Medium-term Outlook for the Croatian beef and veal market using the AGMEMOD Partial Equilibrium model

David Kranjac[1], Krunoslav Zmaić[1], Tihana Sudarić[1], Lucija Pečurlić[1], Maja Petrač[1], Magdalena Zrakić Sušac[2], Marija Ravlić[1], Emil Erjavec[3]

[1] Josip Juraj Strossmayer University in Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, 31000 Osijek, Croatia
(david.kranjac@fazos.hr)

[2] University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

[3] Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, Ljubljana, Slovenia

Abstract

This paper analyses the medium-term outlook of the Croatian beef and veal meat market using the AGMEMOD partial equilibrium model. Despite more than a decade of EU membership, Croatia's beef sector remains structurally weak, with declining production and increasing dependence on imports. Simulation results under the *baseline* scenario (2023–2030), which assumes a continuation of current CAP instruments and stable macroeconomic conditions, project a further drop in domestic production, from 38.4 thousand tonnes in 2023 to 30.1 thousand tonnes by 2030. Meanwhile, consumption is expected to rise, deepening the trade deficit and reducing the self-sufficiency rate from 60% to 52%. The results highlight the growing gap between domestic supply and demand, emphasizing the need for targeted structural and policy interventions to reverse this negative trend.

INTRODUCTION

Croatia, the last of the Central and Eastern European Countries (CEECs) to join the European Union (EU), became a full member on July 1st, 2013. Like many other post-communist member states, Croatia's agricultural sector is marked by structural dualism—featuring both large-scale agricultural enterprises and a high prevalence of small family farms characterized by limited production capacity, low input use, and relatively low productivity. The integration into the EU's single market, the adoption of the Common Agricultural Policy (CAP), and the gradual convergence of domestic agricultural prices with those in the EU-27 created new opportunities and challenges for the sector (Erjavec et al., 2006). These processes were expected to stimulate modernization, improve competitiveness, and enhance market integration. However, after more than a decade of EU membership, Croatia continues to face significant structural and performance-related challenges in agriculture, particularly in the livestock sectors (Grgić et al., 2019.). Productivity growth has remained limited, and self-sufficiency levels have not improved. This is especially evident in key livestock markets, including the beef sector, where stagnating production levels, declining cattle numbers, and persistent reliance on imports reflect a broader inability to capitalize on available policy instruments and market potential (Table 1, 2, 3, 4).

Table 1. Number of cattle in the Republic of Croatia in the different categories (2013 – 2023)

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023 vs 2013
Young cattle up to 1 year old	Calves for slaughter	19267	13126	19964	20147	20263	19412	19179	18604	19737	18744	18596	-3.5%
	Young female bovine	51689	52998	47067	53623	57081	61890	62449	60285	65248	58705	56215	8.8%
	Young male bovine	73806	65578	80959	81211	78524	73209	69956	66863	71346	70693	69949	-5.2%
	Total	**144762**	**131702**	**147990**	**154981**	**155868**	**154511**	**151584**	**145752**	**156331**	**148142**	**144760**	**0.0%**
Cattle from 1 to 2 years old	Heifers	37771	36750	38101	38847	40319	42061	49824	47116	47535	47242	54216	43.5%
	Heifers for slaughter	7450	8917	7296	6855	7115	7711	8688	9102	8734	9199	9429	26.6%
	Male bovine	46957	41585	42770	43063	52489	45689	48177	55082	50394	55895	51666	10.0%
	Total	**92178**	**87252**	**88167**	**88765**	**99923**	**95461**	**106689**	**111300**	**106663**	**112336**	**115311**	**25.1%**

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	%
Cattle older than 2 years	Heifers	12197	23246	27215	28123	28275	13907	14368	14601	14689	15167	15885	30.2%
	Heifers for slaughter	2004	1177	1645	1795	1805	985	1104	1128	1152	1130	1048	-47.7%
	Dairy cows	168025	159394	151502	146510	139443	135851	130025	109807	102333	79042	71423	-57.5%
	Other cows	13460	20886	18999	20320	21550	9503	11867	34088	39807	58758	59927	345.2%
	Other (bulls, oxen)	9806	16980	4574	4119	3893	3907	4602	6205	6612	7269	6850	-30.1%
	Total	**205492**	**221683**	**203935**	**200867**	**194966**	**164153**	**161966**	**165829**	**164593**	**161366**	**155133**	**-24.5%**
Cattle total		**442432**	**440637**	**440092**	**444613**	**450757**	**414125**	**420239**	**422881**	**427587**	**421844**	**415204**	**-6.2%**

Source: Croatian Bureau of Statistics 2013-2023

The Croatian beef and veal market remains heavily dependent on the import of live animals. In 2023, imports reached 41.9 thousand tonnes, compared to 42.3 thousand tonnes exported, yet the trade balance remains negative in value terms, with imports amounting to €142.5 million and exports only €118.2 million. This reflects a structural reliance on imported livestock to sustain domestic production and processing capacities (Table 2).

Table 2. Export and import of live cattle in the Republic of Croatia (2013 – 2023)

							Live animals						
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023 vs. period avg.
Export	Quantity (1000 t)	16.81	9.20	9.29	14.37	14.59	24.19	22.12	27.99	40.84	41.96	42.33	77%
	Value (EUR)	30.76	15.45	14.87	26.71	26.26	46.01	41.80	54.40	84.14	108.13	118.22	129%
Import	Quantity (1000 t)	21.57	20.39	23.31	22.41	27.27	26.74	31.19	30.30	37.14	35.80	41.86	45%
	Value (EUR)	57.27	52.76	60.85	58.41	74.49	74.55	83.69	79.11	99.53	111.84	142.50	75%

Source: Croatian Bureau of Statistics 2013-2023

Croatia is a net importer of beef and veal meat, with imports of fresh, chilled, and frozen beef significantly exceeding exports both in quantity and value (Kranjac et al., 2021). In 2023, import volumes reached 35.4 thousand tonnes, more than four times the export volume of 7.4 thousand tonnes. The value of imports (€203.5 million) was over five times higher than that of exports (€37.5 million), highlighting a growing trade deficit and the limited competitiveness of domestic beef and veal meat production (Table 3).

Table 3. Export and import of beef & veal meat in the Republic of Croatia (2013 – 2023

							Beef & veal meat fresh or chilled and frozen						
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023 vs. period avg.
Export	Quantity (1000 t)	3.35	4.18	4.33	6.54	5.85	7.58	7.66	6.22	6.66	7.09	7.36	21%
	Value (EUR)	12.07	15.99	18.13	25.25	24.60	32.05	34.13	26.63	31.37	39.32	37.49	39%
Import	Quantity (1000 t)	10.22	14.50	17.38	19.98	22.04	22.56	24.75	22.47	26.84	31.30	35.44	58%
	Value (EUR)	35.73	49.35	60.44	70.96	82.18	90.87	98.71	83.11	113.22	175.91	203.49	110%

Source: Croatian Bureau of Statistics 2013-2023

Domestic meat production declined from 47.3 to 38.4 thousand tonnes, while consumption remained consistently higher, averaging around 60 thousand tonnes annually. This imbalance has resulted in a continued reliance on imports, which peaked at 41.9 thousand tonnes in 2023. Although export volumes increased over the decade, they have not been sufficient to offset the trade deficit. Consequently, Croatia's self-sufficiency in beef and veal production fluctuated but ultimately declined to just 60% in 2023.

Table 4. Beef & veal meat market outlook in the Republic of Croatia (2013 – 2023)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Live animals (000 heads)	442	441	440	445	451	414	420	423	428	422	415

Production (1000 t)	47,27	44,42	42,26	44,43	42,2	43,78	45,43	43,37	43,18	41,23	38,38
Domestic con-sumtpion (1000 t)	60,44	60,21	60,92	59,66	62,18	58,42	65,56	59,67	59,90	56,05	61,07
Import (1000 t)	21,57	20,39	23,31	22,41	27,27	26,74	31,19	30,30	37,14	35,80	41,86
Export (1000 t)	16,81	9,20	9,29	14,37	14,59	24,19	22,12	27,99	40,84	41,96	38,33
Neto export (1000 t)	-4,76	-11,19	-14,02	-8,04	-12,69	-2,54	-9,07	-2,31	3,70	6,16	-3,53
Self sufficiency	69%	67%	61%	63%	57%	70%	63%	70%	69%	71%	60%

Source: Author's calculation according to Croatian Bureau of Statistics 2013-2023

This paper aims to analyse the medium-term outlook of the Croatian beef sector by applying the AGMEMOD partial equilibrium model. By simulating market developments under a baseline scenario aligned with current CAP instruments, the research provides insights into expected trends in production, consumption, trade and self-sufficiency up to 2030.

MATERIALS AND METHODS

This study employs the AGMEMOD (*Agriculture Member State Modelling*) framework, a dynamic, econometric, partial equilibrium model that operates at the multi-country and multi-commodity level. Its primary objective is to provide medium-term market projections for key agricultural commodities, with a simulation horizon extending to the year 2030 (Salamon et al., 2019). The modelling approach follows a bottom-up structure, where individual country models—developed according to a standardized template—are integrated into a consolidated European Union-level model (Chantreuil et al., 2012). Each national model consists of several commodity-specific sub-models that represent major agricultural sectors, including cereals (such as wheat, barley, and maize), oilseeds, livestock and meat (including cattle, beef, pigs, pork, poultry, sheep, and mutton), and dairy products (such as cheese, butter, whole milk powder, and skimmed milk powder).

In the case of Croatia, the sub-model used in this study is based on annual time-series data covering the period from 1995 to 2023. These data were collected primarily from national institutions, such as the Croatian Bureau of Statistics (CBS, 2025). The underlying database includes variables related to production volumes, domestic use for food and feed, imports, and exports—structured in the form of market balance sheets.

Each commodity market within the model is interconnected, allowing for the capture of competitive relationships among products for limited resources, as well as interactions between crop and livestock sectors. Supply, demand, trade flows, and prices are determined endogenously within the respective sub-models (Chantreuil et al., 2012). Country-specific models simulate the behaviour of economic agents (producers and consumers), respond to changes in exogenous drivers (e.g., macroeconomic indicators, technological developments, and policy instruments), and reflect market price dynamics. Based on a system of econometrically estimated equations, the model generates projections for endogenous variables using both historical data and assumed future trends in exogenous variables. The general form of the equations illustrates how supply and demand are modelled in the Croatian beef and veal sector inside AGMEMOD sub-model. The first set of equations represents how supply is modelled.

Number of cattle (i) produced from the breeding herd $cct_{i,t}$ can be expressed as follows:

$$spr_{i,t} = f\big(cct_{i,t-1}, ypa_{i,t}\big) \qquad\qquad i = 1, \dots, n \qquad\qquad (1),$$

where $spr_{i,t}$ represents number of cattle (i) produced by breeding herd $cct_{i,t}$, and $ypa_{i,t}$ represents yield of calves per cow (i) in year t.

The number of breeding cows (breeding herd) (i) is expressed as follows:

$$cct_{i,t} = f\big(cct_{i,t-1}^{k}, p_{i,t}, V\big) \qquad\qquad k = 1, \dots, n \quad i = 1, \dots, n \qquad\qquad (2),$$

where $cct_{i,t-1}^{k}$ represents the final stock of breeding cows (i) in year t-1, $p_{i,t}$) is the actual price of breeding cows (i) in year t, a V represents a vector of exogenous variables that can affect the number of breeding cows (i) (e.g. various political instruments such as state subsidies that are not part of the CAP).

Total beef and veal meat production (i) is derived from the average slaughter weight j multiplied by the number of slaughtered cattle i, , and the number of slaughtered cattle can be expressed as follows:

$$ktt_{i,t} = \sum_{j} ktt_{i,t}^{j} \qquad\qquad i = 1, \dots, n \ j = 1, \dots, m \qquad\qquad (3)$$

$$ktt_{i,t}^{j} = f\big(cct_{i,t}^{j}, p_{i,t}, z_{i,t}^{j}, V\big) \qquad\qquad i = 1, \dots, n \ j = 1, \dots, m \qquad\qquad (4),$$

where $ktt_{i,t}^{j}$ is the number of slaughtered cattle i in the current year t, $cct_{i,t}^{j}$ represents the closing stock of breeding cows (i) in year t, $z_{i,t}^{j}$ represents exogenous variables that affect the number of slaughtered cattle i, and V is a vector exogenous variables that can affect the number of cattle slaughtered.

The average slaughter weight of cattle (i) is expressed as follows:

$$slw_{i,t} = f\big(slw_{i,t-1}, p_{i,t}, z_{i,t}^{j}, V\big) \qquad\qquad i = 1, \dots, n \ j = 1, \dots, m \qquad\qquad (5),$$

where $slw_{i,t}$ represents the average slaughter weight of cattle i in year t, $p_{i,t}$ is the real price of beef i in year t, $z_{i,t}^{j}$, represents the exogenous variables that affect the average slaughter weight j, and V is a vector of exogenous variables that can also affect the average slaughter weight of cattle..

Demand is modelled through the total domestic consumption of beef, and is determined by the consumption of beef per capita and the product of the total number of consumers, which represents an exogenous variable in the model. The equation of beef consumption per capita can be expressed as follows:

$$upc_{i,t} = f(upc_{i,t}, p_{i,t}, p_{k,t}, gdpc_t, V) \qquad k, i = 1, \dots, n; \quad k \neq i \qquad (6),$$

$upc_{i,t}$ is beef and veal meat consumption i per capita in the current year t, $gdpc_t$ represents real income per capita in the current year t, and V is a vector of other exogenous variables that can affect consumption.

The equations of import (Im) and export (Ex) can be shown as follows:

$$Im_{i,t}^k = f(PR_{i,t}^k, DU_{i,t}^k, Im_{i,t-1}^k) \qquad (7)$$

$$Ex_{i,t}^k = f(PR_{i,t}^k, DU_{i,t}^k, Ex_{i,t-1}^k) \qquad (8),$$

Where import $Im_{i,t}^k$ and export $Ex_{i,t}^k$ of the beef and veal meat i in year t are expressed through $PR_{i,t}^k$ i $DU_{i,t}^k$, which represent production and consumption of beef and veal meat i and in year t.

A set of exogenous data related to the Croatian CAP Strategic plan, i.e., envelope for direct payments, were recalculated and included as an addition to the producer price according to the harmonized approach, forming a reaction price (Salputra et al., 2011). The modeling approach takes into account the different effects of tied and untied payments through multipliers that represent the share of individual aids in the reaction price. Since coupled supports have a stronger impact on the production of a particular market, the multiplier is set at 1.0, while for uncoupled supports it is 0.3 (OECD 2006).

An example of the final appearance of the general equation, in which direct payments are added to the price, thus making the reaction price, looks like this:

$$cct_{i,t} = f(cct_{i,t-1}, (p_{i,t} + prc_{i,t}), V) \qquad i = 1, \dots, n \qquad (9).$$

The simulation of the development of the beef meat market in Croatia was modeled according to the baseline scenario. The baseline scenario assumes the continuation of the current instruments and measures of the CAP (2023-2027) and stable climatic conditions, without major market shocks (general economic environment, diseases, etc.), with a stable demand trend until 2030.

RESULTS AND DISCUSSION

The AGMEMOD *baseline* simulation results suggest a continued downward trend from 2023 onwards in domestic beef and veal production, which is simulated to fall from 38.4 thousand tonnes in 2023 to just 30.1 thousand tonnes by 2030—marking a 37% decline compared to 2013 levels. Despite this decline in production, domestic consumption is expected to gradually increase, reaching 64.6 thousand tonnes by 2030, similar to the peak consumption levels observed in 2017 and 2019. Consequently, imports are projected to rise steadily, surpassing 52 thousand tonnes by the end of the projection period. The trade balance, which turned slightly negative again in 2023, is expected to deteriorate further, with net imports reaching 19.2 thousand tonnes by 2030 (Figure1).
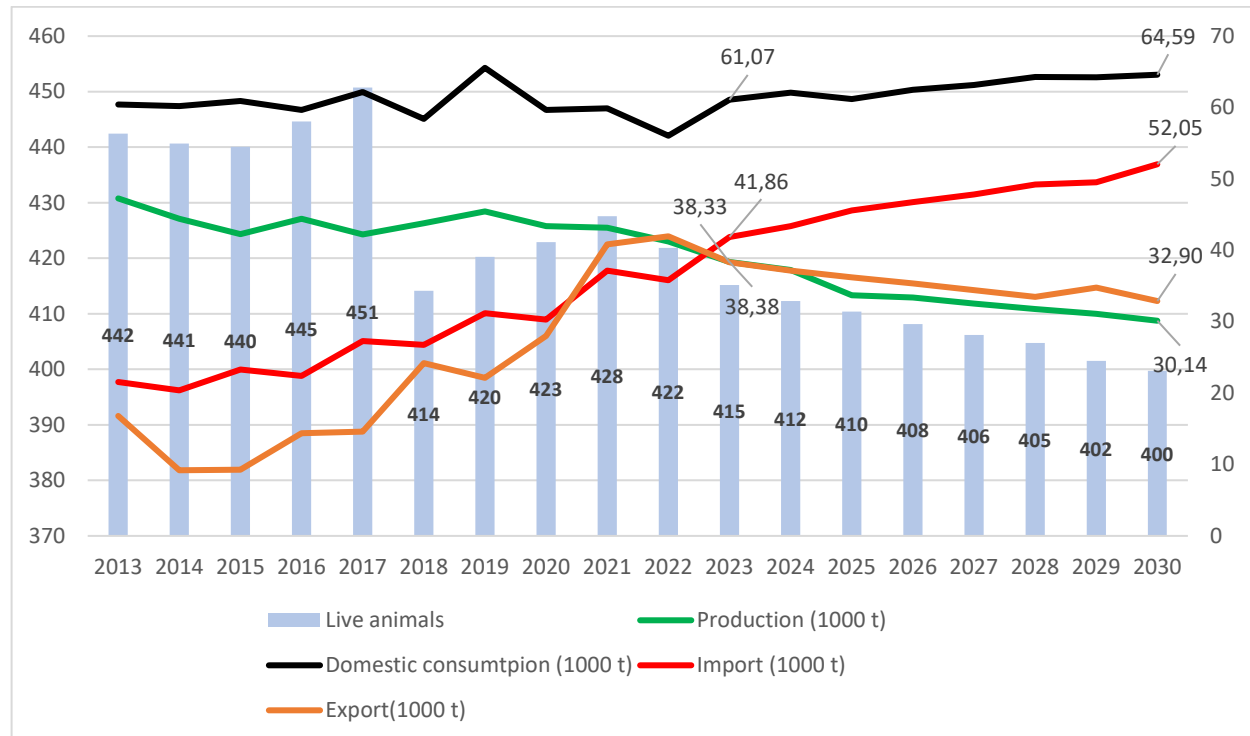

Figure 1. Beef & veal market baseline simulation in the Republic of Croatia up to 2030.
Source: AGMEMOD modelling results

As a result, the self-sufficiency rate is projected to decline from 60% in 2023 to 52% by 2030, reinforcing the trend of growing dependence on foreign supply observed over the past decade (Figure2).
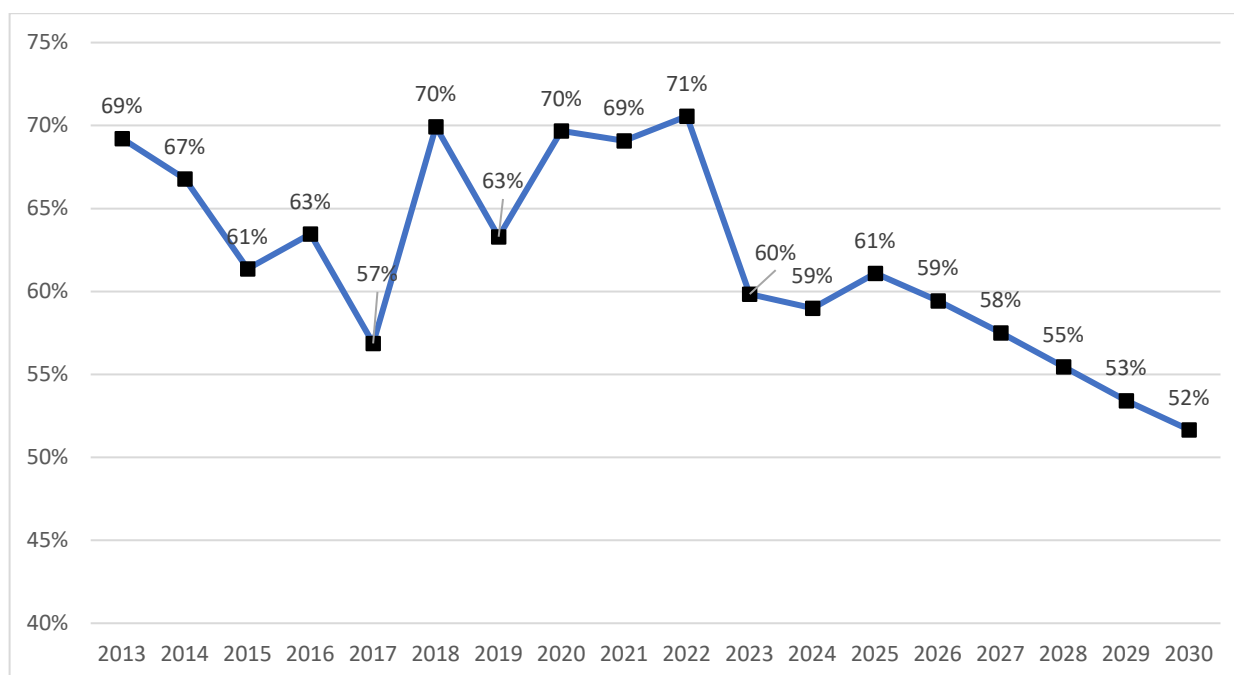
Figure 2. Baseline simulation for self-sufficiency ratio within beef & veal meat market in Croatia up to 2030.

Source: AGMEMOD modelling results

CONCLUSION

The AGMEMOD partial equilibrium model has proven to be a suitable analytical tool for simulating *baseline* outlook of the Croatian beef and veal market, offering insights into potential future developments based on available data and policy assumptions. However, several limitations inherent to models of this type must be acknowledged.

First and foremost, the accuracy of the simulation outcomes is directly linked to the quality of input data, primarily sourced from the Croatian Bureau of Statistics. These data can sometimes be incomplete or imprecise, which may reduce the reliability of the model results. Additionally, AGMEMOD and similar models are not designed to incorporate rural development support measures into their simulations. This is a significant limitation, as such measures can have a substantial impact on production decisions, farm income, and long-term structural change in the sector.

Moreover, the model does not fully capture the volatile nature of agricultural markets. External shocks such as extreme weather events, sudden price collapses, outbreaks of livestock diseases, or geopolitical disruptions are difficult to integrate into a deterministic modelling framework. As a result, the projections should be interpreted with caution, especially over the longer term.

Future improvements to the model should focus on integrating rural development support and adopting a more stochastic or risk-based simulation approach. This would enhance the model's capacity to reflect the real-world uncertainties and complexities of agricultural production and trade.

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