
PATTERNS OF AGRI-FOOD INTRA-INDUSTRY TRADE BETWEEN CZECHIA AND EU MEMBER STATES: TWO DECADES OF THE EU MEMBERSHIP

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ABSTRACT

The article assesses the dynamic of Czechia's agri-food intra-industry trade (IIT) with other EU countries. Methods such as Grubel-Lloyd index, Greenaway, Hine and Milner method, and Fontagné and Freudenberg method were applied using EUROSTAT bilateral trade data at 6-digit HS code from 1999 to 2022. Although the inter-industry trade still prevails in the structure of Czechia's agri-food trade, the IIT intensity has increased. Nonetheless, the increase started to slow down and stopped in the last decade. The IIT is mostly vertical in nature and significant variations across specific agri-food sectors exist. Increased intensity of IIT indicates potentially positive welfare effects when compared to inter-industry trade and advocates the integration into the economic structures of the Single European Market. Findings inform policymakers in countries aspiring to EU membership when assessing the potential nature of the trade dynamic during participation in the Single European Market.

Introduction

The accession of Czechia into the EU in 2004 meant liberalization of agri-food (A-F) trade with former and new Member States, as well as further unification of the institutional framework by the adoption of, e.g., Common Trade and Agriculture policies. These changes led to an increase in the value and volume of A-F trade between Czechia and other EU Member States. The A-F trade in the region has increased and the share of EU countries in the territorial shape of Czechia's A-F trade has grown to about 90% (Smutka et al., 2018; Kuzmenko et al., 2022; Zdráhal et al., 2024).

Multiple studies (Burianová, 2010; Smutka et al., 2012; Svatoš and Smutka, 2012; Bielik et al., 2013; Smutka et al., 2018; Bajan et al., 2021; Kuzmenko et al., 2022; Rumankova et al., 2022; Vondráček et al., 2022) assessed the nature and competitiveness of the

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Czechia's A-F trade using the traditional Ricardian approach that predicts trade as inter-industrial. Inter-industry trade means trade flows between two countries are expected to be according to the comparative advantages of industries and with complementary goods with differing factor intensities. These studies analysed competitiveness from different vantage points. Among others, Burianová et al. (2010) studied the competitiveness and commodity structure of A-F trade after Czechia acceded to the EU using revealed comparative advantage methodology (2004 to 2008). They found Czechia to be most competitive in milk, sugar and sweets, oilseeds, and cereals. Study of Smutka et al. (2016) concluded that Czechia reveals comparative advantages in cereals, live animals, oilseeds, tobacco, dairy, sugar, animal and vegetable fats, and beverages.

There are several reasons for intensively studying the intra-industry trade (IIT) in A-F trade. Intra industry trade is simultaneous exports and imports within industries between countries of similar development levels and was one of the most important empirical finding of the 1960s concerning international trade (Fontagné et al., 2006).

Traditional trade theory assumes constant returns to scale, a homogeneous product, and perfect competition. However, fundamental changes in the business environment in A-F value chains limit the applicability of these models as these general assumptions may no longer fully correspond to the reality of current food systems where product differentiation, economies of scale, and imperfect market structures have taken place (Reardon et al. 2003; Henderson and Isaac, 2017). The theoretical IIT models emphasize the existence of product differentiation, economies of scale, and imperfect market structures as major factors determining IIT. This is probably a reason why until recently most IIT studies have not paid much attention to the A-F trade. There is also general agreement that the activities of multinational companies and global value chains had a significant influence on the trade dynamic in recent years (Gereffi, 2014), even in the A-F trade segment (De Backer and Miroudot, 2013). This provides another reason to study IIT because the fragmentation of production and multinational companies organizing regional and global A-F value chains were identified as one of the drivers behind the dynamic of IIT (Falvey and Kierzkowski, 1987; Jones and Kierzkowski, 1990).

Last, but not least, it is two decades since the Czech Republic became an EU member State in 2004 and started fully participating in the Single European Market. Existing studies of IIT proposed a positive relationship between the process of economic integration in the EU and IIT's appearance. This has important implications because the increasing intensity of IIT leads to the positive welfare effects of economic integration because of the smaller social costs of IIT when compared to the social costs of structural changes stimulated by inter-industry specialization (Brühlhart and Elliot, 1998; Cabral and Silva, 2006).

Against this backdrop, the article aims to assess the dynamic of Czechia's agri-food intra-industry trade and reveals the country's A-F IIT patterns with other EU countries during the participation in the Single European Market in the last two decades of Czechia's EU membership.

Although Czechia has already been included in some comparative studies on IIT (e.g. Jambor 2014; Łapińska, 2014; Ferto and Jambor, 2015; Jambor and Leitao, 2016), this article expands these analyses in terms of time coverage and details.

Theoretical background

Traditional economic theory explains ongoing trade between countries based on the theory of comparative advantages (so-called inter-industry trade). On the other hand, IIT is simultaneous exports and imports within industries between countries of similar development levels and was one of the most important empirical findings of the 1960s concerning international trade (Fontagné et al., 2006). Empirical studies have shown that IIT has been a phenomenon of growing importance in the structure of international trade (McCorrison and Sheldon, 1991; Fontagné et al., 2006; Krugman et al. 2012) and has been expanding also in the segment of A-F trade (e.g. Bojnec, 2001; Ferto, 2015; Jambor and Leitão, 2016; Benešová et al. 2020).

While some authors expressed doubt that IIT exists because of its inconsistency with predictions of the Hechsher-Ohlin model, further shifts in trade theories started to develop theoretical explanations for trade in similar goods (e.g. Lancaster, 1980; Krugman, 1979, 1980, 1991; Brander, 1981; Shaked and Sutton, 1984; Helpman and Krugman, 1985; Falvey and Kierzkowski, 1987; Jones and Kierzkowski, 1990, 2000; Lüthje, 2001). When compared to the Hecksher-Ohlin model, this new stream of trade theories indicates that the determinants behind IIT are product differentiation, economies of scale, imperfect market structures and the fragmentation of production process, and activities and sourcing strategies of multinational companies.

The existence of IIT is important because of its welfare implications. Traditional inter-industry trade stimulates specialization of a country's economic structure as predicted by the theory of comparative advantage. In other words, it is a process of specialization (for) those industries that reveal comparative advantages. Such a structural change involves significant adjustment costs of adaptation. The proponents of the so-called smooth adjustment hypothesis (Brülhart and Elliott, 1998; Cabral and Silva, 2006) suggest that IIT stimulates specialization, but inside the industry, not among industries. Thus, subsequent changes do not attract similar social costs as in the case of inter-industry specialization and trade.

Materials and methods

Various methods exist to measure the intensity of intra-industry trade (IIT). A classic method of identifying intra-industry trade is a group of indicators based on the Ballasa index (Ballasa, 1965). Among these indicators, the most used is Grubel-Lloyd index (GL). The GL is defined as follows (Grubel and Lloyd, 1975):

$$GL_i = 1 - \frac{|EX_i - IM_i|}{(EX_i + IM_i)} \quad (1)$$

where i is an industry, j is a year, EX_i (IM_i) is the export (import) value of a particular country. The GL index indicates the share of IIT in total trade and its calculation is based on a decomposition of total trade in trade overlaps (representing intra-industry trade) and the imbalance (inter-industry trade). The flows related to inter-industry trade are explained by traditional (Ricardian) trade theory, whereas intra-industry trade is explained by the new international trade theory (Fontagné and Freudenberg, 1997). The index can range between 0 (only inter-industry trade) and 1 (only intra-industry trade). The index can also be aggregated to the level of sectors and countries:

$$GL = \sum_{i=1}^n GL_{ij} \times w_{ij} \quad \text{where} \quad w_i = \frac{(X_i + M_i)}{\sum_{i=1}^n (X_i + M_i)} \quad (2)$$

where w_i represents the share of industry i in the country's total trade for the given product group.

The GL index has been extensively used despite continued criticism of both of its theoretical and empirical aspects. One of the reasons is a distortion in the event of a trade imbalance. As the imbalance increases, a higher share of inter-industry trade is reported and thus the share of IIT drops. The GL index also causes an analytical-interpretive problem. Even if the trade flow decomposition is done, there is still the possibility of two different theoretical explanations (traditional trade theory or new international economics) for the same trade flow (Fontagné and Freudenberg, 1997). Also, the Grubel-Lloyd index allows distinguishing between horizontal and vertical IIT. Modified indices were proposed (e.g. Aquino, 1978) to overcome some of the problems. Nonetheless, resorting to the GL index while the alternative indices are available, implies that alternatives to GL index are probably still far from satisfactory.

An alternative methodology was introduced by Abd-El-Rahman (1986) and refined by Fontagné and Freudenberg (Fontagné and Freudenberg, 1997; FF method) for inter- and intra-industry trade analysis. This methodology is based on the comparison of minority and majority trade flows. The trade flow is defined either as intra-industry (two-way trade) trade if the value of the minority trade flow represents at least a certain share of the majority trade flow; or is defined as inter-industry (one-way trade) trade, if the minority flow represents a lower share of the majority flow. A benchmark value (a share of a minority in the majority flow value) of 10% or 15% is typically chosen arbitrarily. The formal notation is as follows:

$$\frac{\min(EX_{p,s}, IM_{p,s})}{\max(EX_{p,s}, IM_{p,s})} > \gamma\%, \quad \text{where } \gamma = 0.1 \text{ or } 0.15 \quad (3)$$

If the value of the minority flow compared to the value of the majority flow is below this threshold, the trade exchange (export and import) is classified as inter-industry. If it is greater, it is classified as intra-industry (Fontagné and Freudenberg, 1997).

Both the GL and FF methodologies are sensitive to product and geographical aggregation bias. IIT is sensitive to the choice of product aggregation and may thus suffer from aggregate/sectoral bias (Fontagné and Freudenberg, 1997). The more products are grouped together, the more intensive IIT will be identified. If calculations are not performed at the bilateral level, the intensity of IIT may be overestimated. The IIT is typically analyzed from trade data at the 4–6-digit HS numeric code or 3-5 digit SITC code level. A study by Finger (1975) suggested that the occurrence of IIT is normal because the existing classifications place goods of heterogeneous factor endowments in a single group. However, the evidence shows that intra-industry trade still occurs even when industries are highly disaggregated. Nonetheless to deal with Finger's (Finger, 1975) argument 6-digit HS numeric codes are used in this article. The IIT was also calculated using 5-digit SITC code level to check the robustness of the results. The analysis of trade patterns is conducted on a strictly bilateral basis (between Czechia and each EU28 member state) to avoid geographical bias.

Unit prices of products are used (Abd-el-Rahman, 1991) to distinguish between horizontal and vertical IIT trade (and thus assess the quality of traded products). The initial idea is the assumption that relative prices should reflect the relative quality of products (Stiglitz, 1987). Horizontal IIT (HIIT) is therefore a trade with horizontally differentiated products, i.e. homogeneous products (perfect substitutes) of the same quality. Vertical IIT (VIIT) is then traded with vertically differentiated products with different prices that reflect different quality (Falvey, 1981).

However, several authors point out that unit prices may not fully reflect differences in product quality (e.g., Crespo and Fontoura, 2004). The procedure for the separation of horizontal and vertical IIT was proposed by Greenaway, et al. (1994, 1995). Later the procedure was modified (Azhar and Elliott, 2006) to gain symmetrical form. IIT is considered horizontal if the following criterion of the ratio of unit prices (UV) of exports and imports is met. Otherwise, it is a vertical IIT. The procedure was further advanced by Blanes and Martin (2000) to do the decomposition of VIIT to high and low VIIT. Formally:

$$\frac{1}{1+\alpha} \leq \frac{UV^{ex}}{UV^{im}} \leq 1 + \alpha \quad (4)$$

Where UV is the unit price of the traded product. In the literature, the α is typically set as 15% or 25% (arbitrarily) to distinguish horizontal and vertical (low and high) product differentiation. A threshold of 15% is considered sufficient if differences in unit price correspond only to differences in quality (assuming perfect information). In a situation of imperfect information, the threshold of 15% would be too narrow and it would be more appropriate to set it at the level of 25%. However, setting this threshold value is arbitrary. A threshold of 25% is recommended for trade analysis of developing countries. We assume that a threshold of 15% should be appropriate because the EU's single market area and the integration of institutions and rules limit situations of imperfect information. However, we perform a sensitivity analysis to assess the robustness of the results.

The specific procedure for distinguishing horizontal and vertical (low and high) IIT depends on the applied method. One alternative is the Greenaway, Hine and Milner method (Greenaway et al, 1994, 1995; GHM) and is based on the decomposition of the Grubel-Lloyd index. Formally:

$$GHM_k^p = \frac{\sum_i [(EX_{i,k}^p + IM_{i,k}^p) - |EX_{i,k}^p - IM_{i,k}^p|]}{\sum_i (EX_{i,k} + IM_{i,k})} \quad (5)$$

where p is either a horizontal or vertical (low, high) trade type, i is a product group/industry ($i=1, \dots, n$) and k is a trading partner. Another alternative is the procedure suggested by Fontagné and Freudenberg (1997). Formally:

$$FF_k^p = \frac{\sum_i ((EX_{i,k}^p + IM_{i,k}^p))}{(EX_{i,k} + IM_{i,k})} \quad (6)$$

The FF index is rather complementary than substitutive of the GHM. The FF index inclines to reach higher values than the GHM, and the values of the GHM index are typically between the values of the GL index and the FF index (Fontagné and Freudenberg, 1997).

The analysis of the dynamic of Czechia's A-F IIT with other EU countries is using bilateral trade data from EUROSTAT database (EUROSTAT, 2024) at 6-digit HS numeric codes in the period 1999-2022. The nominal values of the trade flows are in current prices in EUR.

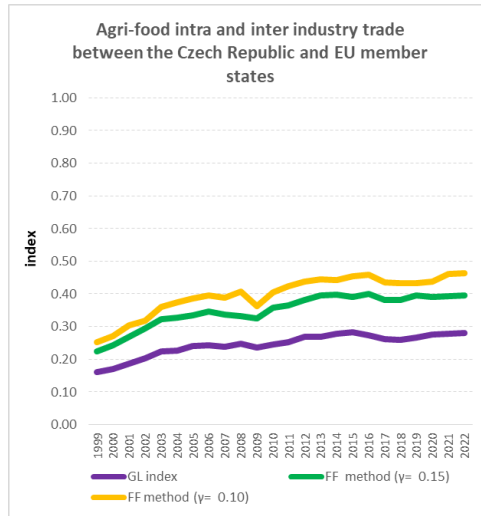
Results

Intensity and forms of A-F IIT

Although, with variations across methods (Figure 1), the inter-industry trade still prevails in the structure of the A-F trade between Czechia and EU Member States. Nonetheless, the intensity of the A-F IIT increased between 1999 and 2022. The figure (Figure 1) shows an increase in FF and GL indices indicating an increasing share of IIT in the structure of the A-F trade between Czechia and other EU Member States (while simultaneously a decreasing share of inter-industry trade). The analysis revealed two different trajectories in the dynamics of the A-F IIT intensity. First, scores of GL and FF ($\gamma=0.10$ and $\gamma=0.15$) indices suggest an increased intensity in Czechia's A-F IIT with other EU Member States even before 2004. This corresponds with the process of partial and gradual liberalization of the A-F markets even before Czechia joined the EU and the EU common market. This increase in the intensity of IIT continued after Czechia acceded to the EU, until around 2014. The results also suggest that the Great Recession didn't significantly influence the trend of increasing intensity of IIT. This is consistent with findings of existing empirical studies concluding that the intensity of A-F IIT in new EU Member States has increased in the new millennium following the liberalization at the global and regional level and the integration of the region into

the structures of the EU (e.g. Łapińska, 2014; Jámboř, 2015; Jámboř et al., 2016). Second, from about 2014 to the end of the period under review, the increase in the intensity essentially stalled. In other words, the proportion of IIT in the structure of Czechia's A-F trade with other EU Member States has remained static. The outbreak of COVID-19 and the subsequent policy restrictive measures did not seem to influence this A-F IIT trajectory significantly.

Figure 1. Disentangling the A-F intra and inter-industry trade between Czechia and other EU member states; GL and FF indices; 1999-2022

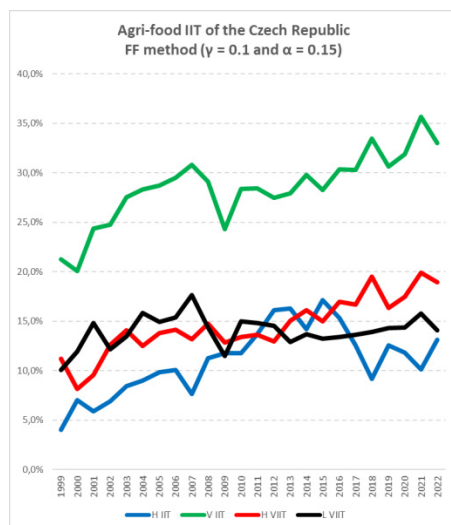


Source: Own calculation and construction based on data retrieved from EUROSTAT (2024)

Next, the IIT was decomposed into its horizontal and (high and low) vertical components, applying both Fontagné and Freudenberg (FF) method and the Greenway, Hine and Milner (GHM) method (Figure 2).

Both methods rely on the same assumption regarding the association of price, unit values, and the quality of traded products. The difference is that the GHM method further decomposes the GL index, while the FF method categorizes trade flows and computes the share of each category in total trade. The results suggest that Czechia's A-F IIT mostly consists of vertical IIT. The increased intensity of the A-F IIT in the structure of Czechia's A-F trade was due to the growth of both horizontally and vertically differentiated A-F products; however, the intensity of vertical IIT reached almost double the share when compared to the share of horizontal IIT (depending on the methods and parameters). The intensity of the vertical IIT increased throughout the period under review, indicating the exchange of products of different quality and revealing the specialization process taking place along the quality spectrum. The intensity of horizontal IIT started to decrease and stagnate in the second half of the period under scrutiny.

Figure 2. Disentangling horizontal and (high and low) vertical IIT of Czechia with other EU member states using FF and GHM methodologies, 1999-2022



Source: Own calculation based on EUROSTAT (2024)

Note: H IIT – horizontal IIT, V IIT – vertical IIT, H VIIT – high vertical IIT, L VIIT – low vertical IIT

The vertical IIT was further disentangled into high- and low-quality categories, using the method of Blanes and Martin (2000). The results revealed that high-quality A-F IIT started to prevail in the last decade. In other words, within bilateral two-way A-F flows with other EU Member States, Czechia exported higher quality A-F products than it imported lower quality ones. More in detail, despite both low and high vertical IIT showed similar shares in the structure of A-F trade and shares of both forms were slightly increasing during the first half of the period under scrutiny, in the second half of the period the low vertical IIT started to stagnate and the high vertical IIT continued to grow.

Other structural characteristics of IIT and sensitivity analysis

Results show that the minority trade overlaps are more and more represented as a structural feature of Czechia's A-F trade. The trade flows are defined either as IIT (two-way trade) trade (the value of the minority trade flow represents at least a certain share of the majority trade flow) or as inter-industry (one-way trade) trade (minority flow represents a lower share of the majority flow) in FF methodology. The table (table 1) presents the share of two-way trade (IIT) and one-way trade (inter-industry) flows in the total A-F trade between the Czech and other EU Member States, according to the degree of overlap (the minority flow as a percentage of the majority flow) used in FF methodology and calculated at the 6-digit HS level.

The data shows that cases of extreme overlap between Czechia's A-F exports and imports are rare. For example, less than 4% of A-F bilateral trade between Czechia

and other EU member states has an overlap of more than 90% through the period under review. On the other hand, 30.2% of Czechia's A-F trade with other EU Member States was, in a strict sense, one-way (inter-industry) during 1999 (i.e. exports with no corresponding imports, and vice versa). In 2022, the one-way trade contributed only 10.3% to Czechia's A-F trade. The overlap of more than 10% represented about 25.3% of Czechia's A-F trade in 1999 and about 46.2% of A-F trade in 2022.

Existing IIT empirical studies (Greenaway et al., 1995; Ferto and Jambor, 2015) propose that the choice of γ is arbitrary and the results for a threshold of 0.1 or 0.2 are the same or very similar. While results for $\gamma=0.1$ and $\gamma=0.2$ were about the same at the beginning of the period under review, results for both γ differ by about 7 percentage points at the end of the period.

Table 1. FF method - sensitivity of IIT depending on the degree of overlap (γ) between export and import - 1999, 2011, 2022

Degree of trade overlap (%)	1999		2011		2022	
	TWT (%)	OWT (%)	TWT (%)	OWT (%)	TWT (%)	OWT (%)
95	1.1	98.9	1.5	98.5	1.7	98.3
90	3.0	97.0	2.5	97.5	3.7	96.3
85	3.2	96.8	3.7	96.3	4.8	95.2
80	3.8	96.2	4.3	95.7	6.2	93.8
75	4.2	95.8	5.5	94.5	7.0	93.0
70	5.4	94.6	6.8	93.2	8.2	91.8
65	6.0	94.0	8.8	91.2	11.4	88.6
60	7.4	92.6	10.6	89.4	13.5	86.5
55	8.0	92.0	11.4	88.6	15.9	84.1
50	8.5	91.5	14.2	85.8	17.8	82.2
45	9.0	91.0	16.8	83.2	20.1	79.9
40	13.3	86.7	19.8	80.2	23.3	76.7
35	14.2	85.8	21.9	78.1	25.7	74.3
30	16.5	83.5	25.5	74.5	27.6	72.4
25	19.0	81.0	27.8	72.2	30.6	69.4
20	20.5	79.5	31.6	68.4	35.4	64.6
15	22.4	77.6	36.4	63.6	39.6	60.4
10	25.3	74.7	42.4	57.6	46.2	53.8
5	30.2	69.8	50.8	49.2	53.8	46.2
0	30.2	69.8	13.2	86.8	10.3	89.7

Source: Own calculation based on EUROSTAT (2023)

Note: TWT – two-way trade, OWT – one way trade

Similarly, the choice of α also matters (Table 2), although literature proposes that $\alpha=15$ or $\alpha=20$ should provide similar results. However, the sensitivity analysis of the relative importance of horizontal and vertical two-way trade (Table 2) shows the difference to be 15.9 percentage points in 1999 and 11.3 percentage points in 2022 when using $\alpha=15\%$ and $\alpha=20\%$, respectively. The sensitivity analysis revealed that the results are slightly sensitive to the choice of the threshold values. Figure A1 (in the Appendix) shows that a higher value of α leads to a decrease in the level of identified IIT and to an increase in inter-industry trade.

Table 2: FF method - sensitivity of relative importance of horizontal and vertical two-way trade in total IIT, 1999, 2011, 2022

Unit value threshold α (%)	1999		2011		2022	
	TWTH (%)	TWTV (%)	TWTH (%)	TWTV (%)	TWTH (%)	TWTV (%)
95	82.8	17.2	84.3	15.7	82.4	17.6
90	82.3	17.7	82.5	17.5	80.9	19.1
85	82.0	18.0	82.3	17.7	77.7	22.3
80	80.3	19.7	81.8	18.2	74.7	25.3
75	78.8	21.2	79.6	20.4	74.0	26.0
70	75.6	24.4	76.1	23.9	72.0	28.0
65	72.2	27.8	73.3	26.7	69.5	30.5
60	70.1	29.9	70.6	29.4	67.0	33.0
55	68.5	31.5	66.6	33.4	61.7	38.3
50	61.9	38.1	65.0	35.0	59.5	40.5
45	60.4	39.6	62.4	37.6	56.9	43.1
40	58.0	42.0	56.6	43.4	55.1	44.9
35	53.3	46.7	52.4	47.6	52.9	47.1
30	48.5	51.5	46.4	53.6	47.9	52.1
25	26.9	73.1	42.4	57.6	39.9	60.1
20	22.0	78.0	36.8	63.2	35.1	64.9
15	15.9	84.1	32.5	67.5	28.6	71.4
10	10.7	89.3	21.5	78.5	20.7	79.3
5	4.1	95.9	11.9	88.1	11.7	88.3

Source: Own calculation based on EUROSTAT (2023)

Sectoral analysis of IIT

The scores of FF and GL indices of the A-F IIT were analyzed on the sectoral level between Czechia and other EU Member States (Table 3). Sectors are described in the table in the Appendix (Table A1). The consistency test (Balance, 1987) of the indices as ordinal categories (cross-sector ranking) and calculated rank correlation coefficients for each pairing of both indices (FF and GL) revealed a high level of correlation (0.925), suggesting that FF and GL scores are highly consistent giving similar rankings of sectors regarding the intensity of IIT in a particular year. Therefore, we present here only the results for one method (the FF method).

The results suggest that the intensity of A-F IIT between Czechia and other EU Member States in particular sectors differ (on average over the period under scrutiny) from 0.107 (FF) HS03 to 0.697 (FF) HS18. Using FF scores, sectors such as HS05, HS09, HS17, HS18, HS19, and HS21 revealed FF scores higher than 0.5. This means that the IIT makes up more than half of the trade turnover of these sectors between Czechia and other EU Member States. On the other hand, sectors such as HS01, HS03, HS07, HS08, and HS10 revealed FF scores lower than 0.2 and inter-industry trade prevails in these sectors.

Table 3. Intensity of IIT for product groups (HS 2-digit) between Czechia and other EU member states, results of FF method ($\gamma = 0.1$; $\alpha = 0.15$) and GL method, index, selected years

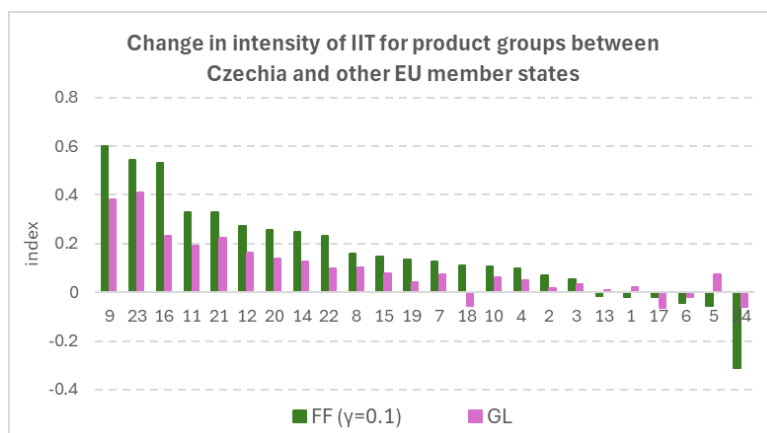
	FF ($\gamma=0.1$)				GL			
	average				average			
	1999-2022	1999-2002	2009-2012	2019-2022	1999-2022	1999-2002	2009-2012	2019-2022
1	0.189	0.158	0.183	0.14	0.1	0.074	0.111	0.093
2	0.208	0.126	0.232	0.195	0.124	0.088	0.145	0.105
3	0.107	0.023	0.168	0.078	0.062	0.023	0.074	0.055
4	0.415	0.318	0.391	0.416	0.264	0.219	0.263	0.267
5	0.642	0.643	0.667	0.587	0.367	0.269	0.408	0.343
6	0.218	0.217	0.217	0.173	0.107	0.119	0.094	0.099
7	0.199	0.097	0.226	0.225	0.12	0.06	0.127	0.134
8	0.189	0.052	0.2	0.21	0.125	0.035	0.137	0.136
9	0.579	0.166	0.6	0.765	0.368	0.12	0.364	0.503
10	0.136	0.04	0.168	0.147	0.091	0.037	0.112	0.097
11	0.255	0.056	0.259	0.386	0.154	0.04	0.148	0.231
12	0.387	0.208	0.48	0.48	0.234	0.113	0.344	0.275
13	0.402	0.384	0.404	0.369	0.237	0.198	0.245	0.206
14	0.368	0.256	0.299	0.505	0.197	0.1	0.212	0.228
15	0.368	0.244	0.368	0.389	0.23	0.15	0.224	0.229
16	0.359	0.028	0.44	0.558	0.181	0.021	0.218	0.251
17	0.629	0.611	0.672	0.592	0.408	0.422	0.442	0.358
18	0.697	0.61	0.719	0.719	0.447	0.456	0.473	0.398
19	0.657	0.597	0.61	0.731	0.363	0.357	0.337	0.397
20	0.343	0.21	0.352	0.467	0.215	0.142	0.213	0.28
21	0.687	0.467	0.744	0.794	0.43	0.303	0.458	0.525
22	0.431	0.266	0.503	0.498	0.26	0.167	0.294	0.266
23	0.349	0.06	0.358	0.605	0.24	0.041	0.226	0.452
24	0.286	0.538	0.261	0.225	0.154	0.228	0.131	0.166

Source: Own calculation based on EUROSTAT (2024)

Note: blue color indicates low scores and red color indicates high scores

In the first half of the period (when the intensity of A-F IIT increased at the national level) the intensity of IIT increased in most sectors (except for HS06, HS13, and HS 24) in the A-F trade between Czechia and EU Member States. In the second half of the period under scrutiny (when the intensity of A-F IIT started to stagnate at the national level) most of the sectors slightly decreased the intensity of IIT or slowed down the increase in intensity except for HS14 and HS19. At the end of the period, 9 out of 24 sectors revealed an FF score higher than 0.5. Some sectors as HS09 and HS21 revealed FF scores even higher than 0.75 (prevailing strong intra-industry trade).

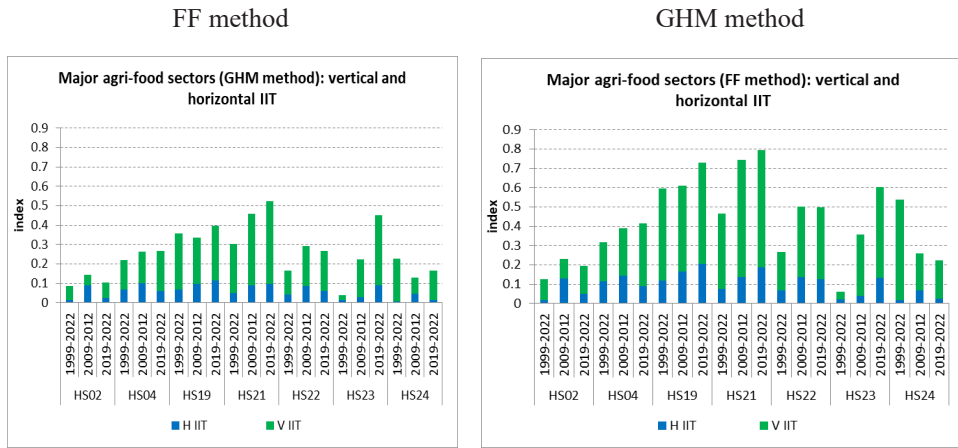
Figure 3. Change in intensity of IIT for product groups (HS 2-digit) between Czechia and other EU member states, results of FF method ($\gamma = 0.1$; $\alpha=0.15$) and GL method, index, selected years



Source: Own calculation based on EUROSTAT (2024)

The trade flows of major sectors were decomposed into horizontal and vertical IIT components (figure 4). Seven major sectors in Czechia's A-F trade with other EU Member States are HS04, HS23, HS21, HS02, HS19, HS22, and HS24 were contributing to 53.4% of the overall Czech Republic's A-F trade turnover with other EU Member States in 2022. These sectors revealed mixed characteristics regarding the change in IIT's intensity and composition when comparing the beginning and the end of the period under scrutiny. Both horizontal as well as vertical IIT have significantly increased in the product group HS21. The HS19 revealed a decrease in the intensity of vertical IIT on the one hand and an increase in the intensity of the horizontal IIT. The intensity of IIT (mostly vertical IIT) has decreased in the product group HS24. These results suggest that the specialization pattern differs among these sectors as well as it indicates the influence of sector-specific factors and their effect on IIT dynamics (besides the nationwide and general A-F sector-specific factors).

Figure 4. Disentangling horizontal and vertical A-F IIT ($\gamma = 0.1$; $\alpha=0.15$) of Czechia with EU Member States; major A-F sectors; selected years



Source: Own calculation based on EUROSTAT (2024)

Discussions and conclusions

The article aimed to assess the intensity and forms of Czechia's A-F IIT with other EU Member States after two decades of membership in the EU.

The accession of Czechia into the EU in 2004 led to an increase in values and volumes of A-F trade between Czechia and former and new Member States. The intensity of trade in the region has increased and the share of EU countries in the territorial shape of Czechia's A-F trade has become dominant.

Although with variations across methods the inter-industry (one-way trade) trade still prevails in the structure of the A-F trade between Czechia and EU Member States. Nonetheless, during the period under review, the intensity of the A-F IIT was increasing corresponding with the process of partial and gradual liberalization of the A-F markets when Czechia joined the EU. The Czechia's A-F IIT mostly consists of vertical IIT indicating the exchange of products of different quality. The positive feature is that within the bilateral two-way A-F flows, Czechia exported higher quality A-F products than it imported lower quality ones. These results are in line with previous studies (e.g. Łapińska, 2014; Jambor, 2014; Jambor et al., 2016; Jambor and Leitão, 2016) on the A-F IIT in the region identifying the increased intensity and vertical nature of IIT in the new EU Member States. It also corroborates the positive relationship found between economic integration and IIT appearance (e.g. Krugman, 1991; Ecochard et al. 2006).

In the last decade, the increase in the intensity of IIT essentially stalled. The possible explanation for this stagnation in the A-F IIT intensity could be the e.g. slowed economic growth in the EU after the Great Recession, change in global value chains activities, and uncertain external and domestic environments that have reshaped trade patterns (e.g.

Kobrin, 2020; Pawlak et al., 2021). Identification of the reasons behind this change in trend opens questions for further research and was not the aim of this article.

The importance of inter-industry trade identified in this study suggests that the comparative advantages of individual A-F sectors are still substantially shaping the dynamic of Czechia's A-F trade. Nonetheless, the increased intensity of the IIT in Czechia's structure of A-F trade suggests the increased importance of other determinants (product differentiation, economies of scale, activities of multinational companies, and fragmentation of the production process) shaping Czechia's A-F trade. This puts existing studies on Czechia's distribution of comparative advantages among A-F sectors (e.g. Burianová et al., 2010; Smutka et al., 2016; Smutka et al., 2018; Vondráček et al., 2022; Kuzmenko et al., 2022) into perspective. These studies found Czechia to be most competitive (revealed comparative advantages) in live animals (HS01), milk (HS04), cereals (HS10), sugar and confectionery (HS17), oilseeds, vegetable oils (HS12) and beverages (HS22). Results in this article show dominance of inter-industry trade in these HS categories, except for sugar and confectionery (HS17) and beverages (HS22) that contain differentiated products and thus the IIT is relatively high. Traditional trade theories suggest that Czechia A-F exports are going to evolve around those products/industries revealing comparative advantages. The results in this article suggest the increasing relevance of IIT theoretical models and more complex Czechia's A-F trade pattern with other EU member states.

Surprisingly and contrary to some existing empirical studies (Greenaway et al., 1995; Ferto and Jambor, 2015), the choice of parameters γ and α in FF and GHM methods matters. The minority trade overlaps are increasingly represented in Czechia's A-F trade and $\alpha=15$ and $\alpha=20$ do not provide similar results. Also, from a methodology point of view, the result of the analysis indicates that using different methodologies to assess the IIT reveals and/or confirms that Fontagné and Freudenberg (1997) method provides higher intensity scores of IIT when compared to results of GL index.

Given the evidence of beneficial economic outcomes from the increased intensity of IIT, this study advocates the positive welfare effects of European economic integration in the A-F sectors of Czechia because of the smaller social costs than the structural changes stimulated by inter-industry specialization. In other words, the increased intensity of A-F IIT that followed Czechia's integration into the EU softened the integration process by allowing the country's A-F sectors to partially avoid harsh adjustments. Nonetheless, the results of this study show the diversity of IIT intensity in particular A-F sectors. The results suggest that the increased intensity of the IIT in the structure of Czechia's A-F trade with other EU Member States was mostly due to the growth of trade with vertically differentiated A-F products. It indicates ongoing specialization along the quality spectrum.

Findings in this study can help inform industrial, agricultural, and trade policymakers when assessing the nature of liberalization and structural transformation of A-F sectors in Czechia as well as when assessing the potential benefits and risks. Also, findings

in this study help to inform countries aspiring to EU membership when assessing the nature of A-F trade dynamics during participation in the Single European Market.

Having said this, the results indicate that the increase in the intensity of Czechia's A-F IIT with other EU Member States essentially stalled in the last decade. This opens questions for further research 1) Is it a specific change in Czechia or it is a more general trend among the EU Member States; 2) what factors are causing this change in the trend; 3) what IIT theoretical models explain the dynamic and structural features of the Czechia's A-F IIT trade.

Conflict of interests

The author declare no conflict of interest.

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Appendix

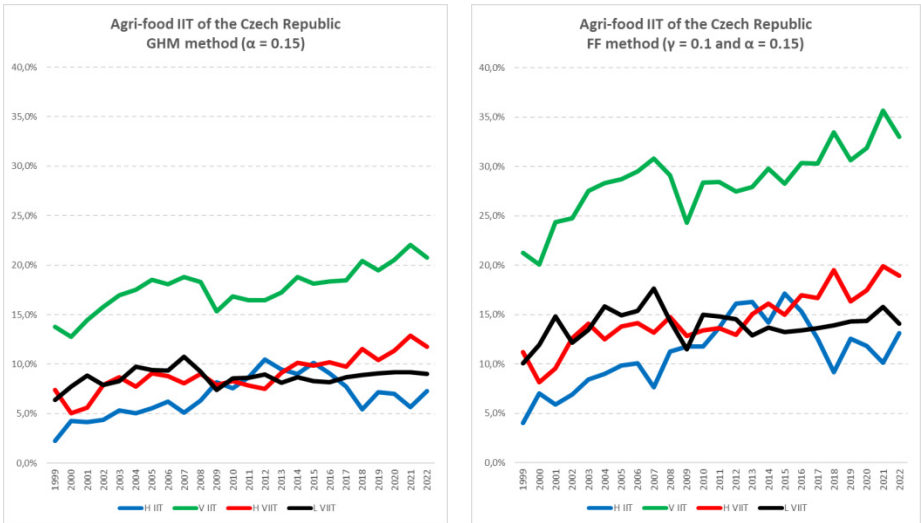
Table A1: Specific product groups according to Harmonized System (HS) classification

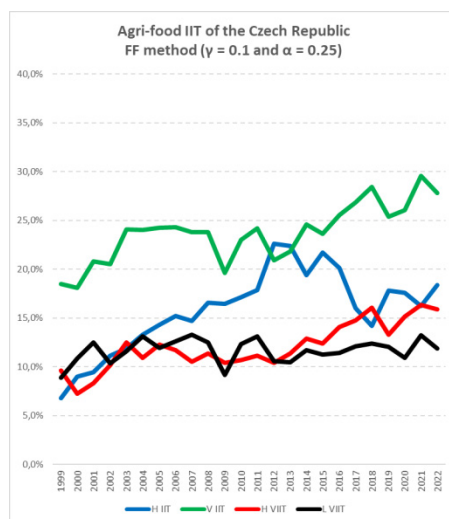
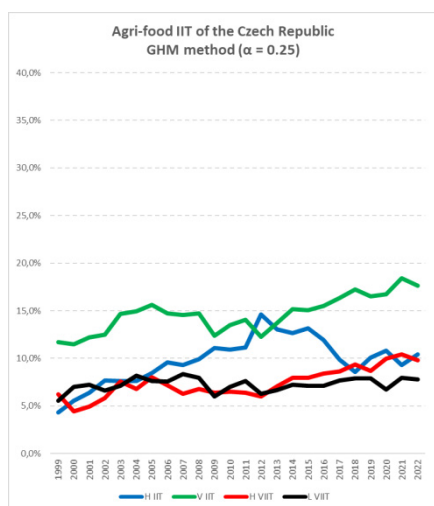
Code	Description
01	LIVE ANIMALS
02	MEAT AND EDIBLE MEAT OFFAL
03	FISH AND CRUSTACEANS, MOLLUSCS AND OTHER AQUATIC INVERTEBRATES
04	DAIRY PRODUCE; BIRDS’ EGGS; NATURAL HONEY; EDIBLE PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
05	PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
06	LIVE TREES AND OTHER PLANTS; BULBS, ROOTS AND THE LIKE; CUT FLOWERS AND ORNAMENTAL FOLIAGE
07	EDIBLE VEGETABLES AND CERTAIN ROOTS AND TUBERS
08	EDIBLE FRUIT AND NUTS; PEEL OF CITRUS FRUIT OR MELONS
09	COFFEE, TEA, MATE AND SPICES
10	CEREALS
11	PRODUCTS OF THE MILLING INDUSTRY; MALT; STARCHES; INULIN; WHEAT GLUTEN
12	OIL SEEDS AND OLEAGINOUS FRUITS; MISCELLANEOUS GRAINS, SEEDS AND FRUIT; INDUSTRIAL OR MEDICINAL PLANTS; STRAW AND FODDER
13	LAC; GUMS, RESINS AND OTHER VEGETABLE SAPS AND EXTRACTS

14	VEGETABLE PLAITING MATERIALS; VEGETABLE PRODUCTS NOT ELSEWHERE SPECIFIED OR INCLUDED
15	ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE FATS; ANIMAL OR VEGETABLE WAXES
16	PREPARATIONS OF MEAT, OF FISH OR OF CRUSTACEANS, MOLLUSCS OR OTHER AQUATIC INVERTEBRATES
17	SUGARS AND SUGAR CONFECTIONERY
18	COCOA AND COCOA PREPARATIONS
19	PREPARATIONS OF CEREALS, FLOUR, STARCH OR MILK; PASTRYCOOKS' PRODUCTS
20	PREPARATIONS OF VEGETABLES, FRUIT, NUTS OR OTHER PARTS OF PLANTS
21	MISCELLANEOUS EDIBLE PREPARATIONS
22	BEVERAGES, SPIRITS AND VINEGAR
23	RESIDUES AND WASTE FROM THE FOOD INDUSTRIES; PREPARED ANIMAL FODDER
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES

Source: EUROSTAT 2024

Figure A1: Disentangling horizontal and (high and low) vertical IIT of the Czech Republic with other EU member states using FF and GHM methodologies, 1999-2022





Source: Own calculation based on EUROSTAT (2023)

Note: H IIT – horizontal IIT, V IIT – vertical IIT, H VIIT – high vertical IIT, L VIIT – low vertical IIT