungarian broiler input costs under 11 kg/m2 stocking density



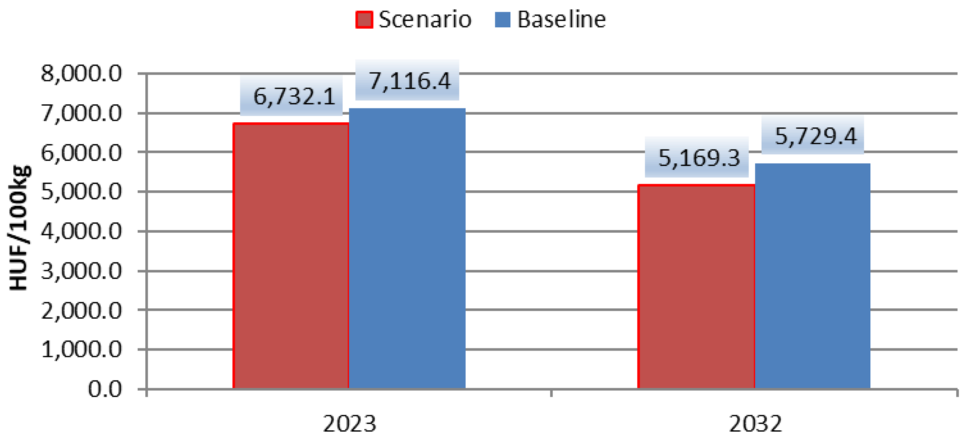
Source: Own elaboration based on the research carried out (2023)

Annex 36 Scenario and baseline variations of broiler input costs under 11 kg/m2 stocking density



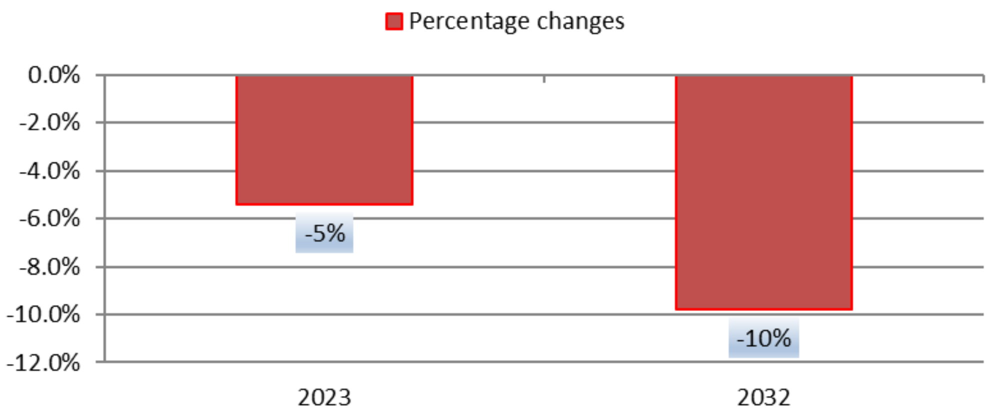
Source: Own elaboration based on the research carried out (2023)

Annex 37 Hungarian soft wheat prices under 11kg/m2 stocking density of broilers



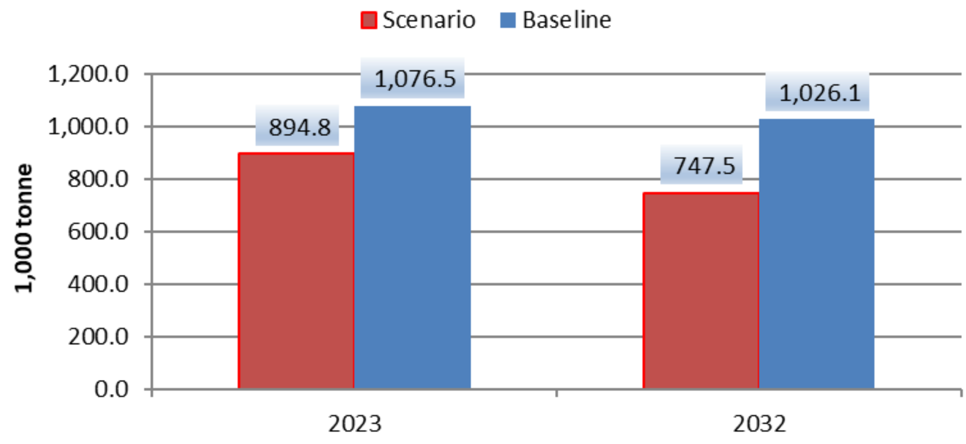
Source: Own elaboration based on the research carried out (2023)

Annex 38 Scenario and baseline variations of soft wheat price under 11 kg/m2 stocking density of broilers



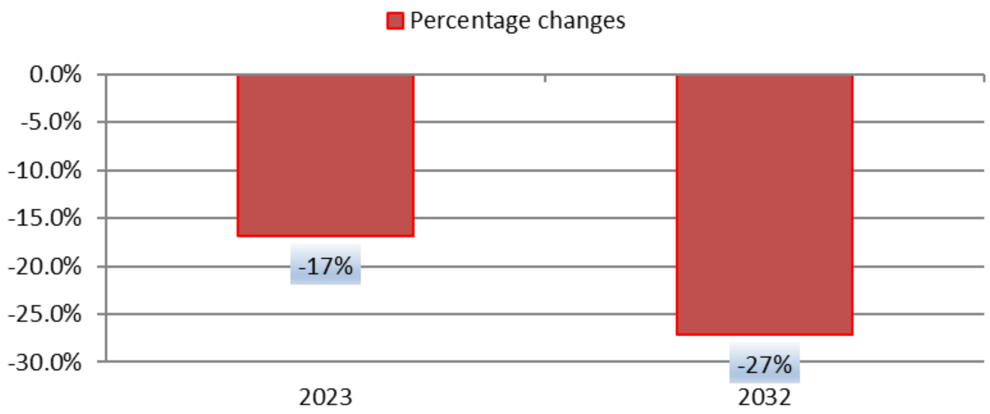
Source: Own elaboration based on the research carried out (2023)

Annex 39 Hungarian soft wheat feed use under 11kg/m2 stocking density of broilers



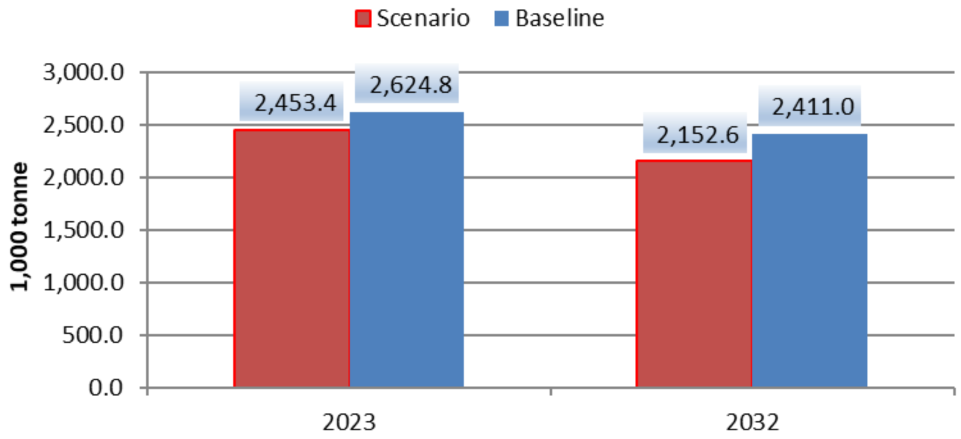
Source: Own elaboration based on the research carried out (2023)

Annex 40 Scenario and baseline variations of soft wheat feed use under 11 kg/m2 stocking density of broilers



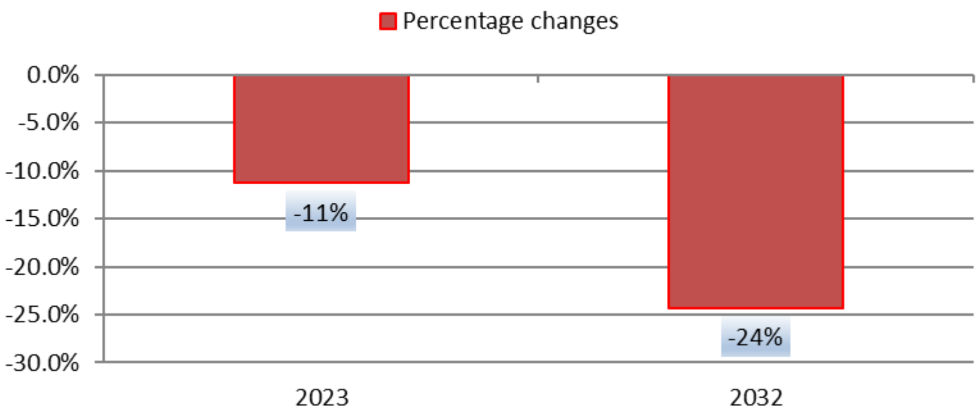
Source: Own elaboration based on the research carried out (2023)

Annex 41 Hungarian soft wheat domestic use under 11kg/m2 stocking density of broilers



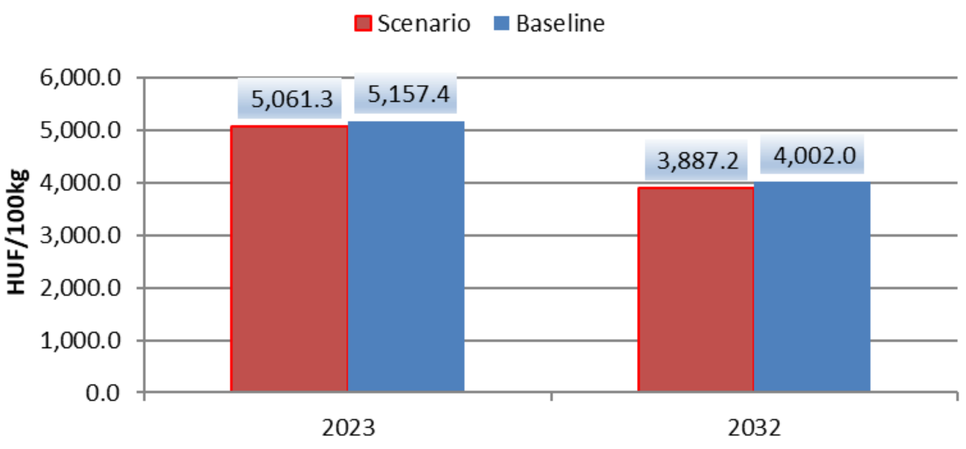
Source: Own elaboration based on the research carried out (2023)

Annex 42 Scenario and baseline variations of soft wheat domestic use under 11 kg/m2 stocking density of broilers



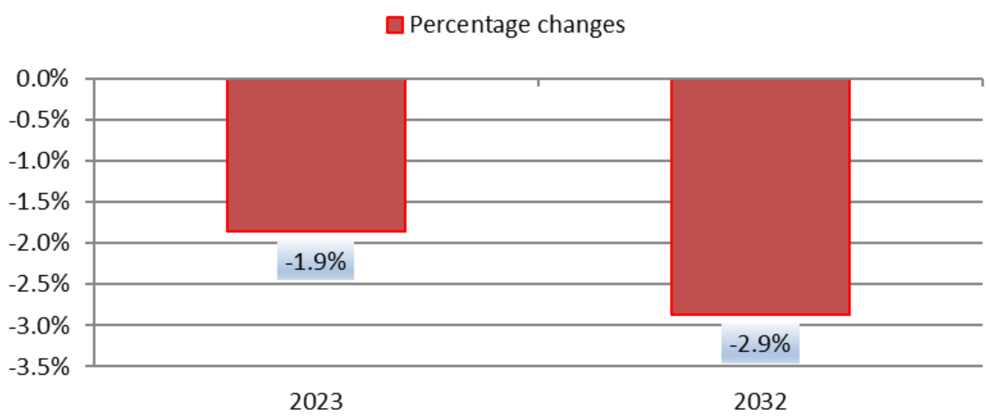
Source: Own elaboration based on the research carried out (2023)

Annex 43 Hungarian corn price under 11kg/m2 stocking density of broilers



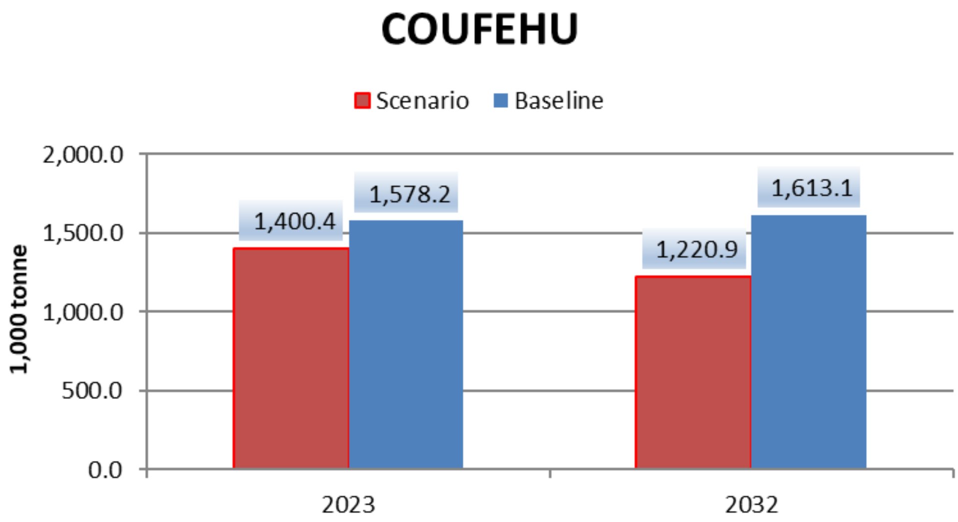
Source: Own elaboration based on the research carried out (2023)

Annex 44 Scenario and baseline variations of corn price under 11 kg/m2 stocking density of broilers



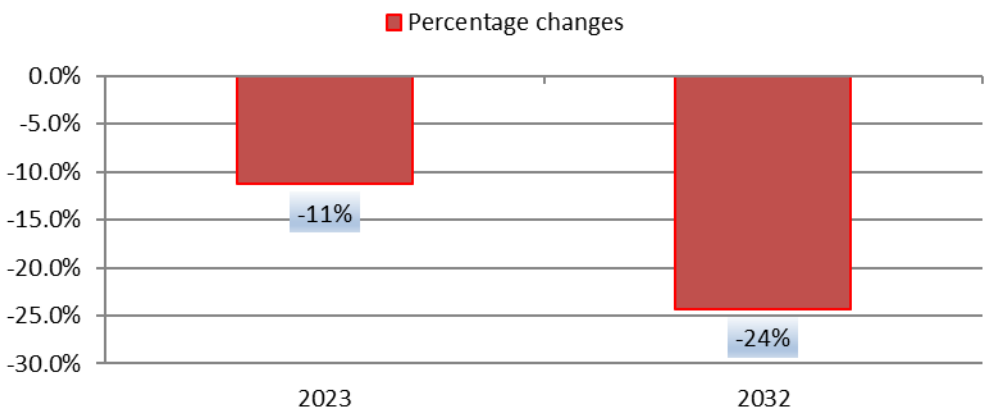
Source: Own elaboration based on the research carried out (2023)

Annex 45 Hungarian corn feed use under 11kg/m2 stocking density of broilers



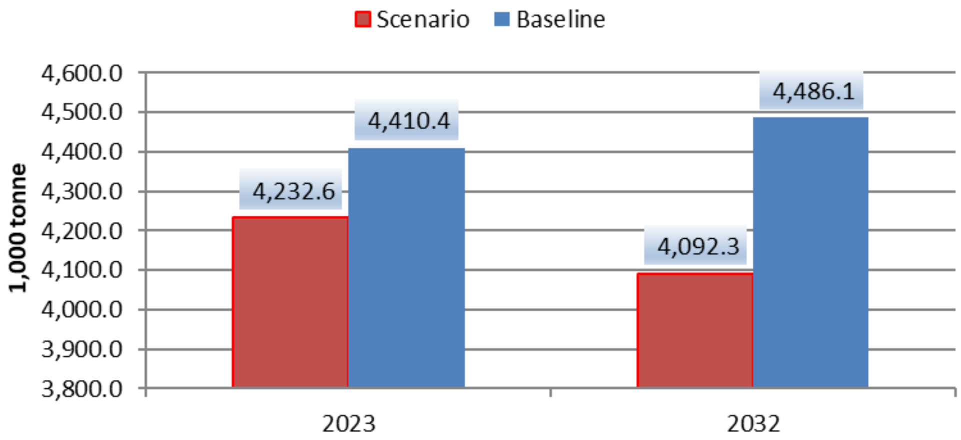
Source: Own elaboration based on the research carried out (2023)

Annex 46 Scenario and baseline variations of corn feed use under 11 kg/m2 stocking density of broilers



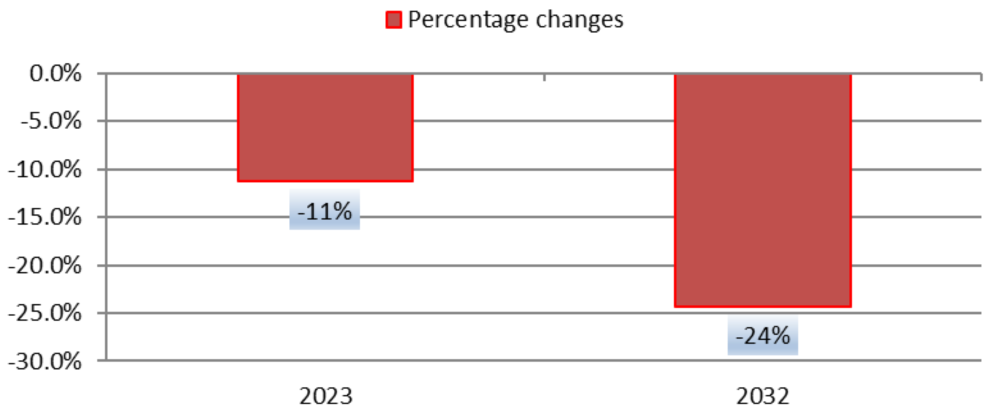
Source: Own elaboration based on the research carried out (2023)

Annex 47 Hungarian corn domestic use under 11kg/m2 stocking density of broilers



Source: Own elaboration based on the research carried out (2023)

Annex 48 Scenario and baseline variations of corn domestic use under 11 kg/m2 stocking density of broilers



Source: Own elaboration based on the research carried out (2023)

Appendices

STUDENT DECLARATION

Signed below, Anthony Cristian Medina Paredes, student of the Szent István Campus of theHungarian University of Agriculture and Life Science, at the MSc Course of Rural Development Engineering declare that the present Thesis is my own work and I have used the cited and quoted literature in accordance with the relevant legaland ethical rules. I understand that the one-page-summary of my thesis will be uploaded on thewebsite of the Campus/Institute/Course and my Thesis will be available at the Host Department/Institute and in the repository of the University in accordance with the relevant legal and ethical rules.

Confidential data are presented in the thesis: yes **no***

Date: 2023 May 02

Student

SUPERVISOR'S DECLARATION

As primary supervisor of the author of this thesis, I hereby declare that review of the thesis wasdone thoroughly; student was informed and guided on the method of citing literature sources inthe dissertation, attention was drawn on the importance of using literature data in accordance with the relevant legal and ethical rules.

Confidential data are presented in the thesis: yes **no** *

Approval of thesis for oral defense on Final Examination: approved not approved *

Date: 02. 05. 2023.

signature

*Please, underline the correct choice!

Appendix 2 – Sample Abstract

ABSTRACT OF THESIS

Thesis title: Assessing the sectoral and cross-sectoral impacts of new EU animal welfare measures in Hungary

An economic analysis on the recent proposal by the European Food Safety Agency and the European Commission on broiler chicken growth rate and stocking density reduction

Author name: Anthony Cristian Medina Paredes

Course, level of education: M.Sc. in Rural Development Engineering

Host Department/Institute: Faculty of Economics and Social Sciences

Primary thesis advisor: Dr. Tibor Farkas, Chair of the Department of Rural and Regional Development

Independent consultant: Dr. Norbert Potori, Director of Research, AKI, Agricultural Economics Directorate

The present thesis shows a sectoral and cross-sectoral economic analysis on the recent animal welfare proposal by the European Food Safety Authority and the European Commission offering a maximum stock density of 11kg/m² and a 50 grams/day growth rate for conventional broilers.

The main objective of the present thesis is to identify the combined sectoral and cross-sectoral economic impact of reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary. However, an independent analysis is also presented, which means the sectoral and cross-sectoral impact

if only the stock density reduction measure is applied and the economic impact if only the growth rate reduction measure is applied.

In order to achieve the thesis objectives, two research methods will be used. Firstly a multivariable analysis of agricultural products through a software called AGMEMOD to analyze the impacts of the animal welfare measures to build scenarios projected until 2032. Besides this method, the leading Hungarian poultry producers' enterprises were analyzed. Based on anonymised and non-public AKI farm-level data, a sample of 24 enterprises for 2019 and 23 for 2021 were analyzed to calculate the impact of the growth rate reduction and stock density in their production.

The main conclusion shows that there will be a substantial sectoral economic impact by reducing the broiler chicken growth rate by 50 grams per day and the stock density by 11 kilograms per meter square in Hungary, identifying a decrease in 84% of the production and an increasing of 141% of the imports by 2032. However, there will be a moderate cross-sectoral impact of the abovementioned animal welfare measures, identifying a decrease in 10% of the soft wheat prices, 26% of soft wheat domestic use, 3% of corn prices, and 26% of corn domestic use by 2032.

The economic effect will be different If the measures are applied independently, for instance, if only a growth rate reduction measure is applied, the effect on the market will be smaller than the scenario in which a stocking density reduction is applied. At the same time, the biggest effect occurs when a combined measure is applied. the details of the independent analysis are explained in detail in the thesis body.

It is recommended to extend this research, exploring other variables that could influece the model, for instance, other including other crops in the equations, elasticities in demand according to the import chicken prices, to establish a transition period and to compare the results of the AGMEMOD with other agri-economic models, suc as CAPRI, in order to enrich the scientific and methodological support.