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COMPETITIVENESS OF THE POLISH BEEF MARKET – ECONOMIC AND ENVIRONMENTAL ASPECTS

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ABSTRACT: The paper discusses economic and environmental aspects of the competitiveness of the beef market from the Polish perspective. Features of the growth in this market after the economic transformation are presented, with emphasis on progress in the specialisation and quality of production. We analysed market trends, production quality improvements, and export dynamics to show Poland's role as a major beef producer and exporter within the EU. The aim of the paper is to outline the changes that have taken place in Polish trade with EU countries and with third countries, as well as the competitiveness of the beef sector on international markets. The analysis is based on Eurostat data from the years 2003-2022, analysed via import-export coverage ratio, market concentration measures, and analysis of comparative advantages. The results show that Poland is in a strong position in the EU market, although potential risk areas were found. The future of the Polish beef market will depend on its ability to adapt to global market trends, changes in consumer preferences, and challenges related to sustainable production.

KEYWORDS: beef market, economic aspects, competitiveness, international trade, import-export coverage index, relative comparative advantage, Grubel-Lloyd intra-industry trade index

Introduction

Beef is a valuable meat that sells for relatively high prices on international markets. However, it is also a market that is highly competitive, with price and quality being very important elements in this competition. The Polish beef market occupies a key place both in the European Union and more broadly in the international arena. However, the global beef market is dominated by a few major players, including the United States, Brazil, China, and India. Poland is one of the main producers of beef in the EU. Together with countries such as France, Germany, Spain, and Ireland, it is responsible for a considerable proportion of beef production in the EU (Bąk-Filipek, 2018; Trajer, 2020; Zajączkowski et al., 2019). Poland is also an important beef exporter within the EU as part of the EU single market. Export activity in Poland is growing in sales, volumes, and target markets. Activity in international markets is usually regulated by shared norms and EU trade agreements with third countries. Competitiveness in an international market also requires compliance with local regulations applicable in a given country.

Poland's beef sector success was enabled by systemic changes. A very rapid transformation resulted in the specialisation of farms in milk production or meat production. The introduction of a wider scale of beef cattle breeds resulted in a considerable improvement in the quality of the meat obtained, which in turn made its export to foreign markets viable (Olszańska, 2012). Specialisation also resulted in a considerable increase in the average milk yield of cows. Along with the rapid concentration of production, both in the field of milk production and in the use of cattle for meat, this made considerable improvements in quality possible in both these markets (Olszańska, 2017; Zawadzka, 2018). As a result, the growing popularity of Polish meat products provided an opportunity to increase Poland's share in the global beef trade.

This paper aims to explore the competitiveness and development of the Polish beef sector within the twenty-year timespan of evolving market conditions and environmental challenges. The research is guided by the following questions:

- RQ1: "What are the trends in Polish beef exports, and how do they differ between EU and non-EU markets?"
- RQ2: "How does Poland's position in the global beef trade reflect its comparative and competitive advantages?"
- RQ3: "What economic and environmental factors shape production costs and market accessibility?"

Overview of the literature

Beef production costs depend mainly on raw input and food prices (Ptak-Iglewska, 2023; Tubilewicz, 2022; Wójcik, 2011; Wysoczańska, 2024). However, Poland also profits from a geographical advantage in reducing transport costs (Michalczyk, 2017). In the last five years, refrigeration costs, influenced by energy prices, have become important (Bąk-Filipek, 2021; Sosnowski & Nowakowski, 2020). Moreover, investments in modern farming technologies and logistics infrastructure have enhanced overall efficiency and competitiveness (Ministerstwo Rolnictwa i Rozwoju Wsi, 2023).

Price uncertainty is a key factor in agricultural markets. The beef production cycle is long, and decisions are based on current prices. High prices encourage production increases, but prices may drop by the time of sale, affecting profitability (Olszańska, 2012). Price variability is a major risk Buguk et al. (2003). World market price fluctuations impact the livestock and meat market, see Czyżewski & Henisz (2000). Abbott et al. (2008) researched factors behind food price increases: insufficient agricultural investment, rising crude oil prices, and currency depreciation. Distance and sales volume also determine prices (Yan et al., 2017).

Trade policy affects beef sector competitiveness. Trade agreements, customs tariffs, and regulations determine market accessibility. The EU common market's opening significantly raised beef prices in Poland (Borawski et al., 2018). Export market access is crucial (Jarosz, 2002; Tereszczuk, 2012). Finally, Kowalski et al. (2014) and Orlykovskyi & Wicki (2016) added that government policies and support programs strongly impact market competitiveness.

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Among the main threats, sources mention consumption changes and climate change. Consumption trends like ecological and local products, healthy food, and animal welfare influence preferences (Darbandi & Saghaian, 2018; Węsierski, 2017). According to Poore & Nemecek (2018), reducing meat consumption and switching to plant-based diets can limit environmental impact. Plant-based or synthetic meat products may compete with traditional beef (Lotfi et al., 2018). Beef consumption in the EU is declining, with alternative proteins gaining popularity (Chudoba et al., 2008; Wilczyńska, 2015), and the Polish beef market development relies on export opportunities as the consumption of beef per capita in Poland is very small (Zawadzka, 2022).

Research methods

The article aims to show the changes that have taken place in trade between Poland and EU countries and third countries, as well as the competitiveness of the beef sector. To reach the goal, the assessment was made on the basis of Eurostat (2023) data from the years 2003- 2022. The analysis was conducted for the beef market as a whole – fresh, refrigerated, and frozen (nomenclature HS: 0201 and 0202). To investigate the competitive position of the Polish beef market, competitiveness measures were used, i.e., import-export coverage (TC), concentration measurement (HHI), and export specialisation (SI). Comparative advantages were described using the index of relative comparative advantage of exports (XRTA), the index of relative import absorption (MRTA), the index of relative trade advantage (RTA), and the Grubel-Lloyd intra-industry trade index (IIT). Examples in brackets given for each component are later used in our calculation.

The import-export coverage index (TC) will be calculated as a supplement to the analysis of the foreign trade balance in beef market products (Firlej et al., 2017; Verdoorn, 1960):

$$TC_k = \frac{X_{ik}}{M_{ik}}, \tag{1}$$

where:
X_{ik} – the value of Polish export of 'i-th' item (HS: 0201 and 0202) to market 'k' (EU),
M_{ik} – the value of Polish import of 'i-th' item (HS: 0201 and 0202) from the market 'k' (EU).

The TC index determines the relation of exports to imports in the analysed branch, sector or product group in a given country. TC index values exceeding one indicate the specialisation of the country in question in trade in a given branch, sector or product group. This may show that the country under analysis has a relative advantage over partners, while an index value equal to or below 1 shows that there is no such advantage (Kowalska, 2017; Olszańska, 2016).

The HHI index is one of the measures of concentration, calculated as the sum of the squares of the share of all entities on the market, according to the following formula (Kowalska et al., 2022):

$$HHI = \sum_i^n X_i^2, \tag{2}$$

where:
X_i^2 – country participation in Polish export of 'i-th' item (HS: 0201 and 0202),
n – number of countries participating in Polish export.

As shown by Kryzia, the HHI index (taking the values 0-1) is interpreted by the rule: the higher the value, the stronger the concentration. Desired HHI values are those approaching 0, which indicate the geographical diversification of exports in the studied sector or branch, and thus a higher degree of stability of export revenues (Kryzia, 2016).

Meanwhile, the SI index is a measure of export specialisation (Frohberg, 2000; Kowalska, 2016):

$$SSI = \frac{X_{ik}}{X_{jk}} : \frac{X_{iw}}{X_{jw}}, \tag{3}$$

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where:
X_{ik} – the value of Polish export of 'i-th' item (HS: 0201 and 0202) to market 'k' (EU),
X_{iw} – Polish export of 'i-th' item to market 'w' (world),
X_{jk} – the value of Polish export of 'j-th' item (total exports) to market 'k' (EU),
X_{jw} – Polish export of 'j-th' item to market 'w' (world).

High index values above 1 indicate a given country's specialisation in the export of the i-th good to the market studied. It also points to the high degree of competitiveness of a given country in the export of the analysed branch, sector, or group of products. Meanwhile, an SI index value below 1 indicates a lack of export specialisation and thus a lack of satisfactory competitiveness of the studied sector, branch or group of products (Majcher, 2022).

The indicators of relative comparative advantage (RTA) for export (XRTA) and import (MRTA) were determined on the basis of the following formulas:

$$XRTA_{ik} = \frac{X_{ik}}{X_{iw}} : \frac{\sum_{j,j\neq i} X_{jk}}{\sum_{j,j\neq i} X_{jw}}, \tag{4}$$

$$MRTA_{ik} = \frac{M_{ik}}{M_{iw}} : \frac{\sum_{j,j\neq i} M_{jk}}{\sum_{j,j\neq i} M_{jw}}, \tag{5}$$

$$RTA_{ik} = XRTA_{ik} - MRTA_{ik}\ , \tag{6}$$

where:
X_{ik} – the value of Polish export of 'i-th' item (HS: 0201 and 0202) to market 'k' (in our case EU),
X_{iw} – Polish export of 'i-th' item to market 'w' (world),
X_{jk} – the value of Polish export of 'j-th' item (total exports) to market 'k' (EU),
X_{jw} – Polish export of 'j-th' item to market 'w' (world),
M_{ik} – the value of Polish import of 'i-th' item (HS: 0201 and 0202) to market 'k' (EU),
M_{iw} – Polish import of 'i-th' item to market 'w' (world),
M_{jk} – the value of Polish import of 'j-th' item (total exports) to market 'k' (EU),
M_{jw} – Polish import of 'j-th' item to market 'w' (world).

The calculated index values were assessed in total, using the relationships that existed between them. Positive RTA index values and XRTA values greater than one indicate high competitiveness (+), and, on the other hand, if the RTA index is negative and MRTA is above one, a given country is shown to lack competitiveness (-). In the remaining cases, the results of the analysis are not clear (+/-) (Frohberg & Hartmann, 1997; Pawlak, 2009).

The last calculated measure will be the Grubel-Lloyd intra-industry trade index (IIT), measuring the intensity of phenomena and expressing the ratio of the volume of intra-industry trade to total trade taking place within the i-th group from the k-th country (Grubel & Lloyd, 1975; Kowalska, 2016). The formula for the Grubel and Lloyd index, which is the most popular measure of IIT intensity, is on a scale (0-1) and takes the form (Śledziewska & Czarny, 2016):

$$IIT_k^i = 1 - \frac{|X_{ik} - M_{ik}|}{(X_{ik} + M_{ik})}, \tag{7}$$

where:
X_{ik} – the value of Polish export of 'i-th' item (HS: 0201 and 0202) to market 'k' (EU),
M_{ik} – the value of Polish import of 'i-th' item (HS: 0201 and 0202) to market 'k' (EU).

The IIT index takes the value 1 if export equals import within the studied group of products. This means that the entirety of trade is of an intra-industry nature. However, if a given country only exports or imports a given group of products, the index value is zero. That indicates the trade is of an inter-industry nature. Intra-industry trade was measured with regard to the horizontal streams (H – horizontal, where the index value is between 0.85 and 1.15) and vertical streams (V – vertical, where the

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index value is below 0.85 – low product quality, and above 1.15 – high product quality), see (Śledziewska & Czarny, 2015) for details.

Results of the research

RQ1 and Polish foreign trade in terms of value and territory

The first part of the analysis aims to present an overview of the Polish beef sector export activity. The synthetic assessment conducted covers two trade groups: countries of the European Union (intra-EU), trade conducted with third countries outside the European Union (extra-EU), see results in Figure 1. Analysed data from the years 2003-2022 shows that in terms of value, Polish beef exports increased over the 20 years from 61,7 million euros to 2,1 billion euros per year. Such development corresponds to a compound annual growth rate (CAGR) of 19.3%. Total and EU countries' export value (intra-EU) development over the timespan showed an almost linear trend. Intra-EU growth from 37.8 million euros to 1.813 billion euros corresponds to a CAGR 21.4%. That is two times faster growth than that of extra-EU countries (countries outside of the EU), which corresponded to only a CAGR 12.2%. It reflects the growth from twenty-four million euros in 2003 to 287 million euros in 2022. Extra-EU markets were less predictable for Polish exports. Several drops in export values to these markets can be found over the years 2014, 2016, 2019, and 2020.

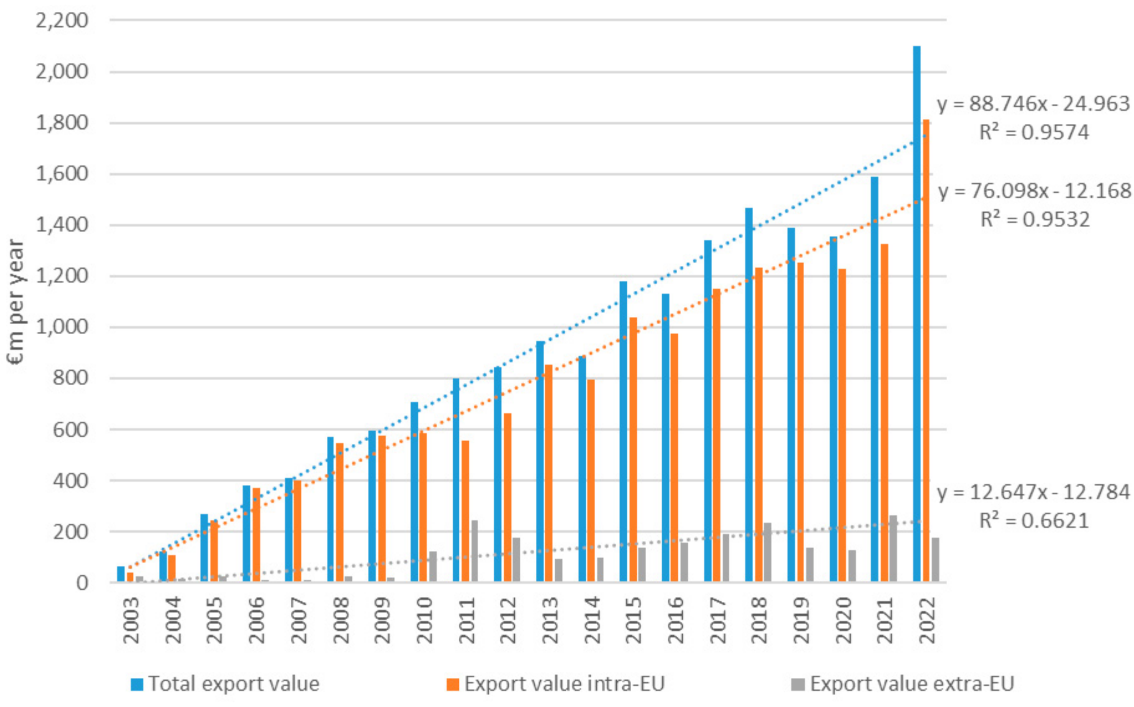

Figure 1. Polish beef industry products' balance of foreign trade

Source: authors' work based on (Eurostat, 2023).

The largest one occurred in 2006. The Polish beef market was just forming after accession to the EU. Significant structural changes were made, and Polish beef exporters were still seeking the most contestable markets. Moreover, external political shocks influenced exports as Russia and Ukraine introduced a temporary ban on Polish meat exports (Tomczak, 2006). Hence, there were greater fluctuations in supply. It took four years to return to the 2005 value of extra-EU trade. Another decrease in exports to extra-EU countries was recorded in 2013 and 2014, but since 2015, the growth has continued again. As indicated by Bułkowska (2017) the increase in beef exports in 2015, the result was a reintroduction of the possibility of conducting ritual slaughter in Poland, which was forbidden in 2013-2014. This reintroduction again opened markets such as Bosnia and Herzegovina, Türkiye,

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and Israel. The significant decline in results in the years 2019-2020 was most certainly caused by the economic and epidemiological crisis around the world, which had a negative impact on national agricultural markets, including the Polish market. The next year was marked by rising input prices, such as energy and fertiliser costs. The Polish beef could not return to 2019 prices, as the US market indicated that pandemic–related shocks were transitory (Ramsey et al., 2021).

The values in Figure 1 showed that in the years 2003-2022, the European Union was the main recipient of Polish beef. The greatest share of exports of beef sector products to EU countries was noted in 2007 (97.8%), while the lowest (61.2%) occurred in 2003, before Poland joined the European Union. The five largest EU importers of beef from Poland were Italy, Germany, France, the Netherlands, and Spain, see Table 1.

Table 1. Largest importers of Polish beef within intra-EU trade and their share of trade with these countries (million euros, %)

Years	Italy		Germany		France		Netherlands		Spain		Other EU countries	
	€m	share %	€m	share %	€m	share %	€m	share %	€m	share %	€m	share %
2003	12.6	33.4	0.9	2.4	-	-	10.4	27.5	0.2	0.5	13.7	36.2
2004*	25.8	24.3	5.6	5.3	7.1	6.7	28.2	26.6	1.4	1.3	38.0	35.8
2005	66.6	27.2	24.4	10.0	14.1	5.8	53.8	22.0	2.8	1.2	83.1	33.9
2006	104.5	28.3	64.7	17.5	23.9	6.5	79.7	21.6	13.1	3.5	83.1	22.5
2007*	99.5	24.9	90.2	22.6	32.2	8.0	67.5	16.9	22.8	5.7	87.6	21.9
2008	143.3	26.3	114.0	20.9	31.7	5.8	96.5	17.7	23.1	4.2	136.0	25.0
2009	174.5	30.4	94.2	16.4	16.6	2.9	98.6	17.2	48.6	8.5	140.7	24.6
2010	171.2	29.2	95.2	16.2	21.5	3.7	109.4	18.7	58.1	9.9	130.6	22.3
2011	143.4	25.8	105.8	19.1	27.3	4.9	98.9	17.8	49.0	8.8	130.8	23.6
2012	156.9	23.6	98.9	14.9	38.7	5.8	132.2	19.9	62.5	9.4	175.2	26.4
2013*	234.4	27.5	128.6	15.1	60.1	7.0	132.6	15.5	75.6	8.9	222.3	26.0
2014	224.8	28.3	116.7	14.7	56.1	7.1	85.6	10.8	72.4	9.1	237.4	29.9
2015	282.7	27.2	168.4	16.2	73.5	7.1	118.6	11.4	78.0	7.5	318.4	30.6
2016	274.4	28.2	131.2	13.5	70.7	7.3	98.3	10.1	88.8	9.1	309.9	31.8
2017	287.6	25.0	168.1	14.6	86.4	7.5	105.5	9.2	115.5	10.1	386.1	33.6
2018	298.0	24.2	182.5	14.8	106.5	8.6	99.3	8.1	126.5	10.3	418.1	34.0
2019	324.9	25.9	216.2	17.3	82.8	6.6	115.8	9.2	116.8	9.3	396.0	31.6
2020	293.5	23.9	240.1	19.6	85.7	7.0	112.8	9.2	96.7	7.9	398.2	32.5
2021*	333.2	25.2	278.7	21.0	105.5	8.0	108.8	8.2	113.4	8.6	384.7	29.0
2022	405.1	22.3	387.6	21.4	182.5	10.1	165.6	9.1	160.2	8.8	512.2	28.3
CAGR 2003/2022	18.95 %		35.43 %		17.63 %**		14.84 %		39.70 %		19.85 %	

* EU membership change: 2004: Poland, Czechia, Slovakia, Hungary, Cyprus, and Malta joined; 2007: Bulgaria and Romania joined; 2013: Croatia joined; 2021: Great Britain left.
** CAGR 2004/2022.
Source: authors' work based on (Eurostat, 2023).

Italy and the Netherlands accounted for almost 61% of Polish exports to the EU countries at the beginning of the analysis timespan. Twenty years later, the main recipients of beef exports are Germany and Italy. The export value increase was observed for all major countries. The value of exports to Italy had increased 32-fold (CARG 18,95%), while exports to the Netherlands increased only 16-fold in this period (CARG 14,84%). The most dynamic changes occurred in the case of beef exports to Spain and Germany. The former one increased over 430-fold and the latter one more than 801-fold. It corresponds to a twenty-year timespan to a CAGR above 35 %. The largest increase in the value of Polish exports to Italy took place immediately after Poland joined the EU. The value increased first by almost 105% in 2004, and then by over 158% in 2005. It shows that Poland's accession to the EU in 2004 allowed its farmers to successfully compete in a common market. Secondly, Table 2 proves a

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secondary benefit in the form of diversification of exports. The two most important markets in Italy and the Netherlands in 2003 lost over the surveyed twenty years 11.1 pp and 18.4 pp of their share in favour of the remaining large EU markets.

Poland's competitive position in the beef trade

The total TC index for the entire research period showed very high values, considerably exceeding 1, see Figure 2. It fluctuated significantly in the interval of 17–139, indicating a very high degree of domestic import coverage by export.

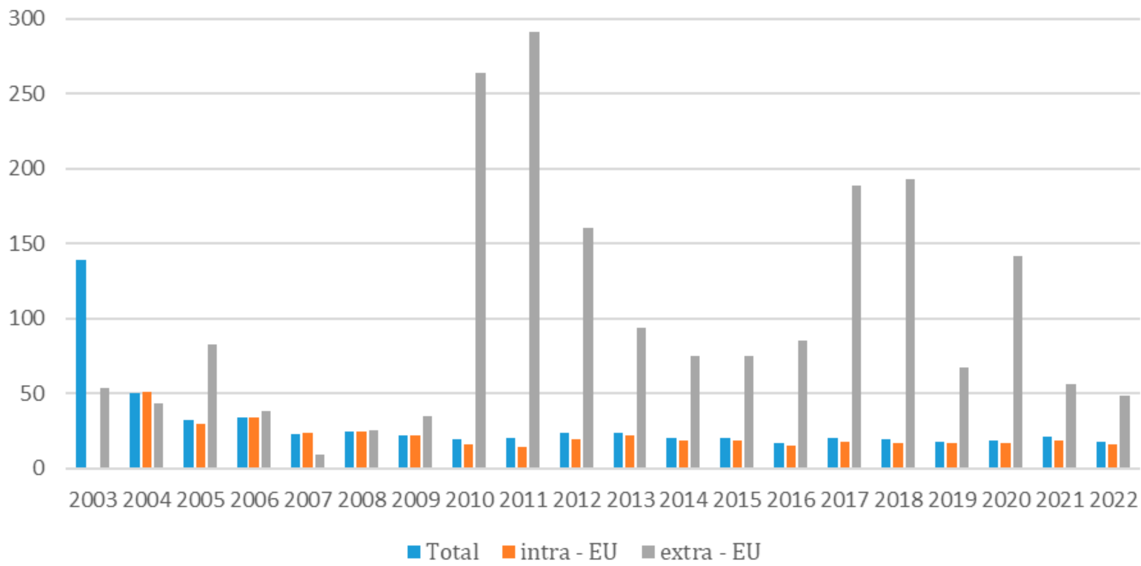

Figure 2. Import-export coverage index (TC) for the beef sector as a whole and by intra-EU and extra-EU countries
Source: authors' work based on (Eurostat, 2023).

The import-export coverage index (TC) underwent a major decrease in 2004 and 2005. Since then, only minor fluctuations were observed, and it stayed positive over the whole timespan. The TC index with EU countries was the highest in the year of Poland's accession to the EU in 2004. The surplus value was 50.9 million euros. In 2011, it amounted to 291.5 million euros and 228.9 million euros in 2010. In subsequent years, it remained mostly stable, showing that a steady trend of export volume increase was also followed by import value increase. Extreme TC index values occurred in trade with countries outside the EU in 2010 and 2011. The result is a combination of rising exports and plummeting imports from non-EU countries. The greatest drop in the value of this index year on year took place in 2012, with countries from outside the EU. At that time, the TC index value decreased by 131 (from 295.1 to 160.5). In spite of this considerable decrease, a comparative advantage for Poland in the beef trade with third countries is still substantial.

The next step in the analysis involved concentration. Beef exports from Poland inside the EU underwent a drop in the level of concentration in the years 2003-2022, see Table 2. Poland's accession to the European Union resulted in the diversification of Polish beef exports. A steady state at the level of 0.14 has been maintained since 2015, indicating that recorded exports to the EU market have been maintained at a similar level of fragmentation. Brexit did not significantly affect index values, as the value of the HHI index in the years 2001-2022 did not change, despite the fact that the United Kingdom was not taken into consideration when calculating the index.

RQ2 and Polish comparative and competitive advantages

In order to assess the degree of concentration of Polish meat exports to individual EU countries, the SI index was calculated, see the lower part of Table 2. The obtained values of this index show that the competitiveness of Polish beef exports in the years 2003-2022 varied greatly. In 2003, relative

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specialisation in the beef trade was manifested in six of the analysed countries. Polish trade manifested a considerable specialisation in the case of Greece, Bulgaria, the Netherlands, Italy, Ireland, and Sweden. Poland's accession to the EU resulted in greater diversification of beef exports to European Union markets. In 2022, Poland had a relative specialisation (SI>1) with regard to the trade in beef in as many as 15 EU markets.

Table 2. Export concentration (HII) and export specialisation (SI) indexes for Poland with regard to trade in products from sections 0201 and 0202 with EU member states in the years 2003-2022

Importers	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	HHI indicator																			
	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	SI indicator																			
Austria	0	0.5	0.9	0.8	1	0.8	0.8	0.4	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	1.1	1.1	0.9	1.1
Belgium	0	0	0	0.4	0.3	0.2	0.3	0.1	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.3	0.4	0.5	0.5
Bulgaria	6.3	0.2	0	0	1.9	1.6	2.7	2.9	1.9	1.2	1.6	2.7	1.4	1.2	5.5	3.3	1.6	1.3	1.4	1.1
Croatia	0	2.5	6.5	0.3	0.2	0.2	0.8	1.1	0.5	1.2	3.4	4.9	3.7	4.2	4.3	3.3	2.9	2.4	2.7	2.7
Cyprus	0	1.3	9	4.3	3	3.1	1.4	4.1	0.6	1.5	1.2	1.5	1	3.6	2.2	2.2	1.7	0.5	0.8	1.2
Czechia	0.3	0.3	1	0.7	0.5	0.5	0.7	0.5	0.4	0.3	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Denmark	0.2	1.5	4.2	2.8	2.6	2.8	2.4	1.5	1.2	1.3	1.7	1.5	1.6	1.4	1.2	1.1	1.2	1.2	1.2	1.2
Estonia	0	0.4	1	0.6	0.7	1	0.5	0.9	0.6	1.1	0.8	0.4	0.4	0.6	0.5	0.8	0.7	0.7	0.8	0.8
Finland	0.2	0.1	0.1	0	0	0.2	0.1	0.5	0.7	0.7	0.5	0.3	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.4
France	0	1	0.8	1	1.3	0.9	0.4	0.4	0.6	0.8	1.1	1.1	1.1	1.1	1.2	1.3	1	1.1	1.2	1.5
Germany	0	0.2	0.3	0.6	0.9	0.8	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.6	0.6	0.6	0.7
Greece	18	9.9	14	8.2	6.8	4	2.5	2.4	2.5	5.5	7	8.5	7	5.9	7	7.5	8.1	7.7	6.5	7
Hungary	0.1	0.1	0.2	0.1	0.1	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.3
Ireland	3.3	16	1.1	0.8	1.7	2.5	2.6	1.7	2.1	5	1.6	0.7	3.3	1.2	2.2	1.5	1.5	0.8	1.1	0.8
Italy	3.5	3.5	4	4.2	3.7	4.2	4.3	4	3.3	3.8	5.7	5.6	5	5	4.4	4.4	5	5.1	4.7	4.2
Latvia	0	0.2	0.2	0.2	0.1	0.1	0.2	0.5	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.5	0.4	0.3
Lithuania	0	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.1	0.2	0.2	0.2	0.1	0.2	0.5	0.5	0.6	0.7	0.8
Luxembourg	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0	0.5	0	0.1	0.1	0.1	0	0
Malta	0	0.1	3.6	13	12	10	14	7.2	3.8	8	4.2	5.9	4.2	4.9	5.6	4.6	7.2	4.5	3.8	5.7
Netherlands	3.7	5.4	4.8	5.4	4.3	4.2	3.9	3.5	2.8	3.5	3.5	2.3	2.3	2	1.8	1.5	1.9	2	1.6	1.7
Portugal	0	0	0	0	0.2	0	1	1.2	0.7	1.7	4.1	6.9	4.3	3.7	3.5	4.1	5	4.3	3.8	4
Romagna	0	0	0.2	0.1	0.2	0.4	0.7	0.3	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.4	0.3	0.2
Slovakia	0.5	0.5	0.8	0.6	0.5	0.3	0.6	0.6	0.6	0.6	0.6	0.8	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4
Slovenia	0	0	2.1	0.8	0.5	0.6	0.7	0.2	0.1	0.1	0.5	0.5	1	1.3	1.1	1.9	2.7	2.6	1.6	1.6
Spain	0.1	0.5	0.4	1.4	1.9	1.6	3.1	3	2.5	3.7	3.6	3.3	2.5	2.8	3.1	3.4	3.2	2.8	2.9	3
Sweden	3.3	1.9	1.2	0.6	0.5	0.8	0.8	0.7	0.7	0.9	0.9	1	1.1	1.1	1	0.9	0.9	0.9	1	1.1
Great Britain	0.7	1.8	0.6	0.3	0.3	0.4	0.3	0.2	0.3	0.6	0.6	0.7	0.9	1	1	0.9	0.8	1.1	1.3	1

Source: authors' work based on (Eurostat, 2023).*SI – no yellow bar; SI – yellow progress bar; SI – the full yellow bar.

The high degree of specialisation and the competitiveness of beef exports to EU markets are positive and important for the industry. Analysis of the trends, however, clearly shows fluctuations. A downward trend in SI values occurred in particular in the case of Greece and the Netherlands. Meanwhile, an upward trend is visible in relation to the United Kingdom, Slovenia, Portugal, France, and Austria.

The next step in the analysis was the XRTA and MRTA calculation for the beef trade with EU countries. The resulting RTA manifested a continuous fluctuation, see Figure 3. Poland recorded export relative comparative advantage with XRTA above 1 in all surveyed years except 2011. The most successful years, in terms of export as well as total trade relative advantage, were 2006-2010, 2013, 2014, and 2019-2020 with both XRTA and RTA above 1. RTA began to decline near the end of the surveyed year span. Poland still had a comparative advantage with both XTRA and MTRA above one. However, MRTA began to rise when XTRA stagnated. The recent development is related to a declining domestic demand for beef caused by rising prices and overall inflation. In Poland, consumers are buying cheaper meat, such as pork and poultry. Also, the fashion for vegetarianism is partly responsible for the declining demand for meat products. This contributed to low market absorption. XTRA's stagnation, on the other hand, reflected emerging export barriers and production costs. Poland is losing the advantage of lower production costs and the resulting ability to offer lower prices in foreign trade. Poland's rising minimum wage in recent years may also have an impact on this.

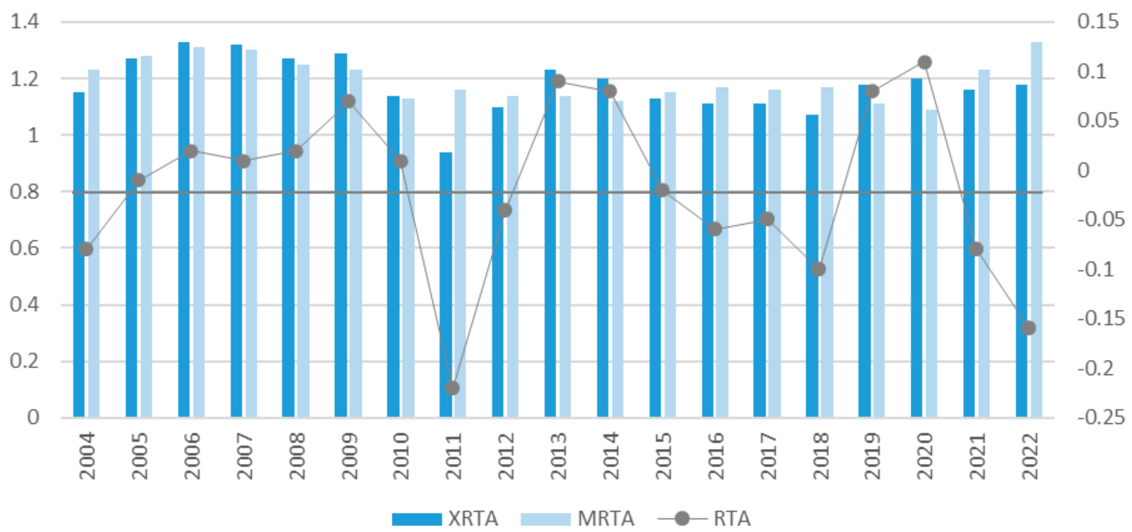

Figure 3. Relative comparative advantages (export XRTA and import MRTA) in Poland's beef trade (left y-axis) and relative advantage (RTA) in trade (right y-axis)

Source: authors' work based on (Eurostat, 2023).

The last part of the analysis concerns the intra-industry trade index (IIT) and the type of flow streams. Table 3 presents the IIT index for Polish beef trade in total and separately for EU and non-EU trade. The value of IIT with the EU varied, fluctuating between 0.059 and 0.141. The low level of the index in the study period in the case of processed products may indicate that export and import streams do not overlap (there is only export or import), which means that a given country is not able to satisfy the demand preferences of foreign recipients (Ambroziak, 2014; Jagiełło, 2003), and as a result is vulnerable to the input of these products from abroad. However, in the case of the sector in question, such conclusions are equivocal, as Poland exports unprocessed products or those used in processing to a large degree.

In EU trade during the study period, horizontal trade decidedly dominates, and despite certain fluctuations, is maintained at a similar level. Vertical trade only occurred in the years 2004-2005, 2015, and 2022. An index value above 1.15 means that high-quality products dominated the beef trade in these years. Although the increase in the share of total intra-industry trade in beef in internal EU trade was mainly achieved thanks to a growth in horizontal trade. This means that Polish companies compete on the EU market mainly through price.

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Table 3. Structure of Polish beef intra-industry trade (IIT) with intra-EU and extra-EU trade in the years 2003–2022

Years	International trade			Trade with					
				intra-EU			extra-EU		
	IIT	HIIT/VIIT		IIT	HIIT/VIIT		IIT	HIIT/VIIT	
2003	0.02	0.88	H	-	-	-	-	-	-
2004	0.04	1.33	V	0.04	1.51	V	0.02	0.73	V
2005	0.06	1.20	V	0.07	1.25	V	0.02	0.87	H
2006	0.06	0.96	H	0.06	0.98	H	0.03	0.51	V
2007	0.08	0.85	H	0.09	0.85	H	0.03	1.28	V
2008	0.08	0.89	H	0.08	0.90	H	0.03	0.89	H
2009	0.08	0.91	H	0.09	0.90	H	0.06	1.01	H
2010	0.10	1.01	H	0.11	0.94	H	0.06	1.54	V
2011	0.10	0.98	H	0.13	0.93	H	0.03	1.53	V
2012	0.09	1.07	H	0.10	1.07	H	0.04	1.16	V
2013	0.08	0.95	H	0.09	0.90	H	0.06	1.38	V
2014	0.09	1.01	H	0.09	1.01	H	0.08	1.01	H
2015	0.10	1.21	V	0.10	1.20	V	0.06	1.19	V
2016	0.12	1.13	H	0.14	1.10	H	0.05	1.28	V
2017	0.10	1.06	H	0.12	1.03	H	0.05	1.29	V
2018	0.10	1.10	H	0.12	1.07	H	0.04	1.28	V
2019	0.11	1.06	H	0.11	1.02	H	0.11	1.34	V
2020	0.10	1.06	H	0.10	0.98	H	0.10	1.51	V
2021	0.10	1.17	V	0.11	1.14	H	0.02	1.44	V
2022	0.11	1.22	V	0.12	1.20	V	0.01	1.89	V
Indicator value in pp 2004 = 100	7.00	34.0		8.00	- 31.0		-1.0	116.0	

Green color: high-quality products domination in the beef trade; Red color: domination of low-quality products in the beef trade
Source: authors' work based on (Eurostat, 2023).

The most significant changes in the years 2003-2022 occurred in the Polish beef trade with third countries. The clearly dominating price competition that existed until 2006 was replaced since 2007 by quality competition, which is confirmed by the higher level of quality competition indicators in relation to price competition indicators. From the above, it can be concluded that on the EU market, Poland overwhelmingly sells products of lower quality in exchange for products of high quality. However, the situation in trade with third countries is the reverse, and the unit value of exports is considerably higher than the unit value of imports.

RQ3 and Polish environmental factors in production

Finally, success in production and its export creates externalities. In recent years, a range of conditions have risen in favour of sensibly limiting this beef production due to its considerable impact on the environment. Karaczun & Kozyra (2020) and Zarzynska & Zabielski (2023) draw attention to changes in the climate. Climate change adaptation is crucial for the beef industry. Climatic fluctuations affect feed availability and farming conditions, impacting production costs. Cattle farming requires significant water, affecting water resources (O'Brien et al., 2023). Effective waste management and water resource management are essential for competitiveness (Accorsi et al., 2017). Pollution is also related to health and food safety norms, influencing production technology and consumer acceptance (Gürsoy, 2020). Other environmental impacts include air pollution (dust), water contamination (ammonia and microorganisms,), and greenhouse gas emissions (Kaur & Singh, 2019; Novikov et al., 2022) where beef has decidedly the largest carbon footprint, almost four times that noted in the production of poultry and 10 to 100 times larger than the majority of plant-based products. Beef

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production generates significant greenhouse gases, especially methane. Sustainable farming practices can limit emissions, enhancing competitiveness (Kupczyński & Śpitalniak-Bajerska, 2018; Rotz, 2020; Samanta et al., 2022), but come at production efficiency costs. Beef has a large carbon footprint compared to other meats and plant-based products (Desjardins et al., 2012; Ritchie, 2020). According to Poore & Nemecek (2018), reducing meat consumption and switching to plant-based diets can limit environmental impact. Plant-based or synthetic meat products may compete with traditional beef (Lotfi et al., 2018).

Conclusions and discussion

Beef is a valuable dietary product with high production costs and the longest production cycle among principal animal production areas. Our analyses show that there has been a considerable dynamic increase in the export of Polish beef, especially to EU markets, with exports increasing 34-fold over 20 years to €2.1 billion annually and CAGR of 19.29%. This growth reflects improved competitiveness enabled by specialisation, technological advances, and systemic changes in the Polish economy during the 1990s. Specialisation and concentration continued during the surveyed timespan, 2003–2022, but the focus was turning more to the exports. While domestic demand remains low, the focus on exports has made Poland's beef industry a global player.

EU membership offers critical benefits such as EU trade agreements increasing the competitiveness of Polish beef, food safety regulation, and support for farmers. However, it was the diversification of exports to non-EU countries that increased export growth. Poland had a relative specialisation with regard to the trade in beef in as many as 15 EU markets, manifesting an upward trend in relation to the United Kingdom, Slovenia, Portugal, France, and Austria. The most successful years, in terms of export as well as total trade relative advantage, were 2006-2010, 2013, 2014, and 2019-2020, all with export relative comparative advantage above 1. Polish companies competed on the EU market mainly through price, and for a third of the surveyed timespan, high-quality products dominated in the beef trade.

The international competitiveness of the Polish beef sector is strong. However, the Polish beef market is vulnerable to changes in world prices and to local crises, which may affect its competitiveness. That requires continuous monitoring of global market trends, adaptation to changing consumer preferences and environmental policies, as well as maintaining high-quality production at competitive prices. Sustaining competitiveness will require dynamic adaptation to trends, including sustainable production, technological innovation, and animal welfare, ensuring alignment with evolving market demands. These are the treats that await at the end of a generally positive assessment of the changes that took place in the export of Polish beef over the analysed timespan. Outside the EU, a clearly dominating price competition existed until 2006 and was replaced by 2007 by quality competition.

Regarding the limitations and further research, we first note that this analysis concentrates on the Polish beef market within the EU, offering limited insight into global markets and supply chains. The reliance on historical data and only selected inputs also limits the ability to forecast future trends in changing market and political environments.

Although the environmental consequences of beef production are acknowledged, further in-depth research is required. A separate issue is the influence on this market of agricultural policies and regulations implemented in the European Union and in other countries that are potential recipients of Polish exports. Such issues that require particular analysis are support for farmers, food safety standards, and environmental regulations. Finally, expanding the research scope to encompass global competition, sustainable development, and innovation will provide a more comprehensive understanding and support strategies for adapting to shifting market conditions.

The contribution of the authors

Conceptualisation, A.S.K. and A.O.; literature review, A.S.K., A.O. and I.S.; methodology, A.S.K.; formal analysis, A.S.K; writing, A.S.K., A.O. and I.S.; conclusions and discussion, A.O.

The authors have read and agreed to the published version of the manuscript.

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KONKURENCYJNOŚĆ POLSKIEGO RYNKU WOŁOWEGO – ASPEKTY EKONOMICZNE I ŚRODOWISKOWE

STRESZCZENIE : W artykule dokonano analizy polskiego rynku wołowiny w kontekście jego roli w Unii Europejskiej oraz na arenie międzynarodowej. Polska, jako jeden z głównych producentów i eksporterów wołowiny w UE, znajduje się w korzystnej pozycji, aby skorzystać z dużego zapotrzebowania na wysokiej jakości mięso wołowe. W pracy skupiono się na ekonomicznych i środowiskowych aspektach konkurencyjności rynku wołowiny. Ponadto, tekst zawiera krótką charakterystykę rozwoju tego rynku w Polsce po transformacji systemowej, z podkreśleniem znaczącego postępu w specjalizacji i jakości produkcji. Przedstawiono również wyzwania i uwarunkowania prowadzenia tego kierunku produkcji związane ze zrównoważoną produkcją, w tym emisją gazów cieplarnianych i wykorzystaniem zasobów wodnych, podkreślając rosnącą świadomość ekologiczną zarówno producentów, jak i konsumentów. Celem opracowania jest ukazanie zmian, jakie miały miejsce w polskiej wymianie handlowej z krajami UE oraz krajami trzecimi, jak również konkurencyjności sektora mięsa wołowego na rynkach międzynarodowych w kontekście uwarunkowań jego rozwoju, ze szczególnym uwzględnieniem uwarunkowań środowiskowych. Analiza wykorzystuje dane z Eurostatu za lata 2003-2022, a także różnorodne metody statystyczne, w tym wskaźniki pokrycia importu eksportem, miary koncentracji rynku i analizę przewag komparatywnych. Wyniki wskazują na silną pozycję Polski na rynku UE, choć zauważono także potencjalne obszary ryzyka ale także możliwości dalszej dywersyfikacji rynków eksportowych. W konkluzjach stwierdzono, że przyszłość polskiego rynku wołowiny będzie zależała od zdolności do adaptacji do globalnych trendów rynkowych, zmian w preferencjach konsumenckich oraz wyzwań związanych ze zrównoważoną produkcją.

SŁOWA KLUCZOWE: rynek wołowiny, aspekty środowiskowe, aspekty ekonomiczne, konkurencyjność, handel międzynarodowy

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