Equilibrium. Quarterly Journal of Economics and Economic Policy
Volume 17 Issue 3 September 2022
p-ISSN 1689-765X, e-ISSN 2353-3293
www.economic-policy.pl

ORIGINAL ARTICLE

Citation: Hamulczuk, M., & Pawlak, K. (2022). Determinants for international competitiveness of the food industry in 43 countries worldwide: evidence from panel models. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 17*(3), 635–667. doi: 10.24136/eq.2022.022

Contact to corresponding author: Karolina Pawlak, karolina.pawlak@up.poznan.pl

Article history: Received: 26.11.2020; Accepted: 5.06.2022; Published online: 30.09.2022

Mariusz Hamulczuk
Warsaw University of Life Sciences, Poland
orcid.org/0000-0002-4956-8516

Karolina Pawlak
Poznań University of Life Sciences, Poland
orcid.org/0000-0002-5441-6381

Determinants for international competitiveness of the food industry in 43 countries worldwide: evidence from panel models

JEL Classification: *L66; Q13; Q17*

Keywords: *international competitiveness; trade balance; food industry; panel models*

Abstract

Research background: Food industry is of key importance to each economy due to its role in ensuring food security, balancing the labour market, as well as contributing to the economic growth and international trade. With a limited increase in demand for food in many highly developed countries, further growth in this sector of the economy will largely depend on the ability to successfully distribute manufactured goods in international markets and cope with competitive pressure from other entities.
Purpose of the article: Therefore, the study attempts to assess the determinants of international competitiveness of the food industry worldwide measured by the trade balance.
Methods: The research was based on data from the United Nations Conference on Trade and Development Data Center (UNCTADStat) and the World Input-Output Database (WIOD). The time frame for the analyses was determined by the availability of internationally comparable data and thus covered the period of 2000–2014. The empirical analysis was performed with the use of panel models, while international competitiveness was measured by trade balance (net export).
Findings & value added: It was proved that increasing trade openness and relative demand, as well as decreasing relative unit labour costs have a positive impact on international competitiveness of the food industry worldwide. However, the nature of the relationship between relative labour productivity and trade balance appears to be ambiguous. A stronger impact of the exam-

ined factors on net exports in the long-run rather than the short-run was also evidenced. The novelty of our analysis is that we consider trade balance determinants of the food industry worldwide using panel models, whereas most of the existing studies focus either on one or a narrow group of countries.

Introduction

The food industry is a branch of the economy involved in the production of final and intermediate food products to meet the basic needs of the population. The food industry may also be treated as one of the elements of the agri-food economy, comprising and linking numerous sectors and cooperating branches of the economy, which all contribute to food production regardless of being themselves part of the primary, secondary or tertiary sectors. The agri-food economy comprises first of all agriculture, the food industry and food distribution (both wholesale and retail) (cf. Davis & Goldberg, 1957). Food industry is of key importance to each economy not only because of the nature of the goods produced, but due to its essential role in generating gross domestic product, balancing the labour market and contributing to growth in international trade. Being a major contributor to Europe's economy, in 2017 the EU food and drink industry was the largest manufacturing industry in the EU, accounting for 13% share of turnover, 10% share of value added and 14% share of employment in the manufacturing industry in total (Eurostat, 2020). Similar shares are visible for the world food industry in the World Input-Output Database (WIOD) (WIOD, 2020).

With a limited increase in demand for food in many highly developed countries, further growth in this sector of the economy will largely depend on the ability to successfully distribute manufactured goods in international markets. This, in turn, will require suppliers to cope with competitive pressure from other entities. The literature in this field is quite rich and focuses both on measuring the international competitiveness of the agri-food sector and on its determinants. Empirical studies differ in terms of the time and spatial scope of the research, the methodology used, or the scope and sources of the variables used. It is worth emphasising that the conducted research may concern relatively different economic aggregates. This type of research may focus on agriculture or food industry themselves, or on the entire agri-food sector comprising both agriculture and food industry.

As far as the measurement of competitiveness is concerned, the competitive capacity of Canadian agriculture based on productivity and prices was analysed by Brinkman (1987), while agricultural potential and performance of the EU and the US agriculture were investigated by e.g. Nowak and Różańska-Boczula (2019) or Pawlak *et al.* (2021). In turn, competitiveness of the EU food industry was explored by Wijnands *et al*. (2008) and Wijnands and Verhoog (2016). Those studies used a set of economic and trade indicators including those based on real value added, real labour productivity, as well as market and trade shares. Trade-related indicators were also applied by Juchniewicz and Łukiewska (2015). Studies on the competitiveness of the agri-food sector most often employ comparative advantage indicators. Such an approach to assess the competitive position of the agri-food sector of the EU countries was employed e.g. by Bojnec and Fertő (2018, 2019), Szczepaniak (2019) or Pawlak (2022). Except for the one by Bojnec and Fertő (2018), all those studies assessed the competitive position of the analysed countries seen as a result of competition processes, while excluding factors affecting competitiveness.

When searching for the determinants of international competitiveness in the agricultural and food sector both descriptive studies (van Duren *et al*., 1991) and empirical research papers can be found in the literature on the subject. The latter most often focus either on one or a narrow group of countries and use the trade balance as a measure of competitiveness. For instance, Sertoglu and Dogan (2016) using the autoregressive distributed lag (ARDL) approach investigated agricultural trade balance drivers in Turkey. Zhuang *et al*. (2007) employed the generalised least squares (GLS) estimation method to analyse the determinants of agri-food trade balance in the US, while Bojnec and Fertő (2009) applied the fixed effects (FE) panel model to decompose determinants of competition in bilateral agri-food trade between five Central European countries and the EU–15. More comprehensive analyses, but still not exhaustive in their subjective scope, related to the factors determining agri-food trade of the EU and the Organisation for Economic Cooperation and Development (OECD) countries were presented by Bojnec and Fertő (2015b, 2018). In those analyses, the gravity model or the survival function were estimated.

In the light of above, it can be noted that most studies devoted to the determinants of competitiveness apply to the entire agri-food sector. Therefore, there is a literature gap as far as empirical evidence from the food industry itself is concerned, while in the field of the methodology used the panel models are in minority. The limited number of studies on the determinants of the competitiveness of the food industry worldwide, the key importance of this industry in the functioning of the economy and new challenges facing the sector (climate change or the COVID-19 crisis) are indications for the need for this research.

Hence, the aim of the paper is to assess the determinants of international competitiveness of the food industry worldwide measured by the trade balance. To fulfil this goal, we: a) discuss and choose international competitiveness measure and its potential determinants (to specify the model); b) show basic characteristics of the worldwide food industry, including competitiveness of the food industry in analysed countries; c) test the significance of selected factors that might influence changes in international competitiveness of the food industry. The empirical research was performed using panel models, while international competitiveness was measured by trade balance.

The novelties and contributions of this paper in the literature are threefold. Firstly, to our knowledge, this is the first attempt to assess the determinants of competitiveness of the food industry worldwide. Secondly, an up-to-date WIOD database has never been used to assess the competitiveness of that sector of the economy. Thirdly, all the explanatory variables used in panel models representing potential determinants of international competitiveness are in relative terms, which is rare in this type of research. The research results will contribute to the development of agricultural economics, the theory of international trade, as well as the theory of international competitiveness at the mesoeconomic level. Additionally, the more utilitarian value may be related to improving the policies enhancing the international competitiveness of the food industry.

The paper is organised as follows. The theoretical background includes a literature review with special emphasis on the most frequently used trade related measures of competitiveness and factors influencing international competitiveness of economies. The following section presents methodology applied, whereas the last one presents the importance of the world food industry and discusses empirical results of econometric modelling. The paper ends with concluding remarks and an indication of the limitations of the study, as well as suggestions for further research.

Literature review

The literature review is focused on two issues which are important in terms of the methodology applied in the conducted study. One is the discussion on measuring competitiveness, while the other is related to the review of the determinants of international competitiveness recognised in empirical research.

Competitiveness and its measures

Competitiveness is a relative, multidimensional concept and can be assessed for different time horizons, on different entity levels and based on different economic theories, including the theory of economic growth and the theory of international trade (see e.g. Porter, 1990; Siggel, 2006; Latruffe, 2010). When applying the theory of economic growth, competitiveness refers to the ability of a nation to produce, distribute and service goods in the international economy when competing with goods and services produced in other countries, and to do so in a way that earns a rising standard of living (Scott, 1985). In this definition producing and selling goods in competition with others, manifested in gaining or maintaining the market share, is a necessary condition; however, it is not sufficient. The sufficient condition is that it also improves the standard of living. In line with Scott's viewpoints, Fagerberg *et al*. (2004) indicated that the objective of a competitive economy is on the one hand to ensure the economic welfare of the population, while on the other hand — to promote international trade. Ezeala-Harrison (1999) also emphasised the importance of foreign trade for maintaining or increasing the level of employment and income of the population. He stated that the export of uncompetitive products makes it impossible to gain a large share in the global market and to increase income and employment levels.

Similarly, Devine (1996) defined competitiveness at the mesoeconomic level. According to that author, a competitive sector is able not only to satisfy the demand on domestic and foreign markets, but also to maintain socially acceptable levels of production, employment and exchange rates (Devine, 1996). These definitions may be considered to refer to the theory of economic growth and international trade, in which competitiveness is commonly defined as the ability to profitably gain and maintain the market share in domestic and/or foreign markets (Fischer & Schornberg, 2007). In this approach, trade related indicators, including trade balance, are used to demonstrate the competitive performance of a country or a sector of the national economy. In view of the above, trade balance may therefore be treated as both a symptom and a measure of competitiveness; however, it may not outline the source of the advantage (Siggel, 2006). For this reason, as a rule most empirical studies (e.g. Bojnec & Fertő, 2015a; Smutka *et al*., 2018; Bojnec & Fertő, 2019; Senyshyn *et al*., 2019; Szczepaniak, 2019; Verter *et al*., 2020) focus on the assessment of competitiveness itself, rather than search for factors determining competitiveness.

When evaluating international competitiveness numerous indicators may be used, originating both from the trade and growth theories of competitiveness. The trade theory suggests that a country's competitiveness is based on the concept of comparative advantage (Latruffe, 2010). The basic and the most frequently used measure of international competitiveness is trade balance (also known as net export, NEX), which is based on information on export and import of the analysed commodity in a given country:

$$NEX_{ij} = X_{ij}/M_{ij} \tag{1}$$

where:
X export,
M import,
i analysed country,
j analysed commodity.

An alternative measure of international trade specialisation is Lafay's Trade Balance Index (TBI). This index assumes values within the interval of [-1, 1] and it is determined according to the formula (Lafay, 1992):

$$TBI_{ij} = (X_{ij} - M_{ij})/(X_{ij} + M_{ij}). \tag{2}$$

Positive values of the index indicate export specialisation of a given country (a country is referred to as a "net-exporter"), whereas negative values show a lack of specialisation ("net-importer" position of a country).

The Revealed Comparative Advantage (RCA) index calculates the ratio of a country's export share of a commodity in the international market to the country's export share of all other commodities and it is determined according to the formula (Balassa, 1965):

$$RCA_{ij} = (X_{ij}/X_{ik})/(X_{nj}/X_{nk}) \tag{3}$$

where:
k all commodities,
n reference country/countries.

Values of the RCA indicator greater than one indicate an advantageous competitive situation, since the country has a strong export sector. Lower values of the RCA index demonstrate a lack of comparative advantages (Latruffe, 2010).

The Relative Import Advantage (RMA) index suggested by Vollrath is similar to RCA, but refers to imports (M) rather than exports (Vollrath, 1991):

$$RMA_{ij} = (M_{ij}/M_{ik})/(M_{nj}/M_{nk}) \quad (4)$$

An RMA index lower than one reflects a revealed comparative advantage and thus higher competitiveness (Latruffe, 2010). Since RCA results in an output which cannot be compared on both sides of unity, Dalum *et al*. (1998) proposed making the index symmetric as the Revealed Symmetric Comparative Advantage (RSCA):

$$RSCA_{ij} = (RCA_{ij} - 1)/(RCA_{ij} + 1). \quad (5)$$

The RCA index ranges from zero to 1 if a country is not specialised in a given sector, while it ranges from 1 to infinity if a country is specialised. This implies that the application of RCA in statistical analysis (especially regression analysis) gives much more weight to values above 1 compared to observations below 1 (Laursen, 2015). The RSCA index falls within the interval of [–1,1], with negative values indicating a lack of comparative advantage and positive demonstrating such an advantage. It should be emphasised here that the above-mentioned indicators are measures of international specialisation rather than international competitiveness or any other concept indicating performance (Laursen, 2015). Moreover, in most cases the RCA index is used for cross-sectoral comparisons. Considering this fact, we decided to use the export/import ratio (NEX) to evaluate the competitive performance of the analysed sector in the countries under investigation.

Hatsopoulos *et al.* (1988) considered trade balance and the rate of economic growth as symptoms of competitiveness, however, they noted that export success may also be achieved at the cost of diminished real income, in which case it does not reflect competitiveness. Nevertheless, reaching a positive trade balance is traditionally considered a desirable economic phenomenon, while Alege and Okodua (2014) believed that export competitiveness of a country is closely associated with its trade performance. It should be stressed here that the use of trade balance as a macro-scale indicator of competitiveness can raise some doubts (see Krugman, 1994), while the use of this measure at the mesoeconomic level is widely accepted (Hilke & Nelson, 1987). In view of the fact that a considerable proportion of trade volume, particularly in the secondary (processing) sector, is exchanged within the global value chain, a measure of the competitive position of a given sector could be provided by the ratio of the domestic value added to the foreign value added in exported commodities. However, since it is impossible to construct long time series based on trade data in categories of value added, it may be assumed that the trade balance is a simple and first of all easily quantifiable measure of competitiveness of the analysed sector. Such an approach was used e.g. by Olczyk and Kordalska (2018) to compare the determinants of international competitiveness for the manufacturing industries in Poland and Czechia. When exploring agricultural and food industries, trade balance as a measure of international competitiveness was employed among others by Zhuang *et al.* (2007), Sertoglu and Dogan (2016) or Bojnec and Fertő (2009).

Key determinants of trade balance

Considering the difference in the trade balance across countries and sectors of their economies, as well as over time, it is essential to determine the main factors influencing the trade balance. Many empirical analyses have been performed to examine the determinants of the trade balance (Table 1). However, most of the studies refer to the aggregate trade balance and discuss the case of one country. For example, interesting works were delivered by Duasa (2007), Mohammad (2010), Shawa and Shen (2013), Elhanom (2016), Sharif and Sheikh Ali (2016) or Weeresinghe and Perera (2019). There were also some studies examining the bilateral trade balance at the macro level (Khan and Hossain, 2010), while the sectoral analyses have been developed less frequently. Determinants of trade balance in Polish and Czech manufacturing sectors were investigated by Olczyk and Kordalska (2018). In turn, Sertoglu and Dogan (2016) searched for factors affecting Turkey's agricultural trade. It can be noticed that there is a lack of evidence originating from the food industry. Our study fills this gap. The novelty of the paper stems also from the fact that we consider the cross-country diversity of trade balance determinants. Such a diversity has been rarely adopted so far, e.g. by Falk (2008) in relation to an aggregate trade balance in industrialised countries.

There are three approaches to explain factors determining the trade balance — the elasticity approach, absorption approach and monetary approach (Khan & Hossain, 2010). The elasticity approach focusing on changes in the real exchange rate is usually explained by the Marshall-Lerner condition, which states that if the absolute sum of the long-run elasticities of import demand and export supply is higher than unity, a rise in the exchange rate (i.e. depreciation of domestic currency) improves the trade balance by changing relative prices between domestically and foreign sourced goods (Sertoglu & Dogan, 2016). The main limitation of the elasticity approach is that it neglects the income and expenditure effects of exchange rate changes. To compensate for this drawback, the absorption approach was introduced (Alexander, 1959). Following the absorption approach, the effects of currency depreciation on trade balance depend on the consequent change in the income of the country (Bošnjak *et al*., 2018). The monetary approach, which was originally suggested by Polak (1957), points out that the trade balance is a monetary phenomenon and arises out of a disequilibrium between demand and supply in the money market. In line with this approach, deficit in the trade balance results from excessive supply over demand for money (Bošnjak *et al*., 2018). Existing empirical studies refer to all these approaches to explain trade balance (Table 1) and finding an appropriate theoretical explanation for a specific country is treated as an empirical issue. However, considering the above-mentioned analyses, the elasticity approach and the absorption approach seem to be the most commonly used to investigate the trade balance position of countries, while the real exchange rate and domestic and foreign demand are the dominant variables. These two approaches support also the mesoeconomic analyses of trade balance. It should be noticed here that some sector-specific factors may be employed in the analysis rather than the exchange rate when searching for determinants of trade balance at the mesoeconomic level. In their study concerning the agricultural sector Sertoglu and Dogan (2016) used the agricultural export and import price ratio and agricultural producer prices, while Olczyk and Kordalska (2018) in their analysis of manufacturing sectors included relative unit labour costs, labour productivity and innovation intensity.

As the food industry is part of the secondary sector, determinants of the trade balance in manufacturing industries deserve special attention. Those determinants include the demand, prices, innovation and labour productivity, as well as trade openness are basic determinants of trade balance. In the light of the elasticity approach and the absorption approach, demand and prices constitute important drivers of trade balance and international competitiveness of a country or a sector of its economy. In line with the elasticity approach, improvement or deterioration in the trade balance depends on foreign elasticity of demand for exports, home elasticity of demand for imports, as well as exchange rates. However, as it is highlighted by the absorption approach, a change in the exchange rate can affect the trade balance if it induces an increase in income which is greater than the increase in total domestic expenditure (Khan & Hossain, 2010).

The demand side is represented by both home and foreign demand. Porter (1990) already indicated that demand conditions, covering the size, structure and nature of home demand, largely affect the level of international competitiveness. Larger, more dynamic, and sophisticated consumer markets drive innovation and product improvement, which are factors strengthening the competitive advantage of nations or industries. Alternative theories of international trade also suggest that home demand is the basic determinant of imports, while the volume of foreign demand affects exports of a given country. It is due to the fact that in the highly globalised and integrated markets without barriers to trade, among the countries with similar demand structures domestic consumers prefer to have multiple varieties of a product over time (the love of variety approach). The consumers' love of variety enhances intra-industry trade in the goods, which are close substitutes in consumption (Dixit & Stiglitz, 1977). However, considering partial substitutability between sales on the domestic and foreign markets, a high domestic demand is not conducive to improving international competitiveness measured by the balance of trade, as it has a negative impact on the growth rate of exports and a positive effect on the dynamics of imports (Olczyk & Kordalska, 2018). On the other hand, a high foreign demand promotes growth of international competitiveness expressed in the balance of trade (see Table 1). It is in line with the imperfect substitutes model by Goldstein and Khan (1985), who stated that the resulting demand functions for imports and exports represent the quantity demanded as a function of the level of income in the importing region, the imported good's own price and the price of domestic substitutes.

As already mentioned, changes in relative prices between domestically and foreign sourced goods significantly affect international competitiveness. The most commonly used measures of trade competitiveness based on relative prices and costs include real exchange rate (RER), real effective exchange rate (REER), price indices such as consumer price index (CPI) or producer price index (PPI), export unit values (export prices), and relative unit labour costs (RULC). The latter is highly recommended by Turner and Golub (1997), and useful in analyses of manufacturing industries. In most cases, a decrease in unit labour costs in a given economy supports the intensity of exports from this country and determines the positive trade balance (Olczyk & Kordalska, 2018).

In Porter's diamond model, innovation and productive capacity are considered key drivers of competitive advantage of industries (Porter, 1990). As stated by Porter (1990), the ability to produce new innovative products using the most advanced methods becomes the dominant source of competitive advantage in innovation-driven economies, in which domestic demand, along with the increase in the income of the population, is more and more differentiated, while the role of price-based competition instruments decreases in favour of the quality-based ones. A strong relationship between innovation (measured simply by research and development (R&D) spending) and international competitiveness was reported by Greenhalgh *et al.* (1994), as well as Anderton (1999).

Trade openness (OPEN) is a decisive factor in technological progress and can drive an increase in R&D expenditure (Rivera-Batiz & Romer, 1991). Moreover, trade openness can lead to the reallocation of production factors to more productive sectors with a comparative advantage in trade (Melitz, 2003). In this way, trade openness will affect the meso- and micro-competitiveness measured by the balance of trade. In the light of the new trade theory only the most productive entities are able to bear fixed costs associated with entering a foreign market and win competition for fixed labour resources, while facing the price pressure resulting from import competition (Melitz, 2003; Melitz & Ottawiano, 2008). Hence competitiveness can also be determined by the productivity level.

As far as the agri-food industry is concerned, Zhuang *et al.* (2007) using the generalised least squares (GLS) estimation method indicated that per capita income in the US appears to be the most important factor behind the growing trade deficit. It results from that study that increases in per capita income along with rising foreign market openness improve the US agri-food trade balance, while US foreign direct investments in food industries abroad, a strong US dollar and membership in the North American Free Trade Agreement (NAFTA) — due to the faster rate of growth of imports from Canada and Mexico compared to exports to those markets — have negative effects on the trade balance. Sertoglu and Dogan (2016) adopted an autoregressive distributed lag (ARDL) modelling approach to investigate the long-run relationship between agricultural trade balance in Turkey and its determinants including real exchange rate, the ratio of export and import prices of agricultural commodities, producer prices and real gross domestic product (GDP). They have showed that the real exchange rate, real GDP and agricultural producer's prices are highly significant and have a negative impact on the trade balance.

In turn, Bojnec and Fertő (2009) used trade balance along with the unit export-import value difference to categorise four competition categories and then investigate determinants of trade competition of Central European countries with the EU. Arable land per capita, human capital endowment, R&D expenditure in agricultural sciences, foreign direct investment (FDI) and GDP were among the explanatory variables. The conducted panel dataset analysis led to the conclusion that the trade balance plays a more important role for the significance of price and quality trade competition than the export-import unit value differences. It was also identified that natural (arable land per capita) and human factor endowments increase both price and quality competition, while R&D expenditures improve quality competition and reduce price competition. The reverse impacts were estimated for the size of the economy measured based on the GDP value. Moreover, it was found that FDI reduces unsuccessful price competition, while GDP per capita as a demand-side variable has significant positive impacts on unsuccessful price and quality competition.

Research methods

The study attempts to assess the determinants of international competitiveness of the food industry worldwide measured by the trade balance. Specifically, we analysed the sector of manufacture of food products, beverages and tobacco products (code C10–C12). This means that our analysis concerns only the food sector, while excluding agriculture. The research was based on data from the United Nations Conference on Trade and Development Data Center (UNCTADStat) and the World Input-Output Database (WIOD), edition 2016 (Timmer *et al*., 2015, WIOD, 2020). WIOD is composed of the Word Input-Output Tables (WIOT) and the Socio-Economics Accounts. The WIOD 2016 edition is compliant with the latest sector and product classification, i.e. ISIC Rev. 4, and covers the years 2000–2014. The time frame for the analyses was determined by the availability of comprehensive, internationally comparable data and thus covered the period of 2000–2014. The WIOD is an only comprehensive and up-to-date database, which offers methodologically uniform tables for each year in the period 2000–2014 and thus facilitates the analysis over time[1]. It also needs to be stressed here that the WIOD 2016 edition is the latest available database. The statistical data used in this study constitute a balanced panel covering 43 countries (see Table 3) and 15 years. It is worth adding here that this group includes both developed countries, for which similar analyses have already been performed, and developing countries, which have not been investigated so far. Trade balance as the endogenous variable was calculated from the UNCTADStat, while exogenous variables, including relative demand for food industry products, relative unit labour cost, trade openness and relative labour productivity, were computed based on the WIOD (only in the case of trade openness data from UNCTADStat and WIOD they were combined to calculate the indices). As our study employs relative ratios,

[1] To our best knowledge there is no other database which allows for the analysis in such dimension. We have also learned that utilised WIOD database will not be updated in the future.

which are unitless indicators, all the monetary variables were expressed in current prices, denoted in millions of US dollars. Justification for the selection of specific variables used in the study along with their description is given below and in the literature review section.

As a measure of international competitiveness we used a log of trade balance (L_NEX; Eq. 1) calculated from the UNCTADStat database. Due to the asymmetry of the NEX indicator its logarithmic form is typically used in econometric practice. To calculate this indicator, we took into account only exports and imports of the sector to (and from) the countries being the subject of the analysis. Selection of the competitiveness measure L_NEX for further analyses was determined by three aspects: relative simplicity, research tradition and the fact that the other measures reflect more international specialisation (cross-sectoral comparisons) than international competitiveness of a given industry.

Considering that competitiveness should be measured with respect to a benchmark (Latruffe, 2010), when choosing explanatory variables for individual countries it was decided to focus on relative indicators with respect to the same variables in the rest of analysed countries. Based on the literature review, the impact on the trade balance of the four most frequently discussed determinants was examined. The first was relative demand for food industry products (RD) being a ratio of foreign demand (demand in all the countries under analysis minus the domestic country) and domestic demand. In view of the recommendation by Turner and Golub (1997), the second explanatory variable was relative unit labour cost (RULC), where domestic ULC is compared to aggregated ULC for the other countries. ULC was estimated as the compensation ratio for employee salaries and value added. The third factor being investigated was trade openness of a given sector (OPEN) that leads to specialisation of production, transfer of new technologies and increase in research and development (R&D) expenditure. The OPEN variable was computed as the ratio of worldwide exports and imports of food products and value added. At a lack of comprehensive and internationally comparable data on R&D expenditure at the food industry level, we assume that trade openness is also a sign of the country's ability to enhance technological progress. Considering the opinion by Krugman (1994) that the rate of productivity growth is essential for competitive capability, the last variable we tested was relative labour productivity (RLPR). It measures productivity in a given country (as a ratio of value added and the number of persons engaged) in comparison to the aggregated productivity in the other analysed countries. Similar variables were used in the study on the determinants of trade balance in Polish and Czech manufacturing sub-sectors by Olczyk and Kordalska (2018). In contrast to that study, all the variables covered by our study are expressed in relative terms.

All analyses were made on log data — log levels or first differences of log data. Two types of methods were used to analyse the relationship between variables representing net export and its potential causes. Preliminary analysis was based on linear correlation coefficients computed for levels and first differences. To eliminate the impact of individual factors influencing the level and development of variables in particular countries we used data levels corrected for cross-section fixed effects (CSFE), as well as CSFE and individual linear trends (IT). In other words, correlations were made on the residuals of the panel models with only cross-section fixed effects or cross-section fixed effects and individual trends.

In the main part of the empirical study panel models were employed. A general specification of the panel model is given by equation 6:

$$Y_{it} = \alpha + \mathrm{X}'_{\mathrm{it}}\beta + \mu_i + \gamma_t + \delta_i t + \varepsilon_{it} \tag{6}$$

where:

Y_{it}	dependent variable,
X'_{it}	vector of k regressors,
α	constant,
β	regression coefficients common across cross-sections and period,
μ_i	cross-section fixed effects (CSFE),
γ_t	period fixed (specific) effects (PFE),
$\delta_i t$	individual trends (IT),
ε_{it}	random component,
$i=1,2,\ldots,M$	cross-sectional units observed for dated period $t=1,2,\ldots,T$.

In the research different specifications of the panel models with respect to deterministic components were employed (see Table 5). These models were estimated using the generalised least squares (GLS) method for log levels or first differences in log levels. Due to autocorrelation problems in calculating the standard errors of parameters in all the models in log-levels, we used an estimator robust to heteroscedasticity and auto-correlation (see Arellano, 2003). In half of the models, before the final estimation the data were weighted according to the potential differentiation of variations between the ij data cross-sections (a weighted least squares procedure was used to form the feasible GLS estimates).

It needs to be stressed that the aim of this analysis is not to indicate determinants of the level of international competitiveness for the food industry in individual countries, but rather determinants of its changes in time. The level of competitiveness (the value of this indicator) in individual countries results from factors specific to a given economy, which are captured by the cross-section fixed effects, e.g. availability of raw materials, the level of socio-economic development or past historical conditions. By including period-specific effects in the model, it is possible to exclude the common effects — factors, which impact all countries simultaneously, such as e.g. global business cycles or trends in tariff and non-tariff barriers worldwide. Thanks to these variables panel models provide more comprehensible analyses.

Results and discussion

Worldwide food industry characteristics

The food industry is composed of an extensive range of activities. This branch of the economy comprises firms involved in processing of animal origin products (e.g. the meat and dairy industries), processing of plant origin products (e.g. the cereal and pasta or fruit and vegetable industries), secondary processing (bakery, feed, confectionary, food concentrate, non-alcoholic beverage industries) or stimulant production (alcohols). Products of this sector may be minimally processed or they may be the result of advanced technological processes. The structure of the food industry in individual countries also varies, depending on their socio-economic development, consumer preferences or availability of the raw material base.

Most of the global food production is concentrated in the USA, China and the EU. The two former states in the years 2000–2014 accounted for 37.4% world production, while the EU countries — for another 24%. In 2014 an increased role of China was observed, as its food production accounted for 30.5% world production, at a slightly lower share of the USA (16.4%) and an over 29% share of the EU. Similar conclusions may be formulated based on value added. An increasing importance of agribusiness and changing shares of its individual aggregates (including the food industry) in the Chinese national economy was discussed e.g. by Mrówczyńska-Kamińska and Bajan (2019). In terms of employment in the food industry worldwide in the period 2000–2014 on average an almost 58% share was recorded for two countries — China and India. In 2014 this share increased to 63.4%, which indicates problems with labour efficiency in these countries, particularly India.

The food industry is one of the most important branches of the economy. Its share in value added and gross output of the secondary sector worldwide is 13.5 and 14.2%, respectively, with no marked trend observed

(Figure 1). Nevertheless, it may be stated that these shares are dependent on the business cycle. In the period of slump its share in the industrial production volume increases, which makes the food industry more resistant to economic crises. The share of the food industry in the total employment in the secondary sector worldwide decreased from over 14.5 % in 2000 to approx. 13% after 2007 despite the increase in employment in the food industry in absolute terms (WIOD, 2020).

It needs to be stressed that the food industry plays a relatively varied role in individual countries (Table 2). On the one hand, in Cyprus food production accounts on average for over 43% production of the secondary sector, at an almost 36% share in employment. On the other hand, in Taiwan the respective shares are as low as approx. 5% each. What is interesting, employment in the food industry in China, which have an average 30% share in the world employment in the food industry, the figure does not exceed 10% employment in the domestic secondary sector, which shows its low productivity compared to the other branches of industry in China. The diversified importance of the food industry in the economies of the EU, USA, Australia, Brazil and Canada was already shown by Wijnands and Verhoog (2016).

As was discussed in literature review various measures of international competitiveness may be applied. Table 3 presents results of comprehensive analysis of international competitiveness and export specialisation in the food industry of countries under investigation ordered according to the NEX indicator.

The strongest interdependence is observed between NEX and TBI measures (linear correlation coefficients is 0.99). Relationships between NEX and the other indicators of comparative competitiveness are much weaker and not necessarily linear. The Brazilian food industry is the most competitive in the world (value of exports of food products exceeds the value of imports of these products on average 15-fold). It is in line with the findings by Wijnands and Verhoog (2016). Countries showing a high competitive advantage in food trade include also Australia, Indonesia, the Netherlands, Denmark or Poland. An increase in the agri-food export competitiveness of the EU countries in world trade under the EU enlargement processes was already discussed by Bojnec and Fertő (2019), while for Poland it was proved by Szczepaniak (2019). Despite this fact, in the years 2008–2012 the competitive position of the EU food industry in relation to the USA, Australia, Brazil and Canada was relatively weaker (Wijnands & Verhoog, 2016). Pawlak (2017) proved that the EU countries reached high comparative advantages in trade in animal origin products, while plant origin products were the source of favourable export specialisation for the

USA. High level of agri-food export specialisation in Central and Eastern European Countries was also indicated by Drabik and Bartova (2007). In turn, Japan is relatively the greatest food importer, since food export accounts for as little as 5% value of its import. Calculations performed show that the greatest positive changes in the L_NEX competitiveness indicator in the years 2000–2014 were observed in Latvia, Romania and Russia. In turn, trade deficit measured using this indicator increased most significantly in China and India — two most populated and dynamically developing countries. Problem of the increasing deficit in the Chinese agri-food trade in the bilateral relation with the EU was mentioned by Pawlak *et al*. (2016). According to these authors, apart from the size of the Chinese market measured by the number of consumers, the net importer position of agri-food products was determined by a faster rate of economic growth and a subsequent increase in the real income of the population.

Relationship between net exports and its key determinants — analysis based on panel models

The entire study was carried out on log data. At first, a preliminary estimation of panel models with fixed effects was made and it turned out that we do not always get the expected signs of parameters, mainly in the case of relative labour productivity (L_RLPR) variable. Therefore, the study was started by calculating the linear correlation coefficients between the variables being the subject of the analysis (Table 4). However, these variables were transformed in such a way so as to eliminate the impact of country-specific factors and / or make the variables stationary. Thus the variables were adjusted for fixed effects, fixed effects and individual linear trends, as well as series differenced. Correcting the data came down to estimating the models with the given formula 6, but without the explanatory variables X_{it}, and period fixed effects, and then using the residuals of these models to estimate the correlation coefficients. These models contained only deterministic components: a) cross-section fixed effects or b) cross-section fixed effects and individual trends.

Such a simple analysis confirms that the faster growth rate of foreign demand compared to domestic demand (L_RD) has a statistically significant (α=0.05) positive effect on the sector's competitiveness on international markets. It is in line with previous studies carried out at the macroeconomic level by Falk (2008), Hossain (2009), Mohammad (2010) and Elhanom (2016), as well as with mesoeconomic analyses related to the agri-food sector presented e.g. by Zhuang *et al.* (2007).

It can be read from Table 4 that an increase in unit labour costs in the country relative to the foreign ones (L_RULC) worsens the competitive position of domestic producers on foreign markets. Such a relationship directly refers to Ricardo's theory of comparative advantage. An increase in the openness of the domestic market to trade (L_OPEN) has generally a positive effect on generating a positive trade balance, although in the case of correlations obtained on the basis of the first differences, the correlation coefficient is not statically significant. In the case of relative labour productivity (L_RLPR), significant negative correlation coefficients prevailed, suggesting that a faster increase in productivity in the country compared to that abroad leads to a deterioration of the domestic trade balance. According to the economic theory positive correlations were expected (see Melitz, 2003; Melitz & Ottawiano, 2008). Logically, a negative coefficient can be explained by the fact that the increase in productivity is accompanied by an increase in wages and domestic demand, which may result in a decrease in the trade balance. This can be confirmed by the high negative and statistically significant correlation coefficients between L_RLPR and L_RD. A similar situation applies to L_RLPR and L_RULC. Thus, this may lead to collinearity problems in panel models and obtaining illogical variable coefficients. It should be noted here that Greenaway *et al.* (2005) proved that the productivity growth of exporters does not appear to differ significantly from that of non-exporters.

The main part of the study was based on panel models, in which L_NEX was the endogenous variable and L_RD, L_RULC, L_OPEN, L_RLPR played the role of exogenous variables. Due to the complexity of methodological issues, 6 models with different specifications were estimated. The results of the estimation for model parameters (β) together with the selected statistics are presented in Table 5. Four models (M1, M2, M4, M5) were estimated at the levels of logarithmic variables (level) and two on the first differences (M3 and M6). Three models (M1-M3) were estimated using ordinary GLS estimation procedures, while the M4-M6 models were estimated based on the cross-sections weighted GLS method.

Model specifications assumed a different set of deterministic variables (CSFE, PFE, IT), which significance was tested using the redundant variable test based on the Fisher-Snedecor F statistic. Null hypothesis in this test is that these effects are redundant (non-significant).

Namely, in the M1 and M4 models the cross-section fixed effect (CSFE) and period fixed effects (PFE) were adopted, while the M2 and M5 models were additionally extended by individual trends (IT) for cross-sections. Individual trends are intended to control specific factors in each country over time, especially those factors that were not included in models (such as the domestic trade policy). The null hypothesis in above mentioned specifications was rejected (see Table 5). In the models based on the first differences in logarithms of variables (M3 and M6) only period effects were taken into account, as only they were statistically significant.

A vast majority of the estimated β coefficients has logical signs and is statically significant. Also, with different model specifications the signs of the β coefficients for variables RD, RULC and OPEN do not change, although their magnitude varies to some extent. Relative labour productivity (RLPR) is the only variable characterised by a lack of significance and changes of sign from positive to negative. It is worth emphasising here that the quality of these models is not entirely satisfactory. Namely, the M1–M3 models are characterised by the lack of normality of residuals distribution, as evidenced by the high statistics of the Jarque-Bera test (J-B) and rejection of the null hypothesis. This is mainly due to the failure to meet the assumption on the homogeneity of cross-sections, which is quite difficult to meet even due to data aggregation problems in large and small countries. In the M1 and M2 models, residuals are characterised by first order autocorrelation (see Durbin-Watson (D-W) statistic) despite inclusion of time effects and individual trends. When considering this problem in these models (as well in the M4 and M5 models) the robust estimator with respect to autocorrelation was used.

The application of cross-sectional weighting in the estimation process significantly improved the quality of analogical models (Table 5). First of all, the residuals from the transformed models are normally distributed (M5 and M6) or their distribution does not differ much from the normal distribution (M4). The standard errors (SE) of regression M4–M6 models are also lower compared to the corresponding M1–M3 models. Similarly, slightly better statistics were recorded for the D-W test.

Generally, the M5 and M6 models can be considered the best among all the models and as such will be focused on. The M5 model was estimated at levels of log variables taking into account cross-section fixed effects (CSFE) and period fixed effects (PFE) as well as individual trends (IT). The inclusion of IT in M5 allowed to reduce significantly the impact of autocorrelation and increase the fit of the model to empirical data (SE) compared to the M4 model. Model 6 was in turn estimated on the first differences, making CSFE and IT statistically non-significant (thus they were not included). Both models are characterised by similar data fitting statistics (SE).

However, the estimated β coefficients differ somewhat between the models. It seems that the coefficients β in the M5 model can be treated more as long-run, while those from the M6 model as short-run due to the fact that the latter model was estimated on the first differences. Consequently, changes in relative demand (RD) by 1% lead to an improvement in export competitiveness by 0.08% in the short-run and 0.10% in the long-run. It can be concluded that due to the high level of regulation and the high importance of local markets RD has a moderate impact on food industry competitiveness worldwide. It should be noted here that a positive impact of relative demand and increasing trade openness on the trade balance in the Czech and Polish manufacturing sub-sectors has already been confirmed by Olczyk and Kordalska (2018). Similar observations for the US agri-food trade balance were made by Zhuang *et al*. (2007), who indicated that as per capita income increases in foreign countries, their imports from the US will grow faster than their exports, contributing to the improvement of the US agri-food trade balance.

Openness to foreign markets (OPEN) is of greater importance. An increase in the sector's trade in the country in relation to its value added by 1% results in an increase in the competitiveness indicator by 0.27% in the short-run and by 0.43% in the long-run. It is worth noting that at the meso level in endogenous growth theories attention is paid to the benefits of trade openness in the long run (Rivera-Batiz & Romer, 1991; Melitz, 2003). Our findings have confirmed this concept for the food industry. This positive relationship is observed because trade openness facilitates transfer of new technologies and encourages enterprises to implement innovation. It also leads to an increase in specialisation coupled with the economies of scale, and to the reallocation of production factors due to the comparative advantage distribution. All those allow countries to gain from trade and reach a positive trade balance. Market openness of the US trading partners was also found to be favourable for the US trade balance. This is in line with the idea that in order to improve international competitiveness at the sectoral level attention should be paid to market size and market accessibility along with technological advantage and institutional framework (Ottaviano *et al*., 2007). The impact of institutional drivers on agri-food trade in the OECD countries was previously examined e.g. by Bojnec and Fertő (2015b).

The next two investigated variables are related to the cost and efficiency dimensions of international competitiveness. The first one is the relative unit labour costs (RULC), for which a 1% increase in the country relative to foreign countries leads to a reduction in the trade balance in the short-run by 0.31% and by 0.42% in the long-run. Those results suggest that RULC is a crucial factor underlying the location of food processing operations and as a result determines the international competitive position of the country's food industry. It is worth emphasizing here that up to date ULC has not been employed to explain the changes in the trade balance of the food industry. For this purpose, agricultural producer prices or unit export-import values were used more often (Sertoglu & Dogan, 2016, Bojnec & Fertő, 2009).

The last variable studied, the relative labour productivity (RLPR), in these two models turned out to be statistically non-significant. Thus, the results of our research do not confirm the claim that increasing labour productivity is a key factor influencing a positive trade balance as was evidenced by Olczyk and Kordalska (2018) for the Polish and Czech manufacturing sectors or Wijnands and Verhoog (2016) for the EU food industry. Lack of significance for RLPR variable probably results from strong income effects due to increased productivity. When analysing the results of our research, it should be taken into account that our analysis also covers developing countries, where the increase in productivity has positive income effects and leads in the first place to an increase in demand for domestic products. This may result in a decline in the trade balance. Hence, it is worth considering the division into developed and developing countries in future research. In the light of our research and referring to the analysis by Greenaway *et al.* (2005), showing that exporting firms are not always more productive than non-exporting ones, it seems also justified to test the hypothesis on learning by exporting (see e.g. Crespi *et al*., 2008), which assumes that experience acquired by exporters on a foreign market has a positive impact on their productivity, rather than vice versa.

It should also be emphasised here that the results of the research always depend on the data: their time range and covered countries. Thus changes in these data may lead to different results and as a consequence make it difficult to compare them with those of other studies. The example of the last variable shows this clearly.

Conclusions

The study attempted to assess the determinants of international competitiveness of the food industry worldwide measured by the trade balance. In the light of our analyses the role of the food industry in the national economy and its competitiveness is diversified between countries. International competitiveness of the food industry was measured by trade balance, which is a widely accepted meso-scale measure of competitiveness. The use of other indicators would lead to an assessment of international specialisation rather than competitiveness. A review of the literature has facilitated selection of potential factors that may affect changes in international competitiveness over time. Panel models were used to assess the determinants of international competitiveness of the food sector. The results obtained on the basis of alternative specifications of the panel models were largely consistent with each other. It was proved that rising trade openness and decreasing relative unit labour costs have a positive and statistically significant impact on international competitiveness of the food industry. Changes in relative demand were a factor of lesser importance in shaping the trade balance; however, their impact was positive. The weak influence of relative demand on net exports may result from the high trade barriers imposed on food products. Only the nature of the relationship between relative labour productivity and net export appears to be ambiguous. The lack of a significant positive impact of improving relative labour productivity on net exports can be explained by the fact that an increase in productivity leads to positive income effects, which may translate into an increase in domestic demand, thus reducing export pressure. Research results also showed a stronger impact of the examined factors on net exports in the long-run rather than in the short-run.

Our findings make it possible to formulate some recommendations for decision-makers on how to improve the policies in order to enhance the international competitiveness of the food industry. Firstly, attention should be paid to promoting free trade policies, which can improve market access both in bilateral relations and at the global level. However, due to the long-lasting impasse at the World Trade Organization (WTO) forum, the impact of that second path on the international competitiveness of the food industry seems to be of lesser importance compared to preferential trade agreements. Secondly, consumer-oriented policies encouraging demand on foreign markets along with domestic policies enhancing productivity growth should be pursued to improve the level of international competitiveness of the food industry.

The limitation of the study is related with not taking into account data on bilateral trade barriers imposed or faced by individual countries. It is extremely important particularly in the food sector, which is — due to the strategic nature and sensitivity of the goods manufactured — under a strong influence of foreign trade policy. For example, in the Russian Federation the increase in the international competitiveness of the food industry largely results from the imposed embargo, while in the new EU countries it is the consequence of changes in the trade policy after accession to the EU. Considering the trade policy dimension in shaping long-run competitiveness of the food industry would be of interest in the next stages of the analysis. In this context, evaluating weighted average equivalents of non-tariff barriers to trade in food products would be a challenge. For future research it also needs to be highly recommended to supplement the models with a separate innovation measure or a foreign direct investment (FDI) variable, as FDI inflow promotes technological progress and can stimulate the trade performance. However, it is strongly dependent on the availability of comprehensive and internationally comparable data at the sectoral level. As far as methodological issues are concerned, it is worth considering the potential applicability of panel co-integration models for in-depth analysis of short- and long-run effects.

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Annex

Table 1. Review of selected studies on determinants of trade balance

Authors (date of study)	Country(-ies)	Research method	Approach to explain trade balance / Trade balance drivers and their impact
		Macro level analyses	
Duasa (2007)	Malaysia	ARDL approach	EA, MA, AA / real exchange rate (0), GDP (N), money supply (N)
Falk (2008)	USA, Greece, Portugal, Spain, UK and Australia	Panel models	EA, AA / real effective exchange rate (N), real domestic GDP per capita (N), real foreign GDP per capita (P), government budget balance (P), foreign direct investment (P)
Mohammad (2010)	Pakistan	VECM	EA, AA / real effective exchange rate (N), domestic consumption (N), foreign income (P), foreign direct investment (P)
Khan & Hossain (2010)	Bangladesh	Log-linear model	EA, AA / real exchange rate (N), import-weighted distance (N), relative domestic GDP per capita (N), relative domestic GNI per capita (P)
Shawa & Shen (2013)	Tanzania	Regression (OLS)	EA, AA / real exchange rate (0), household consumption expenditure (N), foreign income (P), government expenditure (N), foreign direct investment (P), inflation (N), human capital development (P), natural resources availability (P), trade liberalisation (P)
Elhanom (2016)	Jordan	ARDL approach	EA, AA / real exchange rate (0), domestic income (0), foreign income (P)
Sharif & Sheikh Ali (2016)	Somalia	Regression (OLS)	EA, AA / exchange rate (N), foreign direct investment (N), inflation rate (0)
Weeresinghe & Perera (2019)	Sri Lanka	General multiple regression	EA, AA / exchange rate (0), GDP (P), volume of imports (N), foreign direct investment (0), inflation rate (N)
		Sectoral analyses	
Sertoglu & Dogan (2016)	Turkey	ARDL approach	EA, AA / real exchange rate (N), the ratio of agricultural export price to import price (0), agricultural producer prices (N), real GDP per capita (N)
Olczyk & Kordalska (2018)	Poland and Czechia	Panel ECM and SUR model	EA, AA / relative demand growth (P), relative unit labour costs (P), trade openness (P), innovation intensity (0), labour productivity (P)
Zhuang et al. (2007)	USA	GLS estimation	EA, AA / exchange rate (N), domestic per capita income (N), foreign per capita income (P), trade openness (P), foreign direct investment abroad (N), NAFTA (N)

Notes: ARDL – Autoregressive Distributed Lag, VECM – Vector Error Correction Model, SUR – Seemingly Unrelated Regression, GLS – Generalised Least Squares, EA – elasticity approach, MA – monetary approach, AA – absorption approach; Impact: P – positive, N – negative, 0 – statistically non-significant.

Table 2. The role of the food industry in the total secondary sector in selected countries in the years 2000–2014

No.	Share in gross output of domestic total industry (%)				Share in employment of domestic total industry (%)			
	Country	2000-2014	Country	2014	Country	2000-2014	Country	2014
1	CYP	43.11	CYP	51.34	CYP	35.77	CYP	42.64
2	LVA	30.27	HRV	33.71	MEX	27.31	GRC	33.84
3	HRV	30.27	IDN	32.62	GRC	26.52	MEX	29.18
4	GRC	28.57	IRL	32.35	LVA	25.22	AUS	27.81
5	IDN	27.43	GRC	29.09	FRA	23.65	IRL	27.23
6	ROU	27.32	AUS	27.09	IRL	23.04	FRA	25.95
7	DNK	24.05	ESP	26.57	LTU	22.72	LVA	24.08
8	NOR	24.01	LVA	25.15	AUS	22.66	NOR	23.79
9	AUS	23.43	NOR	23.94	NOR	22.10	ESP	23.65
10	ESP	22.34	DNK	23.12	HRV	21.84	LTU	23.58
11	POL	22.29	ROU	22.93	IND	20.30	HRV	23.41
12	LTU	22.17	NLD	22.73	BGR	19.86	BRA	20.24
13	NLD	21.91	FRA	22.73	DNK	19.85	BEL	20.05
14	IRL	21.85	MEX	22.13	BRA	19.18	DNK	19.25
15	MEX	21.67	BRA	21.72	ESP	18.90	MLT	18.83
16	FRA	20.99	MLT	21.49	BEL	17.92	BGR	18.79
17	TUR	20.76	LTU	21.20	POL	17.81	POL	18.38
18	BGR	20.73	POL	21.13	NLD	17.38	GBR	18.15
19	BRA	19.97	TUR	20.76	GBR	16.73	NLD	18.12
20	PRT	19.57	PRT	20.63	MLT	15.80	LUX	17.92
21	EST	18.86	GBR	19.24	RUS	15.56	IND	16.72
22	GBR	18.27	BGR	19.08	HUN	15.45	PRT	16.16
23	RUS	18.19	BEL	18.02	IDN	15.45	EST	15.65
24	MLT	16.34	EST	16.25	LUX	15.33	HUN	15.64
25	BEL	16.24	RUS	16.22	EST	15.25	JPN	14.75
26	CAN	15.71	USA	15.93	PRT	14.61	CAN	14.65
27	USA	15.06	CAN	15.10	CAN	14.20	CHE	14.46
28	IND	14.41	ITA	14.99	JPN	13.91	USA	14.31
29	ITA	13.90	IND	13.85	AUT	13.90	RUS	14.24
30	HUN	13.79	JPN	12.67	TUR	13.40	AUT	14.02
31	JPN	12.64	AUT	12.53	CHE	13.39	IDN	13.73
32	CHE	12.41	HUN	11.86	DEU	13.17	DEU	13.11
33	CZE	11.87	CHE	11.78	USA	13.05	TUR	12.41
34	AUT	11.86	CHN	11.48	ROU	12.82	ITA	12.29
35	DEU	10.65	DEU	10.75	SVK	11.16	FIN	12.08
36	CHN	10.21	FIN	10.57	CZE	11.04	ROU	11.60
37	SVN	9.62	LUX	9.76	ITA	10.86	CZE	10.00
38	FIN	9.39	SWE	9.53	FIN	10.68	CHN	9.90
39	LUX	9.07	CZE	9.03	KOR	9.89	SWE	9.84
40	SVK	8.79	SVN	8.42	SWE	9.64	SVK	9.30
41	SWE	8.78	KOR	6.28	CHN	9.27	KOR	9.29

Table 2. Continued

No.	Share in gross output of domestic total industry (%)				Share in employment of domestic total industry (%)			
	Country	2000-2014	Country	2014	Country	2000-2014	Country	2014
42	KOR	7.01	SVK	5.85	SVN	9.07	SVN	9.20
43	TWN	4.73	TWN	4.50	TWN	5.27	TWN	5.46

Notes: AUS – Australia, AUT – Austria, BEL – Belgium, BGR – Bulgaria, BRA – Brazil, CAN – Canada, CHE – Switzerland, CHN – China, CYP – Cyprus, CZE – Czechia, DEU – Germany, DNK – Denmark, ESP – Spain, EST – Estonia, FIN – Finland, FRA – France, GBR – United Kingdom, GRC – Greece, HRV – Croatia, HUN – Hungary, IDN – Indonesia, IND – India, IRL – Ireland, ITA – Italy, JPN – Japan, KOR – South Korea, LTU – Lithuania, LUX – Luxembourg, LVA – Latvia, MEX – Mexico, MLT – Malta, NLD – Netherlands, NOR – Norway, POL – Poland, PRT – Portugal, ROU – Romania, RUS – Russia, SVK – Slovakia, SVN – Slovenia, SWE – Sweden, TUR – Turkey, TWN – Taiwan, USA – United States

Source: own calculations based on WIOD data.

Table 3. Comparative advantage indicators in the analysed countries in the years 2000–2014 (indices)

No.	Country	Average in 2000-2014					Country	Year of 2014				
		NEX	TBI	RCA	RMA	RSCA		NEX	TBI	RCA	RMA	RSCA
1	BRA	15.01	0.16	4.37	0.35	0.63	BRA	10.73	0.13	4.71	0.41	0.65
2	AUS	2.76	0.06	1.72	0.59	0.23	AUS	2.42	0.05	1.25	0.64	0.11
3	IDN	2.06	0.04	1.83	1.36	0.28	IDN	1.90	0.04	2.35	1.48	0.40
4	NLD	1.87	0.03	2.05	1.34	0.35	NLD	1.82	0.03	1.96	1.38	0.32
5	DNK	1.77	0.03	2.81	1.66	0.47	HUN	1.67	0.03	1.07	0.72	0.04
6	HUN	1.74	0.03	1.05	0.63	0.02	POL	1.59	0.03	1.60	1.04	0.23
7	TUR	1.60	0.03	1.34	0.49	0.14	ESP	1.54	0.02	2.22	1.45	0.38
8	NOR	1.50	0.03	0.82	1.02	-0.10	DNK	1.52	0.02	2.61	1.75	0.45
9	IND	1.45	0.02	1.21	0.59	0.08	NOR	1.45	0.02	0.97	1.16	-0.01
10	CAN	1.43	0.02	1.08	0.89	0.04	CAN	1.39	0.02	1.22	0.98	0.10
11	IRL	1.38	0.02	1.22	1.49	0.09	BGR	1.33	0.02	2.05	1.23	0.34
12	ESP	1.38	0.02	2.29	1.35	0.39	IND	1.31	0.02	1.03	0.55	0.01
13	POL	1.33	0.02	1.35	0.89	0.14	USA	1.19	0.01	1.18	0.65	0.08
14	FRA	1.28	0.01	1.69	1.20	0.26	BEL	1.16	0.01	1.27	1.19	0.12
15	BGR	1.21	0.01	1.79	1.01	0.27	IRL	1.15	0.01	1.31	1.73	0.13
16	BEL	1.20	0.01	1.29	1.16	0.13	FRA	1.14	0.01	1.62	1.25	0.24
17	USA	1.14	0.01	1.12	0.61	0.06	LTU	1.10	0.01	2.19	1.77	0.37
18	LTU	1.14	0.01	2.14	1.45	0.35	TUR	0.99	0.00	1.19	0.64	0.09
19	CHN	1.08	0.00	0.53	0.54	-0.32	MEX	0.97	0.00	0.79	0.87	-0.12
20	AUT	0.92	-0.01	0.90	0.98	-0.05	CZE	0.94	0.00	0.64	0.84	-0.22
21	MEX	0.89	-0.01	0.79	0.91	-0.12	DEU	0.93	0.00	0.74	1.03	-0.15
22	DEU	0.87	-0.01	0.72	1.05	-0.16	LVA	0.91	-0.01	2.14	1.92	0.36
23	SVK	0.84	-0.01	0.60	0.80	-0.26	ITA	0.91	-0.01	1.18	1.52	0.08
24	ITA	0.83	-0.01	1.11	1.43	0.05	AUT	0.89	-0.01	0.96	1.12	-0.02
25	CZE	0.80	-0.01	0.57	0.78	-0.27	EST	0.88	-0.01	1.26	1.29	0.11
26	EST	0.80	-0.02	1.30	1.34	0.13	ROU	0.86	-0.01	1.05	1.08	0.03

Table 3. Continued

No.	Country	Average in 2000-2014					Country	Year of 2014				
		NEX	TBI	RCA	RMA	RSCA		NEX	TBI	RCA	RMA	RSCA
27	LVA	0.65	-0.04	1.85	1.92	0.28	SVK	0.82	-0.01	0.54	0.84	-0.30
28	GRC	0.64	-0.03	3.39	1.93	0.54	CHE	0.78	-0.01	0.44	0.61	-0.39
29	CHE	0.59	-0.03	0.42	0.76	-0.41	GRC	0.77	-0.02	2.92	2.12	0.49
30	SWE	0.56	-0.04	0.61	1.19	-0.25	LUX	0.64	-0.03	1.15	1.50	0.07
31	LUX	0.55	-0.04	0.94	1.41	-0.03	PRT	0.60	-0.03	1.54	2.10	0.21
32	ROU	0.51	-0.05	0.72	1.03	-0.20	SWE	0.59	-0.03	0.86	1.45	-0.08
33	GBR	0.49	-0.04	0.80	1.21	-0.11	CHN	0.50	-0.04	0.35	0.74	-0.48
34	PRT	0.47	-0.05	1.32	1.94	0.13	GBR	0.49	-0.04	0.82	1.23	-0.10
35	FIN	0.42	-0.06	0.33	0.86	-0.50	SVN	0.43	-0.06	0.49	1.18	-0.34
36	HRV	0.38	-0.07	1.18	1.34	0.08	HRV	0.37	-0.07	1.25	1.78	0.11
37	SVN	0.37	-0.07	0.41	1.02	-0.42	RUS	0.35	-0.06	0.29	1.29	-0.55
38	TWN	0.28	-0.08	0.18	0.63	-0.70	FIN	0.31	-0.07	0.34	1.08	-0.49
39	CYP	0.26	-0.10	3.63	2.29	0.55	TWN	0.26	-0.08	0.15	0.66	-0.74
40	KOR	0.25	-0.09	0.19	0.85	-0.69	CYP	0.23	-0.10	1.96	2.47	0.33
41	MLT	0.22	-0.12	0.54	1.18	-0.32	KOR	0.22	-0.09	0.15	0.83	-0.74
42	RUS	0.16	-0.11	0.17	1.86	-0.72	MLT	0.20	-0.13	0.63	0.90	-0.23
43	JPN	0.05	-0.18	0.07	1.81	-0.88	JPN	0.05	-0.17	0.07	1.38	-0.87

Notes: abbreviations and full names of the countries as below Table 2.

Source: own research based on UNCTADStat data.

Table 4. Correlation coefficients between analysed variables

Data corrected by cross-section fixed effects					
Variable	L_NEX	L_RD	L_RULC	L_OPEN	L_RLPR
L_NEX	1.00	0.11	-0.22	0.37	0.02
L_RD	0.11	1.00	-0.10	-0.12	-0.63
L_RULC	-0.22	-0.10	1.00	0.18	-0.34
L_OPEN	0.37	-0.12	0.18	1.00	-0.15
L_RLPR	0.02	-0.63	-0.34	-0.15	1.00
Data corrected by cross-section fixed effects and individual trends					
Variable	L_NEX	L_RD	L_RULC	L_OPEN	L_RLPR
L_NEX	1.00	0.18	-0.11	0.20	-0.12
L_RD	0.18	1.00	-0.04	-0.18	-0.58
L_RULC	-0.11	-0.04	1.00	0.28	-0.31
L_OPEN	0.20	-0.18	0.28	1.00	-0.15
L_RLPR	-0.12	-0.58	-0.31	-0.15	1.00
First differences of data					
Variable	L_NEX	L_RD	L_RULC	L_OPEN	L_RLPR
L_NEX	1.00	0.19	-0.05	0.02	-0.11
L_RD	0.19	1.00	0.04	-0.26	-0.54

Table 4. Continued

First differences of data					
L_RULC	-0.05	0.04	1.00	0.21	-0.49
L_OPEN	0.02	-0.26	0.21	1.00	0.00
L_RLPR	-0.11	-0.54	-0.49	0.00	1.00

Notes: Critical values at 5% significance levels are: 0.077 for corrected levels and 0.080 for first differences of data.

Source: own calculations based on WIOD and UNCTADStat data.

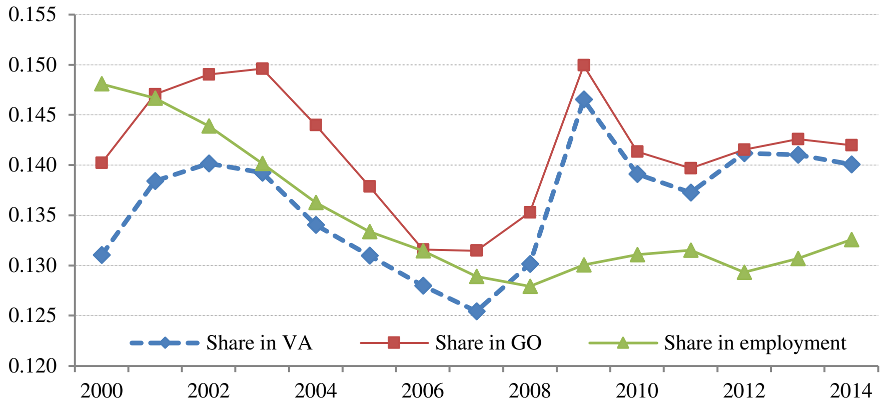
Table 5. Panel models estimated for L_NEX

Model estimated with no cross-sectional weights						
Model:	**M1: level, CSFE, PFE**		**M2: level, CSFE, PFE, IT**		**M3: 1-st diff, PFE**	
Variable	β coeff.	p-value	β coeff.	p-value	β coeff.	p-value
L_RD	0.201	0.108	0.158	0.119	0.172	0.000
L_RULC	-0.385	0.051	-0.339	0.021	-0.269	0.002
L_OPEN	0.545	0.000	0.414	0.010	0.324	0.000
L_RLPR	0.187	0.311	-0.012	0.948	-0.016	0.820
Selected statistics of model and respective p-values						
F(CSFE)	370.728	0.000	241.424	0.000	-	-
F(PFE)	5.920	0.000	3.199	0.000	3.178	0.000
F(IT)	-	-	17.850	0.000	-	-
J-B	175.180	0.000	185.020	0.000	236.720	0.000
D-W	0.501	-	1.095	-	2.268	-
SE	0.177	-	0.119	-	0.118	-
Model estimated with cross-sectional weights						
Model:	**M4: level, CSFE, PFE**		**M5: level, CSFE, PFE, IT**		**M6: 1-st diff., PFE**	
Variable	β coeff.	p-value	β coeff.	p-value	β coeff.	p-value
L_RD	0.196	0.000	0.102	0.048	0.080	0.012
L_RULC	-0.401	0.000	-0.423	0.000	-0.311	0.000
L_OPEN	0.490	0.000	0.435	0.000	0.267	0.000
L_RLPR	0.165	0.039	-0.037	0.613	-0.027	0.598
Selected statistics of models and respective p-values						
F(CSFE)	601.779	0.000	358.010	0.000	-	-
F(PFE)	13.584	0.000	5.604	0.000	3.314	0.000
F(IT)	-	-	25.511	0.000	-	-
J-B	11.940	0.003	3.401	0.182	0.509	0.775
D-W	0.712	-	1.257	-	2.056	-
SE	0.173	-	0.115	-	0.113	-

Abbreviations: CSFE - cross-section fixed effects; PFE - period fixed effects; IT - individual trends for countries; F(…) - F statistics for redundant variables test; J-B - Jarque-Bera test statistic; D-W - Durbin-Watson autocorrelation test statistic; SE - standard error of the regression model

Source: own calculations based on WIOD and UNCTADStat data.

Figure 1. The share of the food industry of all analysed countries in total figures for the secondary sector in the years 2000–2014 (indices)



Notes: VA – value added, GO – gross output

Source: own calculations based on WIOD data.