Article

Czech Comparative Advantage in Agricultural Trade with Regard to EU-27: Main Developmental Trends and Peculiarities

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Abstract: The paper, based on RCA, LFI and GL indices, and logistic regression analysis, allowed us to track the dynamics of the comparative advantage/disadvantage of the Czech Republic in individual commodity aggregates in relation to individual EU partners, and to comprehend the role of the main production factors. The only production factor with a statistically significant effect is capital. Trade with countries richly endowed with agricultural land and capital, in most cases, appeared not favorable for the Czech Republic in terms of having a comparative advantage over them, if measured with LFI index. The values of the GL index disclosed that trade with these countries is mostly of an inter-industry character. The analysis revealed the following top-3 mostly competitive Czech aggregates: S3-08 (animal feed stuff), S3-06 (sugar and sugar preparations), along with S3-04 (cereals and cereal preparations). Some aggregates appeared to not have any comparative advantage: S3-01 (meat, meat preparations), S3-05 (vegetables and fruits), and S3-41 (animal oils and fats). Speaking of developmental trends, from 2000 to 2019 the Czech Republic has managed to improve its position in agri-food trade within the EU-27 by 43.81% if measured with LFI, and by 51.63% if measured with RCA. These positive changes also appeared to be statistically significant.

Keywords: agricultural trade; agri-food aggregations; comparative advantage; competitiveness

1. Introduction

There is no doubt that food security is one of the biggest development challenges humanity faces in the 21st century [1]. The challenge is to feed the increasing population using the finite number of natural resources. According to Bе́nus et al. [2] the agri-food industry is a key industry in every national economy that is responsible for food safety. The competitiveness of this sector has been of central interest to policymakers, entrepreneurs, and researchers. In this context, the production of agricultural commodities and products, and their processing, trade and distribution should be among the primary interests of all countries all around the world. The relationship between production and consumption, import and export should also be considered in this context. Thus, food self-sufficiency, absolute and relative advantages in agricultural production and trade become crucial aspects for the decision-making process focused on achieving the corresponding balance and “optimal” settings. However, as Jeniček and Krepl [3] argue, the whole process of foreign trade is complicated by a number of factors (prices, political distortions, etc.) that often lead to exporting even those products which might have been realized domestically, and on the other hand, importing such commodity groups which compete with domestic production and thus secure a wider assortment of supply.

Concerning production, consumption and trade of agri-food products many theories have arisen. Among them we can mention the Ricardian neo-classical theory, the Hecksher–Ohlin theory, and the theory of comparative advantage, open market, trade liberalization,
etc. All of them define the importance and necessity of international trade from various viewpoints. In this regard, it becomes obvious that different features of trade must be examined. Grossman and Helpman [4] focus on the role of the external trading environment, trade and industrial policies in the determination of long-run growth rates. They find that cross-country differences in efficiency (i.e., comparative advantage) at R&D versus manufacturing bear importantly on the growth effects of economic structure and commercial policies. Besides this, the question of competitiveness is crucial. Nowak et al. [5] emphasize that competitiveness is currently a key issue in understanding the processes on micro-, meso-, and macroeconomic levels.

According to Saboniene [6], export development has contributed significantly in terms of capital inflows, employment, expansion of industry and widening the production base. Moreover, export also allows domestic industries to achieve some economies of scale, which otherwise would not have been possible due to the limited domestic market size. Fertő [7] states that one of the most important features in the international trade over the recent decades, has been the increased fragmentation of the production process. According to Ružeková et al. [8], the competitiveness of a particular national economy and its business environment is critical for the country’s economic, political and societal development. Gilbert and Muchová [9] show that the changes in export competitiveness of central and eastern European countries are driven largely by expansions of the market share within the EU, just a small proportion of the change in trade share is attributable to changes in the extensive margin.

The history of international trade competitiveness’ examination starts in the 2nd half of the 20th century. Currently, just several concepts, focused on different aspects of international trade, are commonly employed. Among them, the Revealed Comparative Advantage (RCA) concept can be mentioned. It is based on the Ricardian comparative advantage and calculated with the use of the Balassa index [10], modified by Vollrath [11] into a Relative Export Advantage (RXA), Relative Import Advantage (RMA) and a related Revealed Competitiveness (RC), Domestic Resource Cost (DRC), allowing one to identify efficient production sectors [12], and the Lafay index (LFI), explaining the competitive strength of individual products or product groups [13], and Grubel–Lloyd (GL) index of intra-trade [14], that are frequently used to examine trade competitiveness. Fertő and Hubbard [15] argue that the utilization of these indices may be problematic as observed trade patterns can be distorted by government policies and interventions and may, therefore, misrepresent the underlying comparative advantage. Hoen and Oosterheaven [16] discuss the properties of the RCA index. They focus on the influence of the number of analyzed countries and industries while calculating the RCA index on its distribution. In conclusion, a proposal of alterative modified RCA indices in the form of an aggregate index and regional specialization index are introduced. Balassa [17] also analyzed the changing pattern of a comparative advantage in the process of economic development. Since every measure and index, when focusing on particular aspects of trade competitiveness, eventually omit the others, Latruffe [18] suggests examining competitiveness by employing different indices in combination to increase their power and the reliability of a research. Török et al. [19] use the revealed symmetric comparative advantage index as a linear transformation of the Balassa index, to treat the asymmetric value problem of the Balassa index in combination with other methods to evaluate the export competitiveness, e. g., the panel data linear regression model. Latruffe [18] also suggests that more attention should be paid to the non-price factors of competitiveness and the impact of government intervention on competitiveness.

Similarly, still in late 1980, Vollrath [20] found that the most competitive agricultural exporters are usually those with the least governmental intervention. However, Mizik [21] points that namely supportive legislation and policy is the most crucial factor that contributes to the competitiveness of domestic producers, followed by higher value-added/more sophisticated goods, and highly efficient, and profitable production. Nagy and Jambor [22] argue that the main reasons behind a strong competitive advantage can be seen in the production of highly processed products and specialization in the
production of one or a few of the competitive products. Pawlak [23] also emphasizes that countries usually reach substantial comparative advantages in trade when trading those assortment groups which correspond to their highest shares in global exports and generate a consistently increasing positive trade balance. Thus, their comparative advantages were the source of their favorable export specialization profile, consistent with the classical theory of comparative costs (the theory of comparative advantage), first formulated by David Ricardo, and later improved by John Stuart Mill, Cairnes, and Bastable. Bojnec and Fertö [24], in turn, emphasize the importance of export basket diversification in achieving competitive export specialization on global markets. Nowak [25] added that the level of competitiveness significantly depends on the historical path and natural conditions with their determinants, and, also, on how long a particular country is a member of the European Union, which in turn determines the level of support to the agri-food sector from EU funds. Similar ideas, expanded by the influence of ecological aspects, were also discussed by Pishgar-Komleh et al. [26].

Besides to the mentioned literature, a number of recent research papers emphasize the examination of agri-food export and EU trade competitiveness, highlighting the main determinants of selected European countries with different viewpoints [5,27–30], including the geographical/climatical aspects of different areas [31–37], or peculiarities of selected agri-food markets [38–43]. These, and other related publications, offer a lot of ground to cover for authors of future research.

According to Smutka et al. [44], the Czech agri-food trade is continuously concentrating just on the EU Single Market, both in terms of exports and imports. Bojnec and Fertö [45] discovered that among other EU countries, the Czech Republic has got a greater number of products with relative trade disadvantages and a greater significance of one-way imports. Smutka et al. [46] state that the main problems of Czech comparative advantages development in relation to the EU countries are: constantly decreasing volume performance and decreasing unit value, while in relation to the non-EU countries, the relationship between increasing volume and value performance is more balanced, and the comparative advantages are, thus, related to quality aspects and higher added value. According to Fertö et al. [47], a better understanding of how the structure of trade linkages evolves is also important.

For that reason, in our analysis, focused on Czech comparative advantage in agricultural trade with regard to EU-27 countries and its dynamics, we investigate the structure of trade linkages between the Czech Republic and its EU partners employing, as Latruffe [18] suggests, several indicators, concretely RCA, LFI and GL indices, in combination to increase their power and reliability of a research.

2. Materials and Methods

In the analysis of Czech comparative advantage in agri-food trade within the EU the following raw data were used: data on exports and imports in current USD prices were retrieved from UN COMTRADE, data on Employment in agriculture and Consumption of Fixed Capital (Agriculture, Forestry and Fishing) were retrieved from FAOSTAT. Raw data on exports and imports were collected for all the commodity aggregates listed in Table 1.

| Table 1. List of aggregations representing the commodity structure of agricultural trade. |
|----------------------------------------|----------------------------------------|
| S3-00 LIVE ANIMALS | S3-08 ANIMAL FEED STUFF |
| S3-01 MEAT, MEAT PREPARATIONS | S3-09 MISC. EDIBLE PRODUCTS ETC |
| S3-02 DAIRY PRODUCTS, BIRD EGGS | S3-11 BEVERAGES |
| S3-03 FISH, CRUSTACEANS, MOLLUSC | S3-12 TOBACCO, TOBACCO MANUFACT |
| S3-04 CEREALS, CEREAL PREPRTN.S | S3-41 ANIMAL OILS AND FATS |
| S3-05 VEGETABLES AND FRUIT | S3-42 FIXED VEG. FATS AND OILS |
| S3-06 SUGAR, SUGR.PREPTNS, HONEY | S3-43 ANIMAL, VEG. FATS, OILS, NES |
| S3-07 COFFEE, TEA, COCOA, SPICE | |

Source: UN COMTRADE (2012).
Using data on exports and imports within the EU, the LFI, RCA and GL indices were calculated reflecting the position of the Czech Republic in relation to individual EU-27 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom) for the time span 2000–2019.

The competitiveness of individual countries in export of analyzed aggregations was evaluated using the following competitiveness indices.

- **RCA—Revealed Comparative Advantage** [10,48]

  Balassa index was calculated to determine the export specialization as following:

  \[
  \text{RCA}_{ij} = \frac{x_{ij}}{\sum_i x_{ij}} / \frac{\sum_j x_{ij}}{\sum_i \sum_j x_{ij}},
  \]

  where \(X_{ij}\) represents export values of each commodity \(j\) by country \(i\).

  The result \(\text{RCA}_{ij} > 1\) shows that the country possesses a comparative advantage while the result \(\text{RCA}_{ij} < 1\) shows that the country possesses a comparative disadvantage.

- **LFI—Lafay index** [49]

  Lafay index was employed to assess the mutual trade flows as following:

  \[
  \text{LFI} = \left(\frac{x_i - m_i}{x_i + m_i}\right) \times \left(\frac{x_i + m_i}{x_i + m_i}\right)
  \]

  where \(x_i\) is export, \(m_i\) import of product \(j\) in country \(i\) and \(N\) is the number of items.

  The \(\text{LFI}\) positive value shows that the country possesses a comparative advantage while the negative \(\text{LFI}\) value shows that the country possesses a comparative disadvantage.

- **GL—Grubel–Lloyd index** [14,50]

  Grubel–Lloyd index was employed to examine the intra-industry trade in the overall trade as following:

  \[
  \text{GL} = \frac{(X_i + M_i) - |X_i - M_i|}{X_i + M_i} = 1 - \frac{|X_i - M_i|}{X_i + M_i}; 0 \leq \text{GL} \leq 1,
  \]

  where \(X_i\) is export, \(M_i\) import and \(i\) countries.

  The result \(\text{GL} = 1\) indicates a decent level of intra-industry trade, meaning that a country under analysis exports the same quantity of a particular product as it imports. While the result \(\text{GL} = 0\) shows that there is no intra-industry trade, meaning that a country under analysis either exports a particular product or imports it only. This trade is called inter-industry trade.

  In addition to index analysis, logistic regressions were applied as well. Logistic regression analysis, based on the modelling probability of a response variable in terms of explaining variables, was employed to estimate whether developmental trends in gaining a comparative advantage of Czech agricultural trade, in relation to EU-27 partners, appear statistically significant or not, and if there is any substantial effect imposed by foreign production factors.

  The likelihood function for logistic regression model in general notation we want to fit is as follows:

  \[
  \ln L = \sum_{j \in S} w_j \ln F(x_j; b) + \sum_{j \notin S} w_j \ln \{1 - F(x_j; b)\}
  \]

  where \(S\) is the set of all observations \(j\), such that \(y_j \neq 0\), \(F(x) = e^x / (1 + e^x)\) is the predicted probability of a positive outcome (a corresponding index = 1), and \(w_j\) denotes the optional weights. \(\ln L\) is maximized, as described in Stata manual [51]. This maximum likelihood
model has a dichotomous dependent (left-hand-side) variable coded as 0/1, where 1 stands for either \( RCA = 1 \), \( LFI = 1 \) or \( GL = 1 \).

More technical details on usage of logistic functions are given by Aldrich and Nelson [52], Cameron and Trivedi [53], Jones [54], Long [55], Long and Freese [56], Pampel [57], or Powers and Xie [58].

The summary descriptive statistics of all the individual variables used in the present analysis are given below (Table 2).

**Table 2.** Descriptive statistics of the analyzed variables.

| Variables | Obs | Mean       | Std. Dev. | Min   | Max      | p1      | p99     | Skew. | Kurt. |
|-----------|-----|------------|-----------|-------|----------|---------|---------|-------|-------|
| Land      | 1215| 6867.338   | 8137.164  | 9     | 29,807.4 | 9       | 29,807.4| 1.487 | 4.191 |
| Labor     | 1200| 446.641    | 745.788   | 1.843 | 4926.244 | 1.843   | 4926.244| 3.603 | 18.918|
| Capital   | 1215| 2399.798   | 3559.393  | 4.643 | 15,357.89| 4.643   | 15,357.89| 2.294 | 7.543 |
| LFI       | 1188| 0          | 6.432     | −48.551| 45.25    | −24.084 | 22.176  | −0.807| 19.28 |
| RCA       | 1260| 1.159      | 0.324     | 0     | 24.265   | 0       | 11.548  | 4.686 | 33.87 |
| GL        | 1188| 0.331      | 0.324     | 0     | 0.999    | 0       | 0.605   | 1.983 |       |

Source: authors' calculations in Stata 16.

To simplify manipulating with quite a massive volume of data, we selected three equally spaced time periods: 2000, 2010, and 2019.

3. Results

To construct logistic regressions, the LFI, RCA and GL indices, being essentially dichotomous variables, were replaced by 3 corresponding binary variables, where 0 or 1 stands for, in the case of the LFI and RCA indices—the absence or the presence of a comparative advantage, respectively; and in the case of the GL index—the tendency of inter-industry or intra-industry trade, respectively (see Table 3).

**Table 3.** Frequencies of individual binary variables representing corresponding values of LFI, RCA and GL indices.

|       | Freq. | Percent | Valid     | Cum.     |
|-------|-------|---------|-----------|----------|
| LFI   |       |         |           |          |
| Valid 0| 558   | 44.220  | 46.970    | 46.970   |
| 1     | 630   | 49.920  | 53.030    | 100.000  |
| Total | 1188  | 94.140  | 100.000   |          |
| Missing | 72    | 5.860   |           |          |
| Total | 1260  | 100.000 |           |          |

|       | Freq. | Percent | Valid     | Cum.     |
|-------|-------|---------|-----------|----------|
| RCA   |       |         |           |          |
| Valid 0| 837   | 66.430  | 66.430    | 66.430   |
| 1     | 423   | 33.570  | 33.570    | 100.000  |
| Total | 1260  | 100.000 |           |          |

|       | Freq. | Percent | Valid     | Cum.     |
|-------|-------|---------|-----------|----------|
| GL    |       |         |           |          |
| Valid 0| 822   | 65.240  | 69.190    | 69.190   |
| 1     | 366   | 29.050  | 30.810    | 100.000  |
| Total | 1188  | 94.290  | 100.000   |          |
| Missing | 72    | 5.710   |           |          |
| Total | 1260  | 100.000 |           |          |

Source: authors' calculations in Stata 16.

As it can be seen from the above given tables, the frequencies of positive cases (when Czechia has a comparative advantage over individual EU partners), according to the LFI
index and RCA index, are different. The Czech Republic is more competitive if measured by the LFI index. In addition, the prevailing frequencies of 0 values for the Grubel–Lloyd index point to the fact that, during the analyzed period between 2000 and 2019, the Czech Republic was tended to inter-industry trade, rather than intra-industry, which means the Czech Republic tends either to export or import individual aggregates of products only.

In what follows, we will focus on the analysis of the Czech comparative advantage in trade with individual EU countries with selected aggregates of agricultural commodities.

First, we focus on the LFI index. As it can be seen from the Figure 1 given below (Please, note: Numbers 0 to 43 stand for groups of aggregates representing S3-00 to S3-43 categories respectively (see Table 1)), the most radical, and at the same time positive, change in a number of positive Czech LFI indices within the period from 2000 to 2019 was observed for aggregates of the S3-00 group, followed by aggregates of the S3-04, S3-06 and S3-08 groups. The latter have the same proportion between negative and positive values of the LFI index at the end of the analyzed period. However, it should be noted that in the beginning of the analyzed period, i.e., in 2000, the position of the S3-04 aggregate was the worst among these three, because, on average, the Czech Republic had no comparative advantage for products of S3-04 towards its EU partners. Additionally, a positive on average situation at the end of the analyzed period is registered for the S3-09, S3-11 and S3-12 aggregates, and since there was on average no comparative advantage for S3-09 and S3-12 in 2000, it means that the Czech Republic has noticeably strengthened its position for these aggregates, if compared with the rest of the EU partners.

Furthermore, a positive on average situation at the end of the analyzed period is registered for the S3-09, S3-11 and S3-12 aggregates, and since there was on average no comparative advantage for S3-09 and S3-12 in 2000, it means that the Czech Republic has

Figure 1. LFI measured comparative advantage of the Czech Republic in selected groups of aggregates in trade with all EU partners (as per 2000, 2010, and 2019). Source: authors’ calculations and visualization in Stata 16.
noticeably strengthened its position for these aggregates if compared with the rest of the EU partners.

In contrast, for some categories of aggregates the situation has noticeably worsened (again LFI measured), and it mainly refers to the S3-01, S3-43, S3-41 and S3-05 groups of products.

For the S3-07 and S3-42 aggregates, the competitive position of the Czech Republic over the analyzed period has, on average, become slightly better, but for the S3-02 and S3-03 aggregates, the opposite can be said; the overall situation has gradually become worse.

As for the Balassa RCA index (see Figure 2). Please, note: Numbers 0 to 43 stand for groups of aggregates representing S3-00 to S3-43 categories respectively (see Table 1), the number of cases, when the comparative advantage of the Czech Republic over individual EU partners was revealed, appeared much smaller than if measured by the LFI. The situation has substantially improved for Czech trade in the S3-08 and S3-09 aggregates, followed by the S3-06, S3-12 and S3-04 aggregates. For the latter two aggregates, at the beginning of the analyzed period there was, on average, no comparative advantage; however, in 2019, Czech trade with these aggregates became competitive. In what follows, we will focus on a country-specific analysis to identify which EU countries Czechia has managed to gain this comparative advantage. As for trade in S3-02, S3-11 and S3-43, the situation has noticeably worsened. Trade in the S3-01, S3-05 and S3-41 aggregates was, in 2000, and remained in 2019, the weakest among the rest of the aggregates if measured by the RCA index.

We also enriched the picture by the analysis of Grubel–Lloyd index dynamics. From Figure 3 (Please, note: Numbers 0 to 43 stand for groups of aggregates representing S3-00 to S3-43 categories respectively (see Table 1)), it becomes evident that inter-industry flows are more common for Czechia’s trade rather than intra-industry, which means Czechia tends either to export or import individual aggregates of products. In turn, intra-industry
trade is mainly developed for the S3-06, S3-04 and S3-09 aggregates. In addition, the latter commodity group in Czechia has undergone the most rapid reorientation from almost purely inter-industry to mainly intra-industry trade. Again, thanks to EU partners this reorientation became possible, and we will analyze this in what follows.

![Figure 3. GL measured specifics of Czech trade with selected groups of aggregates with all EU partners (as per 2000, 2010, and 2019). Source: authors’ calculation and visualization in Stata 16.](image)

Having analyzed the comparative advantages of Czech trade in individual commodities, the next aspect that is needed to be addressed is the position of the Czech Republic with regard to individual EU countries. This position will be evaluated with the use of the same indices—LFI, RCA and GL.

From the information represented above (see Figure 4). Please, note: Indices were calculated with regard to individual EU-partners for the entire set of traded agricultural commodities, i.e., S3-00, S3-01, S3-02, S3-03, S3-04, S3-05, S3-06, S3-07, S3-08, S3-09, S3-11, S3-12, S3-41, S3-42 and S3-43 aggregates. The two-letter abbreviations used in the Figure stand for Austria (AT), Belgium (BE), BG (Bulgaria), CY (Cyprus), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GB (United Kingdom), GR (Greece), HR (Croatia), HU (Hungary), IE (Ireland), IT (Italy), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (Netherlands), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SK (Slovakia), and SL (Slovenia), we can conclude that the position of the Czech Republic towards different EU countries significantly differs. In addition, the very dynamics of indices, with regard to individual countries, is diverse. The most significant positive change in the LFI values during the period from 2000 to 2019, was observed towards Romania and Greece, followed by Slovenia, Slovakia, Luxembourg, and Bulgaria.
Having, in the beginning of the analyzed period, a comparative disadvantage in trade with France, Denmark, and Spain, at the end of the analyzed period the Czech Republic managed to turn things around, so in 2019, the number of positive LFI values towards these countries prevailed over the negative ones (later on, we will focus on a deeper analysis which will help to identify which aggregates should be thanked for this happening). Dominantly positive values of the Czech LFI through the entire period were also registered for Malta, Latvia, and Portugal. Although having, on average, prevailing positive LFI values, with regard to Cyprus, Estonia, Lithuania, and Portugal, the position of the Czech Republic compared to these countries revealed a declining trend. Lasting negative on average LFI values were registered relative to Germany, Denmark, Great Britain, Hungary, Ireland, Poland, and Sweden. The Czech Republic has, on average, lost its comparative advantage over Finland, Croatia, and Italy (the most dramatical decline).

If we look at the position of the Czech Republic with regard to individual EU partners, in light of the RCA index (see Figure 5. Please, note: Indices were calculated for the entire set of agricultural commodities, i.e., S3-00, S3-01, S3-02, S3-03, S3-04, S3-05, S3-06, S3-07, S3-08, S3-09, S3-11, S3-12, S3-41, S3-42 and S3-43 aggregates. The two-letter abbreviations used in the Figure stand for Austria (AT), Belgium (BE), BG (Bulgaria), CY (Cyprus), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GB (United Kingdom), GR (Greece), HR (Croatia), HU (Hungary), IE (Ireland), IT (Italy), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (Netherlands), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SK (Slovakia), and SL (Slovenia)), we can see that, on average, negative cases (when Czechia has no comparative advantage) prevail over positive ones. Nevertheless, it should be noted that the overall situation has slightly improved from 2000 to 2019. There are three countries in relation to which Czechia has managed to turn things around by 2019 (when the number of cases with RCA > 1 values prevailed over negative ones), they are Bulgaria, Hungary and Slovakia. In what follows, we will do a
deeper analysis to identify which aggregates should be thanked for this becoming possible. On the contrary, with regard to some countries, Czechia, on average, has lost its revealed comparative advantage, these countries are Italy, Finland and Slovenia.

![Figure 5. The position of the Czech Republic (trade in all selected aggregates) in relation to individual EU partners measured with RCA index (as per 2000, 2010, and 2019). Source: authors’ calculations and visualization in Stata 16.](image)

From Figure 6 (please, note: Indices were calculated for the entire set of agricultural commodities, i.e., S3-00, S3-01, S3-02, S3-03, S3-04, S3-05, S3-06, S3-07, S3-08, S3-09, S3-11, S3-12, S3-41, S3-42 and S3-43 aggregates. The two-letter abbreviations used in the Figure stand for Austria (AT), Belgium (BE), BG (Bulgaria), CY (Cyprus), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GB (United Kingdom), GR (Greece), HR (Croatia), HU (Hungary), IE (Ireland), IT (Italy), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (Netherlands), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SK (Slovakia), and SL (Slovenia)), it becomes evident that there was a gradual shift from mainly inter-industry to intra-industry trade between the Czech Republic and individual EU partners. The most significant relative change in the type of trade by 2019 was registered for partners from Hungary, Austria, France, Germany and Great Britain. To verify whether this change/shift was statistically significant or not we constructed a logistic regression, where each estimated coefficient is the expected change in odds ratios of GL~1 (intra-industry trade) for a one-unit change in the corresponding predictor variable, holding all the other regressors unchanged (see Table 4). In addition, similar analysis was done for LFI and RCA indices as well (see Table 5). The results of modeling are provided below.
Figure 6. The position of the Czech Republic (trade in all selected aggregates) in relation to individual EU partners measured with GL index (as per 2000, 2010, and 2019). Source: authors’ calculations and visualization in Stata 16.

Table 4. Change in odds ratios for GL index in a sequence of years.

| Year       | GL Coef. | St.Err. | t-Value | p-Value | [95% Conf Interval] | Sig |
|------------|----------|---------|---------|---------|---------------------|-----|
| 2000       | 1        | .       | .       | .       | .                   | .   |
| 2010       | 1.537    | 0.249   | 2.64    | 0.008   | 1.118 - 2.114       | *** |
| 2019       | 1.834    | 0.293   | 3.80    | 0.000   | 1.342 - 2.508       | *** |
| Constant   | 0.307    | 0.038   | -9.62   | 0.000   | 0.242 - 0.391       | *** |

Mean dependent var: 0.308, SD dependent var: 0.462, Number of obs: 1188, Prob > chi2: 1188.000, Prob > chi2: 0.000, Bayesian crit. (BIC): 1473.305

As we can see, by 2019 the Czech Republic had almost doubled, by 83%, the number of cases (compared to 2000) where its trade with individual EU partners was intra-industry. It means that the Czech Republic exports as many agricultural aggregates as it imports, and this shift from inter-industry trade to intra-industry trade was statistically significant, at a 0.01 significance level, not just for 2019 compared to 2000, but also for 2010 compared to 2000, confirming that this change is not occasional and can be referred to as validated.

It is worth mentioning that the results of logistic regression analysis of the LFI and RCA indices (see Table 5) disclosed another interesting aspect. When the role of the main production factors of Czech partners in the probability of achieving, by the Czech Republic, a comparative advantage measured by positive LFI values was examined as well, it was found that the coefficient upon the consumption of fixed capital appeared the only statistically significant one among the rest factors’ coefficients, at a 0.05 significance level. The coefficients upon Land and Labor are significant at just a 0.10 significance level. Land
and Capital coefficients point to an inverse relationship between them and positive LFI values, which means if an EU partner possesses bigger agricultural land and its agricultural sector consumes more fixed capital, the odds of having, by the Czech Republic, a LFI-measured comparative advantage over this country decreases. The coefficient for Labor points to an opposite result; however, the absolute values of all these coefficients are not high, constituting just fractions of a per cent. In the case of the RCA, all these coefficients are not statistically significant.

### Table 5. Change in odds ratios for LFI and RCA indices in a sequence of years.

|          | Coef. | St.Err. | t-value | p-value | [95% Conf Interval] | Sig |
|----------|-------|---------|---------|---------|---------------------|-----|
| **LFI**  |       |         |         |         |                     |     |
| 2000b.year | 1     | .       | .       | .       | .                   |     |
| 2010.year | 1.226 | 0.189   | 1.32    | 0.188   | 0.905               | 1.660 |
| 2019.year | 1.438 | 0.222   | 2.35    | 0.019   | 1.062               | 1.947 |
| land     | 0.999 | 0.000   | −1.78   | 0.076   | 1                   | 1    |
| labor    | 1.000 | 0.000   | 1.70    | 0.089   | 1                   | 1    |
| capital  | 0.999 | 0.000   | −2.17   | 0.030   | 1                   | 1    |
| Constant | 1.122 | 0.142   | 0.90    | 0.366   | 0.874               | 1.439 |
| Mean dependent var | 0.527 |         |         |         |                     |     |
| Pseudo r-squared | 0.018 |         |         |         |                     |     |
| Chi-square | 28.771 |         |         |         |                     | 1128.000 |
| Akaike crit. (AIC) | 1543.776 |       |         |         |                     | 1573.946 |

|          | Coef. | St.Err. | t-value | p-value | [95% Conf Interval] | Sig |
|----------|-------|---------|---------|---------|---------------------|-----|
| **RCA**  |       |         |         |         |                     |     |
| 2000b.year | 1     | .       | .       | .       | .                   |     |
| 2010.year | 1.446 | 0.230   | 2.32    | 0.020   | 1.059               | 1.974 |
| 2019.year | 1.516 | 0.241   | 2.62    | 0.009   | 1.111               | 2.07  |
| land     | 1.000 | 0.000   | 0.65    | 0.513   | 0.999               | 1.000 |
| labor    | 1.000 | 0.000   | 0.48    | 0.633   | 0.999               | 1.000 |
| capital  | 1.000 | 0.000   | −0.61   | 0.544   | 0.999               | 1.000 |
| Constant | 0.358 | 0.047   | −7.88   | 0.000   | 0.277               | 0.462 |
| Mean dependent var | 0.328 |         |         |         |                     | 0.470 |
| Pseudo r-squared | 0.006 |         |         |         |                     | 1200.000 |
| Chi-square | 8.531 |         |         |         | Probl > chi2        | 0.129 |
| Akaike crit. (AIC) | 1522.650 |         |         |         | Bayesian crit. (BIC) | 1553.190 |

***p < 0.01, **p < 0.05, *p < 0.1. Source: authors' calculation and visualization in Stata 16.

Despite the change in odds of having more positive values of the LFI between 2000 and 2010 not being statistically significant, between 2000 and 2019 it is statistically significant and equals 43.81%, meaning that in 2019 the Czech Republic increased by 43.81%, and the number of cases of its comparative advantage in trade with individual EU countries is revealed. In the case of the RCA index, the change in odds of having RCA > 1 for the Czech Republic in relation to EU partners from 2000 to 2019, being statistically significant for all periods, has also noticeably increased, by 51.63%.

The associations between the intensity of individual factors’ use/availability in EU-27 and the values of the Czech LFI, RCA and GL indices are provided in Figure 7, which complements the results of logistic regressions, provided above. Since these regressions disclosed quite interesting aspects (regarding the role of main production factors of Czech partners, in probability of achieving, by the Czech Republic, a comparative advantage over these countries), it was decided to verify (visually support) these findings using another statistical tool-box plot.
The box plots of the Czech LFI, RCA and GL indices represent their associations with the amount of production factors used by foreign partners, and the impact of production factors on these indices appeared to be different (as it can be seen from Figure 7). Trade with countries richly endowed with agricultural land and capital in most cases is not favorable for the Czech Republic, in terms of having a comparative advantage over them if measured with the LFI index ($LFI < 0$). The amount of a production factor is represented by a horizontal axis. Values on corresponding axes are given in thousands. The dots that are located outside the whiskers of the box plots represent outliers; in our case these dots are associated with missing observations (see Table 3). By comparing the interquartile ranges and whiskers of corresponding box plots, we can see how the data is dispersed between groups of indices. The longer the box of a particular index, the more dispersed the data in terms of production factor volume available for foreign partners. The values of the GL index ($0.5 \leq GL \leq 1$) confirmed that trade with these countries is mostly of an inter-industry character, meaning that the Czech Republic tends to export analyzed agricultural products to these countries as much as it imports from there. The amount of labor force available in individual EU-27 countries seems to play not a significant role in explaining Czech comparative advantage if measured with all indices, since interquartile ranges and whiskers of corresponding box plots are almost the same. In the case of the RCA index, the amount of any production factor of foreign partners makes no difference in explaining Czech comparative advantages.
Now let’s get back to the question we raised before regarding trade in aggregates that allowed the Czech Republic to gain a comparative advantage over France, Denmark and Spain in 2019, compared to the situation in 2000 (LFI measured, see Figure 8) and over Bulgaria, Hungary and Slovakia (RCA measured, see Figure 9).

**Figure 8.** The dynamics of Czech LFI values relative to Denmark, France and Spain, representing their bilateral trade in selected aggregates. Source: authors’ calculations and visualization in Stata 16.

Please, note: numbers 0 to 43 stand for groups of aggregates representing S3-00 to S3-43 categories, respectively (see Table 1). The depicted above results revealed that in the case of Denmark, it was trade in S3-04, S3-07, S3-11, S3-12 and S3-42 (S3-04 and S3-11 played a dominant role), in the case of France, mainly S3-07, followed by S3-09, S3-04, S3-06, and S3-08; in the case of Spain, a dominant position belonged to S3-12, then S3-08, S3-04, and S3-09.

In the next Figure 9, we can see the dynamics of the RCA indices for individual aggregates in relation to Bulgaria, Hungary and Slovakia. Please, note: numbers 0 to 43 stand for groups of aggregates representing S3-00 to S3-43 categories, respectively (see Table 1).

Since the previous analysis disclosed that, namely with regard to these countries, Czechia has managed to gain, on average, relatively more comparative advantages, the Figure provided above allows one to identify the aggregates that made this possible. In the case of Bulgaria, it was trade with S3-00, S3-11, S3-42, and S3-04. In the case of Hungary, it was also S3-00, and then S3-42, S3-43, S3-06, S3-08, S3-11, and S3-12. In case of Slovakia, again it was S3-00 and S3-08, the comparative advantages within the rest of the sectors rather displayed a declining trend.

Since the previously discussed analysis revealed that trade in the S3-00 category is the dominant one for the Czech Republic in terms of a number of positive LFI values and RCA > 1 cases, it makes sense to take a closer look at the composition of countries involved in that trade.
Figure 9. The dynamics of Czech LFI values relative to Bulgaria, Hungary and Slovakia, representing their bilateral trade in selected aggregates. Source: authors’ elaboration in Stata 16.

As it can be seen from Figure 10, thanks to trade in S3-00, the Czech Republic gained the comparative advantage (LFI measured) with regard to almost all EU partners, except for Denmark, Ireland and Sweden. The strongest position has also been attained relative to the following top-3 countries: Slovakia, Austria and Croatia, as per 2019. (Please, note: the two-letter abbreviations used in the Figure stand for Austria (AT), Belgium (BE), BG (Bulgaria), CY (Cyprus), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GB (United Kingdom), GR (Greece), HR (Croatia), HU (Hungary), IE (Ireland), IT (Italy), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (Netherlands), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SK (Slovakia), and SL (Slovenia).)

To complete the picture about the revealed comparative advantage of the Czech Republic based on the analysis of the LFI index, it was decided to enrich it by a similar analysis, already based on another, the Balassa RCA index. The main idea was to compare all the indices in 2019, the last year of the analyzed period, and to identify aggregates for which both indices provide a similar result of a revealed comparative advantage for the Czech Republic, i.e., $\text{LFI} \geq 0 \text{ U RCA} > 1$. Table 6 given below provides the summary results. At the same time, the overall dynamics were traced through the entire analyzed period, so if the total number of positive outcomes for both indices was increasing in the column “Trend” we will see green arrows, and the greater the quantity of arrows the stronger the trend is. Correspondingly, a red arrow indicates a decreasing trend in having the revealed comparative advantage as measured by both indices. A black horizontal arrow stands for almost no change or a relatively stable situation in this field. Column “EU-27” tells if the Czech Republic has got (+) or has not got (-), a revealed comparative advantage in trade with all the countries forming the EU-27 together in 2019.
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Table 6. The dynamics of Czech LFI and RCA indices towards individual EU partners.

| Trend | EU-27 | LFI ≡ RCA | Key Partners in 2019 |
|-------|-------|-----------|----------------------|
| S3-00 | ↑↑    | +         | AT, BE, DE, ES, GR, HR, HU, LT, NL, PL, RO, SL |
| S3-01 | ↓     | -         | 0                    |
| S3-02 | ↓     | +         | BG, DE, HR, IT, LU, SL |
| S3-03 | →     | -         | 1                    |
| S3-04 | →     | +         | AT, BE, BG, DE, DK, EE, ES, FR, GB, HR, HU, IE, PL, PT, RO |
| S3-05 | ↓     | -         | 0                    |
| S3-06 | ↑     | +         | AT, BE, ES, FR, G, GR, HR, IE, LT, LV, NL, PL, PT, RO, SE, SL |
| S3-07 | →     | -         | DK, FR, LT, PL, SE, SK |
| S3-08 | ↑↑↑   | +         | BG, DE, DK, EE, ES, FI, FR, GR, IE, LT, LU, LV, MT, NL, PL, SE, SK |
| S3-09 | ↑     | +         | BG, CY, EE, ES, FR, HU, LT, LU, LV, MT, NL, PT, RO, SK |
| S3-11 | ↓     | -         | DK, EE, HR, LT, LV, PL, SE, SK |
| S3-12 | ↑↑    | +         | BE, CY, DK, ES, FI, GR, IT, LV, MT, NL, PT, SL |
| S3-41 | ↓     | -         | 0                    |
| S3-42 | ↑     | +         | AT, BE, BG, DE, NL, PL |
| S3-43 | ↓↓    | -         | AT, HU, LU |

Source: authors’ elaboration.

4. Discussion

The results of our research show that the revealed comparative advantage, together with the increasing competitiveness of the Czech Republic over the analyzed period from 2000 to 2019, is identified for the following aggregates: S3-00 (live animals), S3-04 (cereals, cereal preprtns.), S3-06 (sugars, sugr. preptns, honey), S3-08 (animal feed stuff), S3-09 (misc.
Similarly, Smutka et al. [44] state that although the Czech Republic does not have ideal conditions for export-oriented agriculture, the country is able to gain comparative advantages, at least at the level of the following aggregations: HS10 (cereals), HS01 (live animals), HS12 (oil seeds/misc. grains/med. plants/straw), HS24 (tobacco substitutes), HS04 (eggs, honey and ed. Products), HS17 (sugars and sugar confectionery), HS15 (animal or vegetable fats, oils and wages), HS11 (milling industry products), HS16 (ed. prep. of meat, fish, crustaceans, etc.), HS22 (beverages, spirits and vinegar), HS03 (fish and crustaceans) and HS13 (lac, gums, resins, etc.). Moreover, Smutka et al. [46] found that even Czech agricultural trade does not have comparative advantages in general. Jambor [59] states that the Czech Republic, similar to the rest of the V4 countries, decreased the comparative advantage in relation to the EU-15 countries after EU accession. The bilateral comparative advantages of Czech agricultural trade with regard to individual EU partners were revealed by Smutka et al. [46] for the following aggregates: CN10 (cereals), CN24 (tobacco and manufactured tobacco substitutes), CN01 (live animals; animal products), CN12 (oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder), CN15 (animal or vegetable fats and oils and their cleavage products; prepare edible fats; animal or vegetable waxes), CN04 (dairy produce; birds’ eggs; natural honey; edible products of animal origin, not elsewhere specified or included), CN22 (beverages, spirits and vinegar), CN11 (products of the milling industry; malt; starches; inulin; wheat gluten), CN17 (sugars and sugar confectionery), CN03 (fish and crustaceans, mollusks and other aquatic invertebrates), CN16 (preparations of meat, of fish or of crustaceans, mollusks or other aquatic invertebrates), CN09 (coffee, tea, maté and spices), CN13 (lac; gums; resins and other vegetable saps and extracts) and CN14. Similarly, according to Burianová and Belová [60], the Czech agri-food trade as one category does not have a comparative advantage in relation to all trade partners, but if the analysis is focused on the individual agri-food trade components’ (aggregations) competitiveness, at least some aggregations are able to get a comparative advantage in relation to the global market.

In addition to the identification of competitive aggregations, the conducted analysis also allowed us to specify over what countries the Czech Republic has managed to achieve a revealed comparative advantage during the analyzed period. For example, both indices, the LFI and RCA, confirmed that Czech trade of the aggregation S3-02 (dairy products, bird eggs) has a comparative advantage over Belgium, Germany, Croatia, Italy, Luxembourg, and Slovenia; however, with a decreasing trend. Nagy and Jambor [22] found that the most competitive countries in terms of export performance with milk and dairy products (Denmark, France, Ireland and Belgium) do not fully align with the order of the largest dairy producing and processing countries (Germany, France, the United Kingdom, and the Netherlands) or the largest dairy exporters (Germany, the Netherlands, France and Belgium). Simo et al. [61] see the key problem of increasing imports of milk and milk products in several EU countries in the conditions of milk market, where the dominant power is based on the economic and legislative nature of production and trade. These unfavorable conditions resulted in a decline of the significant part of cattle breeders by the reduction in the number of cows, followed by the entire agri-food chain which, in the long run, negatively affects the market of milk and milk products and their non-competitiveness.

Among other Czech aggregations in which the competitiveness was gradually declining within the EU-27 market over the 2000–2019 period, we can list S3-11 (beverages) and S3-43 (animal, veg. fats, oils, n.e.s). However, despite this, the Czech Republic still has a comparative advantage over Denmark, Estonia, Croatia, Lithuania, Latvia, Poland, Sweden, and Slovakia in the trade of S3-11, and over Austria, Hungary, and Luxembourg in the trade of S3-43.

The most unfavorable situation was discovered for the S3-01 (meat, meat preparations), S3-05 (vegetables and fruits), and S3-41 (animal oils and fats) aggregates where Czech trade
has no comparative advantage at all (measured with the LFI and RCA together). This finding is in line with Belová et al. [62], asserting that a comparative disadvantage of Czech meat agri-food trade is obvious. They found that only some sub-aggregations (frozen or chilled unprocessed meat) are capable of maintaining comparative advantages, which are, however, characterized by a low level of processing. The Czech Republic achieved comparative advantages in relation to Cyprus, Greece, Italy, Malta and the Netherlands. Contrary, the most significant comparative disadvantage can be seen in relation to Poland, Hungary, Romania and France. Bojnec and Fertó [24] state that except for some niche meat products, a large number of the EU member states have been experiencing comparative disadvantages on global markets.

On the other hand, it is worth mentioning that in some aggregations, Czech trade appeared quite successful. The conducted analysis revealed an ever-increasing trend in achieving competitiveness over more and more EU countries by the following aggregates: S3-08 (animal feed stuff), S3-00 (live animals), S3-12 (tobacco, tobacco manufacturing), and S3-06 (sugar, sugar preparations, honey). The lists of these countries as per 2019 can be seen in Table 6.

5. Conclusions

The comprehensive examination of Czech comparative advantages in agricultural trade within the EU-27 was, in the present study, based on a combination of special indicators, concretely the RCA, LFI and GL indices that allowed the identifying of the strongest and weakest groups of commodities, along with a type of a corresponding trade (intra- vs. inter-industry one). In addition, the dynamics of the Czech comparative advantage/disadvantage in individual aggregates in relation to individual EU partners was tracked to understand the ongoing tendencies. To simplify manipulating with quite a massive volume of data, we selected three equally spaced time periods: 2000, 2010, and 2019.

Nowak et al. [5] identified a clear difference in agri-food trade and its competitiveness between new and old EU member states regarding the agricultural sector’s competitiveness. The group of countries with a highly competitive agriculture consisted of “old” EU countries, while all “new” member states of the European Union were classified as countries with a low agricultural competitiveness level. Their research shows that although most new member states have been members of the EU for more than ten years, none of them improved its competitiveness to an extent allowing the reclassification to the group of countries with a highly competitive agriculture. Considering the factors that, to the largest extent, determined the classification of countries to a specific group, Nowak et al. [5] recommend that the Common Agricultural Policy should be oriented towards boosting the dynamics of structural changes in the agriculture of many “new” member states. According to Jambor and Babu [1], the Netherlands (NL), Spain (ES) and Denmark (DK) can be considered as the most competitive nations in global agriculture and food trade. At the same time, the present research revealed that even with regard to these leading agri-food trade countries, the Czech Republic has managed to achieve a comparative advantage, which was thanks to the following aggregates: S3-00, S3-06 and S3-09 (with regard to ES and NL); S3-07, S3-11 (DK); S3-08, S3-12 (DK, ES, NL); S3-04 (DK, ES), and S3-42 (NL).

Moreover, the position of Poland in EU agri-food trade, as the closest Czech partner, should not be overseen. According to Lizinska et al. [63], the role of the Polish agri-food sector in the Polish economy is becoming stronger. According to Firlej et al. [64], the Polish food industry has a comparative advantage on international markets. The competitiveness of the Polish food industry is determined by relatively lower prices and costs of production. Besides this, an innovative character was identified as one of the key attributes describing enterprises of the food industry in Poland, which implemented both technological and non-technological innovations. Namely, this aspect, probably, explains why the Czech Republic appeared competitive over Poland just in the commodity groups, with a low or relatively low level of processing (live animals, animal feed stuff, cereals, etc.). The same,
obviously, can be said about the Czech comparative advantage over Belgium, Spain, and the Netherlands.

The results of logistic regression analysis confirmed this finding. The latter was focused on estimating the effect of main production factors, available in individual EU-27 countries, on the probability of achieving, by the Czech Republic, a comparative advantage over these countries. Coefficients on capital pointed to an inverse relationship between the amount of consumed fixed capital and positive LFI values, which means if the agricultural sector of an EU partner consumes more fixed capital, the odds of having, by the Czech Republic, an LFI-measured comparative advantage over this country decreases. The same finding is also valid for another production factor—land.

In addition, the prevailing frequencies of 0 values for Grubel–Lloyd index point to the fact that, during the analyzed period between 2000 and 2019, the Czech Republic tended to inter-industry trade, rather than intra-industry, which means the Czech Republic tended either to export or import individual aggregates of products only.

If we consider the situation in general, the Czech Republic has managed to increase the number of cases (both in terms of extra aggregates and in relation to additional partners) when its trade has a revealed comparative advantage, from 2000 to 2019, of approximately 50% (by 43.81% if measured with the LFI, and by 51.63% if measured with the RCA). These positive changes also appeared to be statistically significant.

Since the conducted analysis revealed that some key, in terms of food security, Czech agricultural aggregates appeared not to have any comparative advantages (S3-01-meat, meat preparations, S3-05-vegetables and fruits, and S3-41-animal oils and fats), considering the issue of achieving and maintaining food security at the national level, this fact should be studied in more detail to understand the underlying reasons and to suggest possible solutions. In this regard, Input–Output analysis of Global Value Chains can be seen as a useful tool for answering the question of where most of the value added is absorbed when producing this type of goods. Additionally, it may help to identify key partners that take part in the production processes of both intermediate and final goods, determine what is their role, and answer the question of why the same activities cannot be organized domestically. At the same time, some limitations are worth being mentioned: The World Input–Output Database (WIOD), that offers data exactly for such type of analysis, released a series of the latest World Input–Output Tables in November 2016 which covers 28 EU countries and 15 other major countries in the world for the period from 2000 just to 2014 [65]. However, we do hope that similar sources of more recent data for Input–Output analysis may exist elsewhere. Another direction of future research that may contribute to a better comprehension of peculiarities in agricultural trade within the EU-27 is investigating similar issues but with regard to the EU’s Eastern Partnership countries, including the Ukraine [34] and Russia. Trade with these countries predictably can noticeably draw resources involved in agricultural production of the EU, both intermediate and final.

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