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EFFICIENCY IMPROVEMENT OF THE CZECH AND POLISH PROCESSORS OF POULTRY MEAT IN 2008 - 2013

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Abstract. The consumption of the poultry meat in the Czech Republic has been increasingly covered by imports from Poland. The low competitiveness of the Czech companies could be rooted in the production efficiency of poultry meat processors. Therefore, the aim of the paper was to evaluate the technical efficiency improvement of the Czech and Polish corporate poultry processors. The analysis of 54 medium and large poultry meat processors in the NACE 10.12 covered the period 2008–2013. The Malmquist index, the Data Envelopment analysis and the Kolmogorov-Smirnov test of the differences between the Czech and Polish companies revealed that improvement of the production efficiency of poultry meat processors in Poland was significantly higher than in the Czech Republic. The change of material and energy productivity significantly differed between two countries in contrast to labour and capital productivity. The author expected that the large investments in technology upgrading and concentration would further strengthen the position of Poland as the one of the largest European poultry producers.

Key words: competitiveness, DEA, financial analysis, investment, Malmquist index

JEL code: M21, L66

Introduction

Poultry meat is the most popular meat worldwide. The consumption of poultry meat in the Czech Republic takes the second place after pork meat. The consumption per capita is about 25 kg per year. So, the significance of the poultry meat processing industry is high. However, the Czech poultry meat consumption has been strongly affected by imports because the Czech Republic is not self-sufficient in the poultry meat (Pohlova, Mezera, 2014). More than 50% of the import of poultry meat to the Czech Republic comes from Poland. According to the External Trade Database of the Czech Statistical Office, the foreign trade balance of the poultry meat (code 0207 of Harmonized System 4-digits code) between the Czech Republic and Poland continuously dropped from CZK -1 064.35 million to CZK -2 325.36 million between 2008 and 2014. It indicates that the Czech Republic is not able to compete with the Polish poultry meat processors. One of the possible reasons could be low technical efficiency and low efficiency improvement of the Czech poultry meat processors.

The question of the technical efficiency and the efficiency improvement in agribusiness in the Central Europe was occupied by many authors. Most papers dealt with the technical efficiency of agricultural companies in recent years (Cechura, 2012; Pechrova, Vlasicova, 2013; Bojnec et al., 2014; Nowak, Kijek, Domanska, 2015; Barath, Ferto, 2015). Unfortunately, only a few authors focused on food processing industry (Dankova, Bosakova, 2005; Cechura, Hockman, 2010). Cechura and Mala (2014) analysed the differences in the technology and the technical efficiency of Czech and Slovak processing companies in the period 2003–2012. They compared oils, dairy, milling and other sectors (not specifically the meat processing industry). They concluded that the technical efficiency was high in all analysed sectors. However, the meat industry and poultry processing industry in the Central Europe has not been sufficiently evaluated so far. There are only some articles about poultry farms (Mahjoor, 2013; Heidari, Omid, Akram, 2015), not about poultry processing industry.

So, it is very topical to evaluate a technical efficiency and efficiency improvement in the poultry processing industry. The problem of negative foreign trade balance between the Czech Republic and Poland is a good reason to make the analysis. The aim of the paper is to evaluate the technical efficiency change of the Czech and Polish corporate poultry processors in the period 2008–2013. The article also deals with the differences in partial efficiency indicators between the Czech and Polish companies.

Methods

As Spicka and Machek (2015) introduced, efficiency measurement is often carried out from two perspectives: total factor productivity (TFP) which takes into account all possible inputs and outputs of an industry (firm, process), multifactor productivity (MFP) which deals with the relationship between output and multiple input factors, and partial factor productivity (PFP) which deals with the productivities of individual inputs. The article uses multifactor productivity (MFP) which deals with the relationship between output and

multiple input factors. MFP and Malmquist index quantify change in a company's efficiency over a period of time.

A producer can be defined as an economic agent transforming a set of inputs $\mathbf{x} = (x_1, x_2, \ldots, x_n)$ into a set of outputs $\mathbf{y} = (y_1, y_2, \ldots, y_m)$. Generally, the author considers the components of these vectors to be strictly positive. In order to define the Malmquist index of productivity (Caves et al., 1982), one considers a period during which the production has changed from $(\mathbf{x}_t, \mathbf{y}_t)$ to $(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})$. Let's assume the output-maximizing approach which means the lesser the distance from a production frontier, the better the efficiency score. The Malmquist index of productivity for period t, respectively for period $t + 1$, would be the ratios

$$M_t(\mathbf{x}_t, \mathbf{y}_t, \mathbf{x}_{t+1}, \mathbf{y}_{t+1}) = \frac{D_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)}$$
$$M_{t+1}(\mathbf{x}_t, \mathbf{y}_t, \mathbf{x}_{t+1}, \mathbf{y}_{t+1}) = \frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_t, \mathbf{y}_t)}; \quad (1)$$

where D_t denotes the value of the distance function in period t. If the technology has changed during the period, these two indexes would result in different values. Therefore, it is common to employ the geometric mean of the two indexes and specify the Malmquist index of productivity as

$$M(\mathbf{x}_t, \mathbf{y}_t, \mathbf{x}_{t+1}, \mathbf{y}_{t+1}) = \sqrt{\frac{D_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_t, \mathbf{y}_t)}} \quad (2)$$

The index can be further decomposed in the product of two terms (Fare et al., 1992):

$$M(\mathbf{x}_t, \mathbf{y}_t \mathbf{x}_{,t+1}, \mathbf{y}_{t+1}) = \sqrt{\frac{D_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_t, \mathbf{y}_t)}} =$$
$$= \sqrt{\frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{D_t(\mathbf{x}_t, \mathbf{y}_t)}{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})} \times \frac{D_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_t, \mathbf{y}_t)}} =$$
$$= \frac{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_t(\mathbf{x}_t, \mathbf{y}_t)} \times \sqrt{\frac{D_t(\mathbf{x}_t, \mathbf{y}_t)}{D_{t+1}(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{D_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}} =$$
$$\Delta TE(\mathbf{x}_t, \mathbf{y}_t \mathbf{x}_{,t+1}, \mathbf{y}_{t+1}) \times \Delta T(\mathbf{x}_t, \mathbf{y}_t \mathbf{x}_{,t+1}, \mathbf{y}_{t+1}) \quad (3)$$

The first term ΔTE reflects the impact of changes in technical efficiency which means that $\Delta TE > 1$ as technical efficiency improves and $\Delta TE < 1$ as technical efficiency deteriorates. The second term ΔT captures the changes in technology (technical change) which can be expressed by the ability of a firm to produce more (or less) with a given level of inputs in t related to the levels feasible in $t + 1$. ΔT is the geometric mean of two terms, when the first term compares the two periods in terms of period t data, and the second term compares the two periods in terms of period $t + 1$ data. $\Delta T > 1$ as technical progress occurred between periods, while $\Delta T < 0$ as technical regress occurred between the two periods.

A value of 1 signifies no change in efficiency, while values greater than 1 or less than 1 signify an increase or decrease, respectively. The Malmquist index is the product of two terms - a "frontier shift" term and a "catch-up" term. The catch-up (recovery) term relates to the degree to which a decision-making unit improves or worsens its efficiency with respect to the frontier in each period, while the frontier-shift (innovation) term reflects the change in the efficient frontiers between the two time periods (Cooper et al., 2006).

The input-oriented Data Envelopment Analysis model assumes the variable returns to scale (DEAVRS method*). The input oriented model was selected because poultry meat processors take price from the market and they are rather able to manage inputs than price. The issue of the returns to scale concerns what happens to units' outputs when they change the amount of inputs they are using to produce their outputs. Under the assumption of the variable returns to scale, a unit found to be inefficient has its efficiency

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* BCC (Banker-Charnes-Cooper) model. The BCC model used in this paper is described in more detail by Cooper et al., 2006.

measured relative to other units in the data-set of a similar scale size only. Three inputs and one output per company were used for efficiency calculation. In order to remove the influence of price development, outputs and three inputs (expressed in monetary units) were deflated using output and input price indices. The indices were taken from the Eurostat database of price indices.

- Output = Sales, i.e. the financial value of production sold to the customers excluding the value added tax. Deflation indicator: Producer prices in industry, total - Processing and preserving of poultry meat (EU-27, 2010 = 100), Eurostat.
- Input 1 (controlled input) = Materials and Energy, i.e. the financial value of material and energy consumption. Deflation indicator: Price indices of agricultural products, output - Poultry (CZ, PL, 2010 = 100), Eurostat. Live poultry produced on farms is the main input in the poultry processing industry.
- Input 2 (controlled input) = Staff costs, i.e. the financial value of wages including all payments of employees and employers. Deflation indicator: Labour input in industry, total – Manufacture of food products – Gross wages and salaries (CZ, PL, 2010 = 100), Eurostat.
- Input 3 (uncontrolled input) = Depreciation and amortization, i.e. the financial value of consumption of the long-term assets within each year. Deflation indicator: Producer prices in industry, total – Capital goods (CZ PL, 2010 = 100), Eurostat.

The Kolmogorov-Smirnov test (K-S) was applied depending on the subjective assumptions about the efficiency determinants. The K-S test was selected because it is not sensitive on normality and equal variances in the sample. Normality test and equal-variance test are not presented in this paper (because of its limited length) but assumption testing through Shapiro-Wilk test and the two-group variance-comparison test rejected the normality and equal-variance of the two subsets.

The DEA method and Malmquist index were applied through Banxia Frontier Analyst 4. The statistical analysis was processed automatically by software Stata 12.1.

Data

The analysis used data from the Amadeus database that provides comparable financial information for public and private companies across Europe. The companies with specialization in the branch 10.12 Processing and preserving of poultry meat in the Czech Republic and in Poland were in focus. The analysis covered the period 2008-2013 that represents the "old" programming period of the Rural Development Programme (RDP). The article focused on the medium and large corporations since they have produced most value of processed poultry meat in both countries. Moreover, small companies do not usually export the products. The Amadeus database generated 19 companies in the Czech Republic and 294 companies in Poland. However, not all companies released complete balance sheet and income statement in the period 2008-2013. So, 10 Czech companies and 44 Polish companies entered into the analysis. It is not random sample but it represents really the largest poultry processors which have significant impact on foreign trade. Table 1 contains the number and turnover (operating revenues) of the companies in the sample and in the population according to the official statistics by Eurostat and the Czech Statistical Office.

Table 1

The comparison of the sample and the population (2013) – 50 and more employees

	Sample	Population	Sample / Population (%)
Number of enterprises (CZ)	10	10	100
Number of enterprises (PL)	44	226	19.5
Turnover (CZ), thou. EUR	352 858	352 858	100
Turnover (PL), thou. EUR	1 122 391	2 826 900	39.7

Source: author's calculations based on Eurostat, Czech Statistical Office, Amadeus

It is an unbalanced panel data set. The sample of the Czech poultry processors is equal to the population of medium and large companies with 50 and more employees. The three largest Czech poultry processors are VODNANSKA DRUBEZ, A. S., DRUBEZARSKY ZAVODKLATOVY, A.S., RABBIT TRHOVY STEPANOV, A.S. The sample of the Polish poultry processors represents 19.5 % of the population number. The three largest Polish poultry processors in the sample are ROLDROB S. A., IKO KOMPANIA DROBIARSKA SP. Z O. O., DROP S. A.

Research results and discussion

The difference in the Malmquist index was tested between Czech and Polish companies. Moreover, development of the technical efficiency over time is described in the Czech Republic and Poland. Table 1 describes the differences of the mean Malmquist index in the period 2008-2013 between two countries.

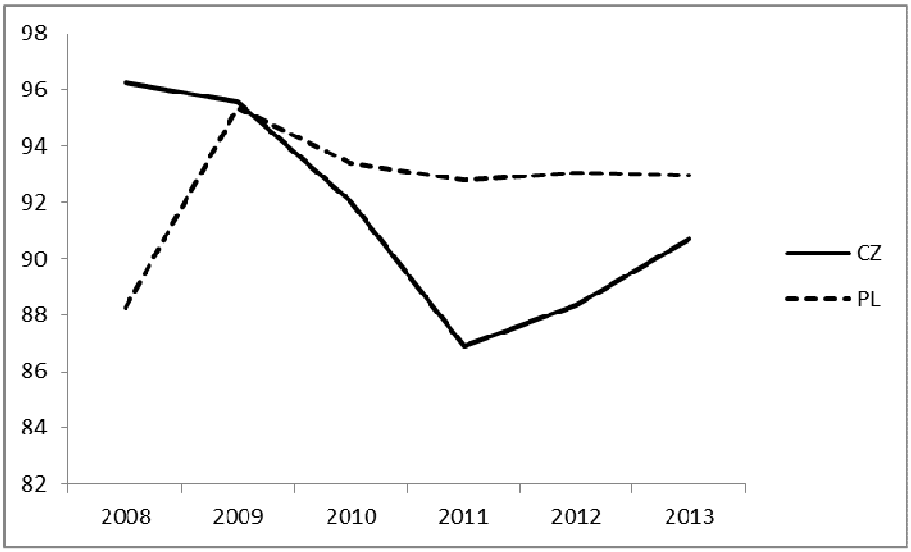
Table 2

Malmquist index (2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	1.005926	0.0067329	0.0212912	0.9906952	1.021157
PL (N = 44)	1.105276	0.0804417	0.5335897	0.9430503	1.267502
K-S test	D	p-value	corrected	**Significance** (α = 0.05)	
CZ (N = 10)	0.6273	0.002	-	**CZ < PL**	
PL (N = 44)	-0.0455	0.967	-	**-**	
Combined	0.6273	0.003	0.001	**CZ ≠ PL**	

Source: author's calculations based on Amadeus

The Polish companies experienced higher improvement of the production efficiency (by 10.5 % p.a. on average) than the Czech companies (by 0.6% p.a. on average). The result is statistically significant. It should be interesting to view a development of the production efficiency over time and see the critical years in the period (Figure 1). The figure shows a sharp drop of the technical efficiency of the Czech poultry processors from 96.3 % (2008) to 86.9 % (2011). The technical efficiency of the Czech poultry processors then increased in 2012 and 2013 but it has not reached the Polish level until 2013.



Source: author's calculations based on Amadeus

Fig. 1. **Development of the production efficiency**

The Malmquist index can be disaggregated into "frontier shift" and "catch-up" effect. This analysis is important to see whether the companies (country) improved the production efficiency with respect to the frontier or there was a change in the efficient frontiers between the time periods rather than an improvement of country's efficiency. Table 3 describes the catch-up effect and Table 4 contains the frontier shift.

Table 3

Catch-up effect (2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	0.99372	0.0034899	0.011036	0.9858253	1.001615
PL (N = 44)	1.013314	0.0025594	0.0169771	1.008153	1.018476
K-S test	**D**	**p-value**	**corrected**	**Significance (α = 0.05)**	
CZ (N = 10)	0.6591	0.001	-	CZ < PL	
PL (N = 44)	0.0000	1.000	-	-	
Combined	0.6591	0.002	0.001	CZ ≠ PL	

Source: author's calculations based on Amadeus

It is evident that the catch-up effect positively determined overall improvement of the production efficiency of the Polish poultry meat processors. It means that there was really a positive shift towards frontier. Alternatively, the Czech companies moved away from the efficient companies which; it shows lower competitiveness of the Czech poultry industry. Frontier shift also helped improving the production efficiency of Polish companies. It indicates that there was overall technology progress. However, the frontier shift effect did not differ between the two countries.

Table 4

Frontier shift (2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	1.005364	0.0053389	0.0168831	0.9932866	1.017441
PL (N = 44)	1.121693	0.1107023	0.7343159	0.8984407	1.344946
K-S test	**D**	**p-value**	**corrected**	**Significance (α = 0.05)**	
CZ (N = 10)	0.3182	0.192	-	-	
PL (N = 44)	-0.0818	0.897	-	-	
Combined	0.3182	0.381	0.267	-	

Source: author's calculations based on Amadeus

The change in production efficiency depends on partial production efficiency. So, material and energy productivity, labour productivity and capital productivity is assessed in the next part of the paper. The partial productivity is measured as a geometric mean of chain index of the indicator in the period 2008-2013.

Material and energy productivity (Table 5) expresses how much sales the company generates from one unit of material and energy used. Unfortunately, the Amadeus database does separate material and energy consumption.

Table 5

Change in the material and energy productivity (index, 2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	99.55767	0.7085014	2.240478	97.95493	101.1604
PL (N = 44)	102.1746	0.2197733	1.457811	101.7314	102.6178
K-S test	**D**	**p-value**	**corrected**	**Significance (α = 0.05)**	
CZ (N = 10)	0.8091	0.000	-	CZ < PL	
PL (N = 44)	-0.0318	0.984	-	-	
Combined	0.8091	0.000	0.000	CZ ≠ PL	

Source: author's calculations based on Amadeus

Material and energy productivity of the Polish poultry processing industry has increased by 2.2 % on average unlike the Czech Republic. An improvement could be affected by investment in modernization and innovation of the processing capacities. The effects strongly depend on effectiveness of investments and investment support from public sources. Meat processing industry in Poland dynamically increased the investments in tangible assets in the period 2007-2013 unlike the Czech Republic. The meat processing capacities have strongly concentrated in recent years (Naglova, Spicka, 2015). Moreover, research indicates weak effects of investment support in the Czech food industry (Mezera, Spicka, 2013).

Table 6 shows a change in the labour productivity. Labour productivity should also be more progressive in the companies which have upgraded technology to be more automatic. Nevertheless, the rural development policy also focuses on stabilization of labour forces in the rural areas. It is somewhat contradictory target against modernization of companies.

Table 5

Change in the labour productivity (index, 2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	96.08195	4.858484	15.36387	85.09129	107.0726
PL (N = 44)	103.1932	1.470645	9.755156	100.2274	106.1591
K-S test	**D**	**p-value**	**corrected**	**Significance (α = 0.05)**	
CZ (N = 10)	0.3909	0.083	-	-	
PL (N = 44)	-0.0864	0.886	-	-	
Combined	0.3909	0.166	0.098	-	

Source: author's calculations based on Amadeus

The labour productivity of Polish companies has increased by 3.2 % unlike the Czech Republic. However, the K-S test did not reveal statistically significant difference at α = 0.05. So, the labour productivity is not the major problem of different technical efficiency between the two countries.

The last partial productivity is capital productivity measured as sales to depreciation. Depreciation expresses the annual consumption of capital employed.

Table 6

Change in the capital productivity (index, 2008–2013)

Country	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
CZ (N = 10)	95.11051	8.754118	27.68295	75.30732	114.9137
PL (N = 44)	104.0172	2.541319	16.85721	98.89214	109.1423
K-S test	**D**	**p-value**	**corrected**	**Significance (α = 0.05)**	
CZ (N = 10)	0.1955	0.537	-	-	
PL (N = 44)	-0.2182	0.460	-	-	
Combined	0.2182	0.833	0.740	-	

Source: author's calculations based on Amadeus

Table 6 also shows improvement of capital productivity of poultry meat processors in Poland. Like in case of labour productivity, there weren't any statistically significant difference in capital productivity between Czech and Polish companies. So, material and energy productivity was identified as the only one partial productivity that significantly differs between the Czech Republic and Poland.

The problem of high exports of poultry meat from Poland to the Czech Republic also depends on price relations of poultry meat in both countries. Since the purchaser price of poultry in the Czech Republic was growing in the period 2008-2013, the processors bought the cheaper poultry meat in Poland in order to keep positive profitability. One possible reason is a higher efficiency of poultry production on farms. Polish farmers have special social security system (Vilhelm, Pickova, 2009) provided by the Agricultural Social Insurance Fund (KRUS). Moreover, the more efficient and concentrated vertical of poultry meat headed by the Polish Poultry Council Chamber of Commerce enables to produce cheaper than in the Czech Republic.

Furthermore, the limitation of the research is that the analysis does not comprise meat processing capacities in large grocery retailers (hypermarkets), such as Tesco (Tesco Stores CR a. s. and Tesco Polska Sp z. o. o.), and discounters (Lidl Ceska republika v.o.s. and Lidl Polska Sklepy Spozywcze Sp z. o. o. Spk; Kaufland Ceska republika v. o. s. and Kaufland Polska Markety Sp z. o. o. Spk). Since the meat processing capacities are not separable in the income statement of retailers, the economic efficiency could not be calculated. The trade flows within the vertical of poultry meat in the large multinational grocery retailers enable to produce even cheaper than in conventional customer-supplier vertical. This aspect and the fact that Poland is one of the largest European poultry producers partly explain the high competitiveness of Poland in the poultry meat production and processing.

Conclusions

The aim of the paper was to evaluate the technical efficiency improvement of the Czech and Polish corporate poultry processors. The analysis of 54 Czech and Polish poultry meat processors in the NACE 10.12 covered the period 2008-2013 as the major part of the "old" programming period of the RDP. The article also deals with the differences in partial efficiency indicators between the Czech and Polish companies. The results can be generalized only for medium and large companies with more than 50 employees because of the limited access to financial statements of small companies in the Amadeus database.

1) The improvement of the production efficiency of poultry meat processors in Poland was significantly higher than in the Czech Republic. Polish companies have maintained the average level of the production efficiency above 92 %. However, the technical efficiency of Czech poultry meat processors increased in last two years of the "old" programming period (2012, 2013) which could indicate that their competitiveness is getting better.

2) The catch-up effect indicates positive shift of Polish poultry meat processors towards efficient frontier. Alternatively, the Czech companies slightly moved away from the efficient frontier.

3) The frontier shift effect was higher in Poland which indicates that there was a change in the efficient frontiers between the two time periods. However, there were not statistically significant differences of the frontier shift between the Czech and Polish companies.

4) The only one statistically significant difference of the partial productivity indicators between the Czech Republic and Poland was the material and energy productivity. Poultry processors in Poland were able to increase the efficiency of material and energy consumption unlike the Czech Republic. Change of capital- and labour productivity did not significantly differ between the two countries.

The analysis shows that the Czech Republic will continuously have low competitiveness of the poultry processing against Poland. Moreover, Poland has intensively invested in the meat processing capacities and concentration and will continue to massively supply retailers with cheaper poultry meat products. This is only the author's opinion because the analysis did not cover trade flow of poultry meat through international retail chains due to the data unavailability.

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