

Article

Vulnerability of European Union Economies in Agro Trade

Lubomír Cívín¹ and Luboš Smutka^{2,*} 

¹ Department of Trade and Finance, Faculty of Economics and Management, Czech University of Life Sciences Prague, Kamycka 129, 16500 Prague, Czech Republic; civinl@pef.czu.cz

² Department of Economics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Kamycka 129, 16500 Prague, Czech Republic

* Correspondence: smutka@pef.czu.cz; Tel.: +420-734-123-432

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Abstract: The European Union (EU) is characterized by a high level of openness to trade, consequently increasing its member countries' vulnerability to external shocks coming from the rapidly changing global environment. The paper's objective was to compare and evaluate the factors of the EU agribusiness, its vulnerability and its measurement tools, and consequently to create subgroupings within EU member countries with different levels of vulnerability to exogenous shocks. The study hypothesized that the EU is not a homogenous unit regarding its trade sensitivity and vulnerability. It analyzed this phenomenon using data of recognized international institutions. Its method was a multi-criteria analysis with summative scaling. The assessment of the analysis was provided by the linear aggregation of 19 relevant vulnerability-influencing parameters, including climate change risk and political stability. The study results confirmed the hypothesis of the EU heterogeneity and identified four groups of member countries with different levels of the vulnerability to global shocks. It can improve an understanding of the agrarian sector position within the EU economy and a more precise re-formulation of its Common Agricultural Policy (CAP) priorities under the new conditions requiring the comprehensive resilience of the sector.

Keywords: economic vulnerability; external shocks; trade openness; EU agro trade; common agricultural policy

1. Introduction

The scenarios of the future global economic development within the framework of actual crisis development look very uncertain. This is not just because its main driver—the globalization process—has been put under a question mark; the global flows of trade and investments have been documented to slow down during the previous decade. The crisis also raised more options for further development, starting from two potential new phases of globalization and up to three other options of de-globalization as described, e.g., by Cívín in [1]. More and more, the higher probability looks in favor of the latter options because of the recent coronavirus global crisis, and because the follow-up adaptation processes will be stressing the topic of de-globalization even more, being the subject of the most actual discussion, e.g., by Keen [2]. It also raised the more general question of economic vulnerability to exogenous shocks as an additional factor promoting this tendency.

The developments during the last couple of years confirmed this thesis already after the US presidential elections in 2016. The follow-up processes opened the process of de-globalization in different forms. Among them, there are traditional trade and customs wars between the dominating global economies, the comeback of geo-economics in the form of political interference in global trade, investments and financial flows, and the reduction of global value chains intensity. It has also influenced

the geopolitical environment by increasing tensions in international relations and a weakening of the global governance rules-based system represented by the weakening position, activities and respect to international formal or informal institutions, such as World Trade Organisation (WTO), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organisation (WHO), G8 (G7) or G20. A relatively new issue influencing the changing global economic and political development that will also modify the future conditions of economic and social development is the environmental and climate change mitigation currently represented and promoted by many world politicians.

All of the factors mentioned above are increasing economic vulnerability in international economic relations. Consequently, they will also have an impact on economic and social developments in individual countries through distortions of supply, demand and price volatility on their local markets, but also on national, regional and world trade. The impact of the economic vulnerability has much broader implications because it increases the threats of social conflict emerging in countries exposed to external and exogenous shocks. The level of those risks considers the severity of such shocks, revealing hitherto hidden internal economic and social conflicts, which they may exacerbate.

Economic vulnerability is a subject of attention from influential global institutions like the UN, United Nations Conference on Trade and Development (UNCTAD), Organisation for Economic Co-operation and Development (OECD), renowned universities and research institutes, as well as individual authors or groups of scientists of different social (mostly economic) disciplines. Until now, the focus had been on the economic vulnerability of developing countries, with particular attention given to the least developed countries. The recent developments of the global economy and geopolitics revealed that economic vulnerability could have a serious influence also within the developed economies group and economic subgroupings like the EU.

In general, the economic vulnerability affects growth, sustainable development and the ability to withstand external shocks caused either by economic, political or other factors, particularly in many small and medium-sized countries. The long-term process of internationalization and globalization resulted in a tendency of national economies to specialize in international trade and opening their economies. This well-known fact can be documented by growing openness to trade worldwide as well as by the concentration and specialization of their foreign trade. The degree of openness to trade as well as foreign trade concentration are generally understood to be in indirect proportion to the economy's dimension. The reason is that smaller economies are usually more open and their trade demonstrates deeper specialization than large ones. The foreign trade then generates sensitivities, increasing the vulnerability to external shocks and potentially impacting particular sectors and markets.

In the upcoming years, there are many new external factors expected to come, which can generate external shocks for many national economies or their integration subgroupings (including the EU). Among them, it is possible to disclose not just expected economic stagnation or depression only, but also a permanently deteriorating geopolitical situation and growing tensions between the US, China, the EU, the Russian Federation, Iran, North Korea, etc. The recent development of international economic and geopolitical relations and partial analyses of their impact (see, e.g., Civin, Smutka [3] or Havlik [4]) shows that global agro trade is sensitive to several events affecting the agricultural sector that originate from global politics. Still, it also has a vice versa effect of de-globalization on them. The extremes of the agro-climatic development in the recent decade show that the ecology is emerging as a new factor affecting the economic vulnerability of economies to global climate change as well as affecting the political-economic response of individual countries or their integration groupings.

The recent coronavirus crisis has revealed the role of the new consequence of globalization—the speed and spread of fatal diseases broadly supported by the intensity of international and interpersonal relations in all spheres of social life. To eliminate the negative effects of this intensification during the pandemic, the push to shorten and bring global supply chains back home in the name of resilience is accelerating among the general public and politicians. The cumulative effects of all these factors represents strategic challenges requiring strategic solutions on the national as well as the regional

(integration) level. This challenge is of particular importance to the agricultural business of many countries and regions of the global economy, among them the European Union, which is one of the key players on the global markets.

Agriculture still plays a vital role in shaping Europe's future, including in the optics of the resilience of its economy. The EU Common Agricultural Policy (CAP) was and remains the key component of its set of common policies. Although the recent coronavirus crisis will modify the EU budget and lead to changes, the CAP will still play an important role in it. Many economists confirmed that both the global food system and the EU food supply did not yet suffer big damages due to the coronavirus crisis. Still there are signs of potential issues in the near post-crisis period [5].

The new situation requires introducing some direct and indirect political measures focused on strengthening the resilience to external shocks of economies, including the agricultural sector. To understand such measures, it is important first to identify and measure the vulnerability acting particularly in the economies' foreign trade, which is the main factor contributing to the transfer of external shocks to the national economies or their regional groupings. Climate change in the broadest sense of the word (including globally spreading pandemic diseases) will also become in the near future an important factor requiring strengthening the resilience of EU economies to shocks that can also act from within economies, especially in the agricultural sector.

Measuring and consequent classification form an important contribution to the identification and potential addressing of this vulnerable part of many national economies of EU member states. As the agrarian politics of the EU are one of the critical items of the EU budget [6], there is also a susceptible political factor that comes under the pressure of potential external shocks coming from the global economic and political environment.

This study tries to identify the vulnerability factors in the sphere of the EU agribusiness and their gauging. This paper hypothesis is that although the overall vulnerability of the EU agribusiness sector is not large, it is not homogenous, but rather has a differentiated and asymmetric character inside the Union. The expected goal in such a case is the creation of subgroupings within EU member countries with different levels of vulnerability to exogenous shocks. Consequently, different member countries should look for different policies to eliminate or at least to reduce their vulnerability and increase resilience in this sphere.

2. Materials and Methods

2.1. Data Used in the study

The study uses data from many different sources of information taken from accessible databases of various international institutions, both intergovernmental and non-governmental. The methodology of multicriteria analysis and a summative scaling solves this problem of data homogeneity. There are three groups of macroeconomic data used:

- The first group consists of general macroeconomic data obtained from international statistics resources: Eurostat, International Monetary Fund (IMF) and World Bank Development Indicators on-line databases, UN Statistical Department Annual Yearbooks, UN Department of Statistics (UN/DESA), Food and Agriculture Organisation (FAO) Yearbooks and online statistical database.
- The second group is represented by basic trade data, partly taken also from the online Eurostat database, UN International Trade Statistics Yearbook, UN Comtrade databases UNCTAD Stat Merchandise Trade Matrix, World Bank Commodity Price Data and TrendEconomy partly calculated from the underlying data. Some trade statistics data use different goods nomenclature systems Standard International Trade Classification (SITC) versus Harmonized System (HS), which do not provide a full compatible definition of agricultural products (i.e., SITC commodity groups 27–28 are included among agricultural products).
- The third group consists of data and indices used by other institutions in the field of political science and environmental research. The vulnerability to climate change is gauged by data

provided by the Notre Dame University project [7] in the US, and Germanwatch [8] from Germany, which systematically collect and evaluate open source data based on their broad research in this sphere. World Bank data are also used as a source for World Governance Indicators (WGIs) used for the assessment of the political climate within EU member states.

The study works mostly with data of 2018, because of their availability in the period of the analysis. In some cases the data for longer periods were used when the character of the analysis required such an approach (e.g., calculation of terms of trade volatility in the five years of 2014–2018) or the secondary data from external sources did not reach all the way to 2018 (2017 and in some cases even 2014). The problem of unification or comparison of some data, which are in many cases different in dependence on the source used, was solved by the method of a multi-criteria and summative scaling approach.

2.2. Methodology of the Study

The methodology of the research on economic vulnerability already exists. UNCTAD, IMF and the World Bank use the Economic Vulnerability Index (EVI) for the definition of Least Developed Countries (LDCs) to gauge their inclusion and graduation from the LDC category and dependence on international support measures in trade and development programs [9]. This index is in the form of a multi-criteria measure designed by Guillaumont [10], and it takes into account the specific position of LDCs in the global economy (see Figure 1 below). The category of LDCs is defined by specific criteria, which are incorporated into the EVI and two other supplementary indices. This approach helps understand their problems and identify the most critical topics characterizing their position in international economic relations and its impact on their internal economic a social position.

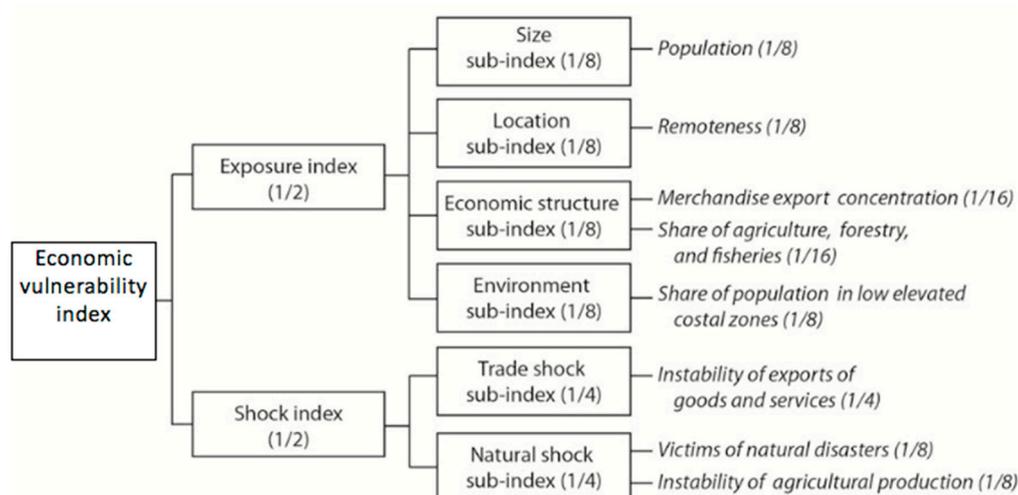


Figure 1. Decomposition of the Economic Vulnerability Index (EVI) for Least Developed Countries (LDCs). Source: [10].

The EVI's construction had been designed for the UN DESA Committee for Development Policy (CDP) as a tool for analyzing LDCs and some of their sub-grouping positions in “the triennial review of the LDC category” [11]. The methodology of EVI, which is just one of three criteria for inclusion into the LDC group, has been upgraded during the period of its existence by Guillaumont [12]. Figure 1 shows its actual composition, which consists of two indices with the same weight—the exposure and shock indices.

Although this methodological approach of multi-criteria analysis is in principle usable, it is not entirely appropriate to use it for the vulnerability analysis of agricultural trade in EU countries, which was the aim of this study, because the EVI applies to other (mostly least developed) countries.

Röhn, Sánchez, Hermansen and Rasmussen presented in an OECD study [13] another approach more suitable for this paper. The authors proposed a method to be used for analyzing the resilience of OECD countries to external shocks and creating an early warning system indicating the impending crises. They proposed the set of indicators allowing the construction of an early warning system of economic risks enabling the identification of economic and financial vulnerabilities and the assessment of specific risks for crisis-affected countries (see Figure 2 below). The empirical evidence and experience with the crisis in the year 2020 confirm the usefulness of the identification of such vulnerability indicators. They help to signal warnings of severe crises in OECD countries and are more related to the characteristics of EU member states' economies. Despite the fact that it is necessary to state that their study is more focused on the financial sector of the economy than on its productive part, and especially on agribusiness, it provides an appropriate model for the construction of the methodology for the goal of our study.

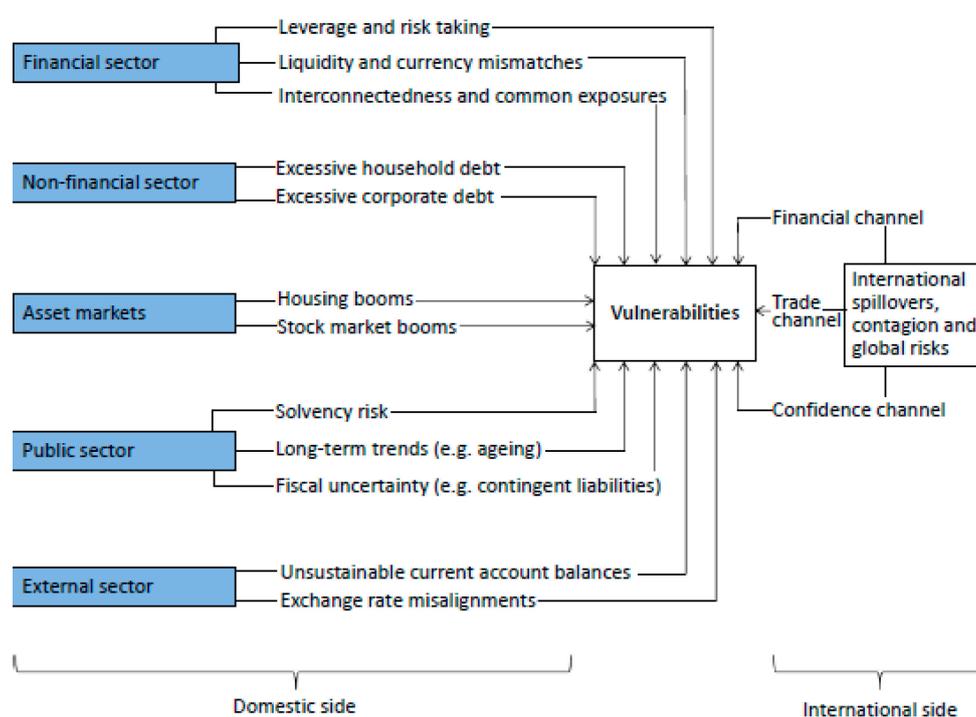


Figure 2. Scheme describing the vulnerability indicators sphere. Source: [13].

The methodological approach of this study uses the basic principle of multi-criteria analysis; however, the parameters and criteria are modified according to the needs of this study, as it aims to focus on agriculture. The final result creates groups of EU member countries with different vulnerability to exogenous shocks, which requires the use of some similar and some specific criteria and parameters for the final assessment. This study, therefore, uses more components and factors, with different groupings and different methods of assessments.

The multi-criteria analysis method used in this study consists of five follow-up steps:

(a) Identification of alternatives and selection of criteria.

The first step is to identify the resulting alternatives and select the criteria that are included in the analysis. In the beginning, the work is based only on the hypothesis of differentiated economies of individual member countries regarding approximately the same degree of vulnerability. The resulting study alternatives are known only in the general quantitative definition of the four expected groups that will form the outcome of the study.

Therefore, the critical factor was the identification of variables affecting the sensitivity, vulnerability or resilience of the analyzed economies to exogenous (i.e., mostly external) shocks. The selection criteria were divided according to different aspects, and in particular according to the nature of the criterion, into:

- Maximizing, where the decision is based on the desirability of a higher criterion value;
- Minimization, for which a lower value of the criterion is desired.

The choice of criteria routing can also be mixed, i.e., in terms of suitability of evaluation, maximizing and minimizing directions of orientation of individual criteria can be met. At the same time, it is important to maintain the correct scaling. The source of the selection is given by the professional expertise presented in different studies published by respectful international institutions (UN, UNCTAD, IMF, World Bank, WTO, FAO, etc.).

(b) Valuation (scaling) of criteria.

The most critical step determining the outcome of the analysis is the numerical evaluation of the criteria. Since these are different parametric values of different criteria, it was necessary to convert the transformations of these values into scales that correspond to the orientation of the influence of the evaluated variables on the resulting parameters. Scaling is a method of measurement that evolved out of efforts to measure “immeasurable” constructs. It requires the use of tools enabling association of qualitative indicators with quantitative metric units. Such a tool should allow the comparison and assessment of numerically non-homogeneous or incomparable data. The basic principle of scaling is the assignment of objects to numbers according to a given rule. Of particular importance here is the distinction between a scale and a response format. According to Trochim [14], there exist two categories of scales: one-dimensional and multidimensional, and three types of one-dimensional scaling methods are mostly used:

- Equal-appearing interval scaling (by Thurstone).
- Summative scaling (by Likert).
- Cumulative scaling (by Guttman).

For this study at this stage, the summative scaling by Likert has been chosen. Generally, for each criterion, a parameter is selected that has the largest informative value allowing to identify its influence on the given criterion and its orientation according to the influence characteristic (ascending or descending). For all criteria, four levels of scaling from the highest to the lowest significant were introduced. For better graphical identification, there are colors coded in the tables, allowing better orientation with the data set and subsequent grouping of countries within individual scales. Scale boundaries were chosen by using statistical quartiles (the first quartile, median and the third quartile) in some cases intuitively modified by an expert evaluation based on comparisons with related characteristics (size and economic level of economies, a similar development of export and import and their quantitative and qualitative values, etc.). Using quantiles, in general, allows orienting quickly in a large set of units and describing its internal structure. In this area, the possibility of further improvement and refinement of the study in the future opens, in particular, by using correlation and regression analysis methods that could refine parameterization.

(c) Normalization

The next step is to normalize (or assign) weights to individual parameters. It allows the result of the evaluation criteria and their weights to correspond to the meaning of the parameter under evaluation. This study applies a simple linear normalization, giving all criteria the same weight. The weights of the existing four scales have an ascending value, which increases the weight of each criterion parameter by one degree, thereby highlighting the final differences between the best and worst subjects of the assessment. Such a normalization does not take into account the differences

in the meaning of the individual criteria. This procedure was chosen to achieve compatibility and comparability between individual heterogeneous indicators and allow their final evaluation in the form of a scored rating. It is also the reason why for the final assessment they are converted into a linear form of the final assessment model, because this is a relatively large number of assessed criteria (19) in a set of 28 countries (the number of EU member countries before Brexit in 2020). Such a simplified procedure can be tolerated taking into account the possibility of clarification in further and deeper research and statistical analysis.

(d) Calculation of final evaluation ratings

The results of the grouping of individual alternatives are at the end obtained as the sum of the multiplication of the evaluation of countries according to particular criteria and weights that were given by the character of the scale to which the individual country was included. The assessment of each criterion was multiplied by the weight assigned to it in the previous step, and for each alternative all such multiples are added together. In the table, the product of weights and valuation are first calculated (i.e., the numbers entered into the cell in the previous two steps) in all cells. Then in the last column, there is the final score as the sum of all results as from individual cells on the given row (for this reason it is named a “summated” scaling). The sum of all ratings gives the final country score on the scale.

(e) Final assessment

The assessment of the interaction of all these factors, using the described multi-criteria analysis, was made in the form of final grouping the countries. It had been done according to the results of the above evaluation. As a result, there is the identification of certain groups of EU member states with different sensitivity to changes in the four most critical spheres of exogenous shocks (economic, trade, political and environmental).

3. The Content of the Study

The above-mentioned multi-criteria method requires the identification of the process steps reflecting the content of the study, which are defined as follows:

1. Identification of factors influencing the EU agrarian sector vulnerability;
2. Definition of parameters and indicators defining the most influential factors;
3. Identification of data sources;
4. Collection of data and their statistical processing;
5. Multicriteria analysis of data by the defined indicators;
6. Discussion on study results;
7. Conclusions and further study improvement and actualization recommendations.

To point 1. Factors influencing the EU agrarian sector vulnerability

This part will identify the key factors determining the economic vulnerability of national economies following the steps of the above-mentioned methodological process.

The economic vulnerability is mostly understood as the sensitivity of the country’s economy to trade shocks and its ability to react and adapt to them. Trade shocks are usually defined (e.g., by Izurieta and Vos [15]) as net extensive gains or losses of the country from its foreign trade. They can be induced by two groups of components, i.e., by changing prices in foreign trade and/or by volume of goods traded on world markets. That means that trade shocks can result from the action of those two components in four different situations, i.e., as the effect of a change in:

- (i) International prices of exported or imported goods;
- (ii) The volume of exports or imports demanded by (or from) the rest of the world.

The net result of the first component effect is in an economic theory usually called the terms-of-trade shock. The second component cannot be aggregated into one category of shocks because the changes in export demand, i.e., coming from the rest of the world, are understood and interpreted as an exogenous event (a true external “demand shock”). Because governmental foreign trade and fiscal policy can influence the change in the domestic demand for imports, it is considered as endogenous to the incomes and behavior of domestic economic entities. From this point of view, the change in the second component of (ii) can be presented as an “internal shock” [15].

The vulnerability is a reaction of individual economies to changes in global market developments that are not under their control, i.e., terms of trade and demand shocks. The relationships between terms of trade shocks and economic volatility are broadly discussed among theoreticians like Kpodar et al. [16], Juvenal and Petrella [17] and Schmitt-Grohe and Uribe [18]. Policymakers on both levels—regional groupings like the EU as well as national member countries—should be able to respond to trade shocks in real-time. This is particularly the case when economies under their political responsibilities and influence are more sensitive and vulnerable to external shocks.

Main factors determining the economy’s vulnerability in general, and particularly for the EU with focus on the agribusiness sector, could, therefore, be identified as follows:

- The dimension of the economy given by the absolute size of the market and its GDP;
- Economic development level;
- Degree of the economic openness to trade;
- The shape of this openness (foreign trade structural characteristics);
- Symmetry and asymmetry of foreign trade relations;
- Degree of diversification of the number of trade partners and their substitutability;
- Food vulnerability;
- Vulnerability to terms of trade shock represented by their volatility;
- Position of the agriculture sector within the economy and its relation to the trade profile;
- The internal potential of the agrarian sector used to replace imports and eventual failure of export markets;
- The sensitivity of the agribusiness sector to climate change risks;
- Vulnerability to extreme meteorological events;
- The nature of foreign policy relations with key trading partners;
- The political stability of the political system of the country.

There are also other factors influencing the vulnerability and resilience of the economy, but the data needed for assessment of their impact (like the creation of strategic reserves within the country in the form of public stockholdings) are for individual countries publicly not available. Many others are included indirectly (e.g., within the internal composition of some indices like ND-GAIN [7]).

To point 2. Definition of parameters and indicators defining the most influential factors

When attempting to analyze the vulnerabilities of individual economies, this study is based on measuring the impact of individual factors that affect it and determine the parameters and indicators that can be used to quantify them, and possibly further multicriteria analysis. The following indicators were used to quantify the effect of the above factors:

3.1. Economic Dimension of the Country

Under the term “the economic dimension of the economy” are included all economic activities understood to be taking place within its territory and market; see, e.g., Filip [19]. According to this indicator, the economic dimension of a given economy is largely determined by its geographic dimension and the size of its market, but this fact is modified by the level of economic development and its maturity. In the global economy, there are economies whose economic dimension contradicts

the real geographical dimension (they may have an economic dimension more or less important than their natural dimension). There exist different indicators of relative economic size, but in this paper the absolute nominal value of GDP in market prices is used as an indicator of the size of the economy, reflecting its dimensions and economic level.

There is a general assumption that understands world prices as an exogenous factor to the domestic economy. Such an approach is reasonable mostly for smaller countries, but may be questionable for some large economies, where internal shocks may influence world market prices. From this point of view, it is of particular interest to also include the country size in the analysis. That was the reason to divide the 28 EU member countries of the panel into quartiles according to their total GDP volume measured in EUR in 2018. This step creates four groups of countries, varying between four to nine members. The division into four groups is consequently used in other evaluation criteria as well.

3.2. Economic Development Level

There is no study known to the authors about the impact of the economic development level emphasizing the role of external shocks as domestic business cycles drivers. In general, it was estimated by Fernández et al. [20] that developed countries usually have a larger share of services in their total output. As a consequence, the higher non-tradable share in GDP should result in lower exposure to trade shocks. At the same time the size of the economy matters as well, and thus small but developed countries tend to be more open to the world economy, which can lead to a larger exposure to foreign trade shocks. To gauge the role of trade shocks as a source of business cycles and a relevant factor at different levels of economic development, the study uses the measure of GDP per capita (EUR in current prices) in four income levels of the EU countries: low income (two countries), lower-middle income (10 countries), upper-middle income (seven countries), and high income (nine countries).

3.3. Openness to Trade

Trade openness is one of the key sources of EU economic growth and also a prime factor determining their vulnerability but also the resilience of its member countries economies. A growing openness of a country to foreign trade limits the negative consequences of internal shocks. On the other hand, openness increases the impact of demand shocks. It is generally recognized that the impact of internal shocks is usually more extensive, whereas external (i.e., demand) shocks are more common. The knowledge of this condition represents the existence of two effects determining the extent and content of the trade openness:

- The structural openness characterizing its extent. This effect is conditioned by the size, production, trade specialization pattern and economic level;
- The functional openness determining a level to which governments can independently define and influence the content of the country trade pattern by their foreign trade policies.

It is necessary to understand that openness to trade itself is not the direct reason of economic vulnerability but plays more a role of the transmitter and amplifier of exogenous shocks to the domestic economy. In this role it can trigger increased exposure to external shocks as well as on the other hand reduce output volatility, creating by its policy opportunities for trade diversification.

The trade openness of national economies is measured in different ways (see, e.g., Fujii [21]), typically by the share of exports, or by the total foreign trade turnover (the sum of exports and imports) to GDP used by World Bank statistics [22]. An optional measure is also one half of the sum of export and import divided by GDP (used by Le Centre d'études prospectives et d'informations internationales (CEPII) [23]. Other trade openness indicators are the export to output ratio, the import penetration ratio and the net export to output ratio.

Openness to trade (OT) is calculated using the following equation:

$$OT(\%) = \frac{(X_i + M_i)}{GDP} * 100 \quad (1)$$

where X_i is the export of the country i , M_i is its import and GDP is the absolute value of its gross domestic product. All parameters are in the current prices of the same currency.

For another openness indicator suitable for gauging the openness of sectors of an economy (e.g., agriculture), the following equation can be used:

$$OT_j(\%) = \frac{X_j}{GDP_j} * 100 \quad (2)$$

where j is the sector of an economy and other data have the same symbols as in (1).

The other **trade openness indicators** allow analyzing the degree to which a national economy and individual economic sectors and industrial segments are exposed to external shocks. The export to output ratio shows the importance of foreign markets for sectorial production. In other words, it is the share of production that is exported and/or imported. The higher the export or import to output ratio, the more important foreign sales and purchases are for the sector. Conversely, the import to output ratio shows the importance and dependency of foreign production for the local market.

This paper uses the following trade openness indicators:

- Trade openness defined by World Bank methodology (see Table 1), i.e., as in (1);
- Trade openness of the agriculture sector measured as a share of agricultural export out of the total production of this sector (2).

A country's strong dependence on international trade leads to a major impact of trade shocks, causing high growth volatility. A simple linear approach to the analysis of these parameters would indicate that reducing trade dependence and implementing an autarchy approach—i.e., protectionist trade policy measures (quite typical for some trade policies in the running period of de-globalization)—might appear desirable. Such a simplified political approach can probably damage the long-term growth perspectives and weaken the country's external shocks resilience. The definition of an appropriate policy to eliminate vulnerability must therefore include both support for self-sufficiency in the production of basic foodstuff items and improving the performance of foreign trade and its diversification.

3.4. Trade Concentration

The stability of export earnings is for many countries the factor also influencing the stability of economic growth. It is conditioned by the degree of their export and import concentration. Some studies, e.g., Steingress [24], revealed that countries export on average only 10% of the whole standardized merchandized goods nomenclature. In this relatively limited scope of export pattern half of their export earnings comes from only 1% of their exported goods. On the other side of the trading structure, countries import approximately a third of all existing goods. However, half of their import expenditure covers on average only 2% of all imported goods. There is an indirect proportion between the size of the economy and the degree of its trade concentration. The result of this negative correlation is that small countries usually have a higher level of exported goods specialization and consequently their export patterns are more concentrated than in large countries. Such specialization patterns generate vulnerabilities that influence the structure of the economy. Trade concentration increases a country's sensitivity to external shocks, which can have a (negative or positive) impact on relevant sectors and the foreign trade effects of the economy. Many less-developed small economies are highly exposed to demand shocks coming from their less diversified export markets and internal shocks based on the dependence upon strategic imports. This level of exposure increases the risk of high vulnerability not only from the economic point of view, but also to political and other exogenous shocks. High export income instability has important macroeconomic consequences, especially in periods of economic depression, by limiting growth and investment rates and raising unemployment, which usually generates negative social implications. The political response allowing to downgrade the high degree of trade relation concentration is the diversification of the country's foreign trade product and partner

profile, which can alleviate export earnings instability and reduce its negative impact on economic growth. Diversification of the export profile can follow two ways, namely either by expanding the product portfolio or increasing the number of trading partners (markets), which is considered an extensive diversification, or by increasing shares of export volumes across active products or trading partners, which is understood as intensive diversification.

The traditional measurement tool of trade (export and import) products and partners concentration is the **Herfindahl–Hirschmann Index** (HHI). It gauges the degree of product and partners' concentration, obtaining values between 0 and 1. A value close to 1 indicates a country's exports or imports are highly concentrated on a few products or trade partners. If there were only one trading partner or product, the HH index would obtain the value of 1. Values close to 0 indicate trade flows that are more homogeneously distributed among a larger set of products and/or trade partners. The value of 0.250 is usually considered as the threshold of monopolized concentration. HH indices of exports and imports of individual countries are annually published by the UN in the International Trade Statistics Yearbooks ([25] and [26]).

The equation of the HH index returning export (import) partners concentration is given as the sum of squares of the partners' share of total exports (imports):

$$HHIx = \sum_{i=1}^n \left(\frac{Xi}{X} \right)^2 \quad \text{and eventually :} \quad HHIm = \sum_{i=1}^n \left(\frac{Mi}{M} \right)^2 \quad (3)$$

where n is the number of trading partners for exports (imports), X_i (M_i) is the value of exports (imports) to partner country i and X (M) is the total value of exports (imports).

3.5. Food Security

To identify the **degree of vulnerability**, particularly in the agri-food sector of the economy, a suite of food security indicators is used by FAO [27,28]; among them there are the indicators in the sphere of foreign trade. For this particular analysis, the **value of food imports in total merchandise exports (%)** is used:

$$FST = \frac{FM}{X} * 100 \quad (4)$$

where FST is the **Food Security Trade indicator**, FM is the value of food imports (SITC 1) and X is the exports value. Its relationship to the food trade vulnerability is descendent.

3.6. Trade Balance

Another indicator of foreign trade that expresses the vulnerability of the economy is the trade balance (BOT), both in overall terms and in individual product or country groups:

$$BOT = X - M \quad (5)$$

or some of its ratios in relation to total exports or imports (specifically for the EU measured against total or extra EU exports/imports), as it is assumed that the EU as a regional trade structure representing a common market for goods, services, capital and persons will behave as a single trade unit, so that it is able to offset the trade balance deficit of its members in the event of intra-EU trade. The BOT Coverage Index (BCI) (6) or the trade balance's share of imports (TBM) (7) can be used for the measurement.

$$BCI = \frac{BOT}{X} \quad (6)$$

$$TBM = \frac{BOT}{M} \quad (7)$$

3.7. Price Changes and Terms of Trade

The vulnerability of foreign trade is in principle reflected in export and import price changes, their volatility and the consequences. This volatility depends on the origin of its sources (external or internal) and the national economy's degree of exposure. The ability of governmental policies to reduce or eliminate world price volatility depends on the correct identifications of these factors. External price shocks are transmitted onto domestic markets at a different from timing as well as a different territorial point of view. Domestic shocks, stemming chiefly from production shortfalls, are typically more frequent than international shocks, so market openness may help reduce the frequency of shocks. International shocks are more influential to smaller open economies (see Schmitt-Grohe and Uribe [29]).

The price development in a country foreign trade is usually characterized by **Terms of Trade (ToT)**. They are defined as the ratio between export and import prices multiplied by 100 to get the result in percentage. *ToT* as a parameter of vulnerability in this paper is calculated as the ratio between commodity export price index Px_j weighted by total commodity exports and commodity import price index Pm_j weighted by total commodity imports with deflation indexation to the basis year (which for purpose of this study is 2015 = 100).

$$ToT = \frac{Px_j}{Pm_j} * 100 \quad (8)$$

As such, a *ToT* shock may result from a shift in export and import prices, or from not perfectly offsetting movements in both. An analysis of *ToT* shocks implicitly assumes that the economies respond symmetrically to changes in both of their components, i.e., export and import prices. Some new studies, e.g., Juvenal and Petrela [16], identified that this is not usual. Their study revealed that the volatility of export price shocks is higher than import price shocks. They also documented that the effects of export price shocks have longer-lasting effects on the domestic economy. Their study results helped reveal the character of the heterogeneous impact of *ToT* shocks on different countries. This impact is determined by different characteristics of export and import flows and the fact that the commodity export share is in general much higher than their import share (see Tables 2 and 3 in the next Chapter).

The *ToT* reflects the situation in one year, which may not reflect the dynamics of development for a longer period of time. The sensitivity of the economy to external *ToT* shocks reflects the stability of the indicator better by averaging it over a longer period than one year. The measurement of statistical deviation from the average value allows identifying *ToT* volatility in time. The greater the deviation, the greater is the volatility of the country's foreign trade prices, which are considered the main source of transfer of external shocks into the economy. The standard deviation from the *ToT* countries' average over the five-year period 2014–2018 is used in this study:

$$S_N = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2} \quad (9)$$

where S_N is the standard deviation, N is the number of periods, x_i is the value in the respective period and \bar{x} is the statistical mean of the values in the period.

The volatility of *ToT* in case the statistical mean and statistical deviation is available, and can be expressed by the coefficient of variation (CV), which indicates the relative importance of the standard deviation from the average, i.e., what percentage of the average is the standard deviation.

$$CV = \frac{S}{\bar{x}} \quad (10)$$

This indicator is the most suitable for comparing the variability of indicators and sets of units at different levels, as it is a dimensionless quantity usually expressed as a percentage.

3.8. Climate Change Risks

The UN, in its last forecasts [30], states that climate crisis risks are increasingly becoming a greater issue for many countries, independently of their economic development level. For all of them, the actions eliminating sources of global warming and its consequences have to become an integral part of their energy and environmental policy mix. The crucial goal has to be to decouple the relationship between economic activity, generation of greenhouse gases (GHG) emissions and global warming.

Addressing climate change requires the implementation of consequent political measures, including publicity to obtain the broad public support to these policies. The real economic and policy decision-making process still underestimates climate risks and promotes shortsighted investment decisions in carbon-intensive assets. The missing long-term vision makes environmental targets extremely difficult to achieve in the near future [30]. A transition to a new structure of the economy minimizing the negative impact of climate change will require enormous efforts by governments, the corporate sector and the general public; see, e.g., Wei and Chase [31].

Climate change represents a big scope of specific global, regional, national and corporate risks to future businesses activities. One group of such risks results from direct physical changes to the environment, while the second is indirectly resulting from the social response to climate change. The first group is usually named a physical risks and the second a transitional risks. Within the first group it is possible to identify two types of risks:

- (a) Event-driven acute ones, such as tornados, cyclones, hurricanes and floods;
- (b) Longer-term chronic ones, arising from changes in climate conditions, such as sea-level rise, drought and periodic heat waves.

Both types of this risk groups influence the entry parameters of the global, regional or national markets with agrarian products and decrease their stability and resilience.

The group of so-called transitional risks consists of:

- (a) Policy and legal risks resulting from a number of measures that will increase the costs related to GHG emissions, and other environmentally conditioned provisions increasing the costs of energy and other inputs;
- (b) Technology risks generated by changes and disruptions resulting from the introduction of new technologies into the production, transformation, information, distribution and other processes, which will drastically modify whole value-creating chains and their localization;
- (c) Market risks that arise as a consequence of climate change affecting customers' market behavior and their consumption customs.

When locating climate risks sources it is possible to distinguish between internal and external shocks originating from climate change. Their impact depends on to what extent the countries:

- Are supplied from climate-vulnerable locations;
- Rely on climate-vulnerable natural resource production inputs;
- Depend on supply chains and distribution systems located in climate change-vulnerable areas;
- Are their institutions not aware of supply risks, or lack resources to mitigate them;
- Create technology, policy or market risks by themselves [31].

Agroclimatic extremes can be seen as typical supply shifters that, on par with economic and structural drivers, distort supply, demand and trade, and induce price variability. Climate risks may also generate negative economic and social consequences to the agricultural sector, such as distortion of the food and water supply, decrease of incomes, financial problems, unemployment and erosion of farmers' livelihood. Economic simulation models (e.g., Chadzopoulos et al. [32]) typically operate under the assumption of "normal" growing conditions, contain no explicit parameterization of climatic anomalies on the supply side, and confound multifarious sources of yield fluctuation in harvest-failure scenarios.

However, some authors (e.g., Zampieri et al. [33]) follow a novel approach by augmenting a partial equilibrium model of global agriculture with a multi-scenario analysis where the most extreme temperature and soil-moisture anomalies of the last decades, be it negative or positive, recur in the near future.

For the identification of vulnerability to **environmental shocks**, the Combined Stress Index (CSI) is used. The CSI, originally developed in Zampieri et al. [33], is a descriptive indicator of historical agroclimatic extremes. Another approach proposed by Feindouno and Guillaumont [34] measures physical vulnerability to climate change and differentiates exogenous factors from factors linked to policy. The main idea is that such a separation of political (which mainly have an impact on resilience) and non-political factors is needed for the design of international policy measures where vulnerability has to be independent from domestic policy.

By definition, **climate is the statistics of weather over an arbitrarily defined time span**. Classical statistical methods use the assumption of stationarity, which implies that a variable's distribution (e.g., mean, variance, no trend) does not vary with time. Obviously, the stationarity assumption is violated under a climate change (e.g., warming) scenario. However, there are reprocessing approaches such as de-trending (see, e.g., Shea [35]), which allow the resulting data to be treated as "approximately" stationary.

3.8.1. Global Adaptation Index

The disadvantage of tools of climate statistics mentioned above for measuring the vulnerability of the country is that the data used for CSI calculations are determined not by country average, but on the regional level (better reflecting the real situation locally), so it is difficult to determine this index nationwide. It was, therefore, better to look for an more comprehensive instrument that can provide data for the EU member states as a whole. This study, therefore, uses the **Notre Dame Global Adaptation Index** (ND-GAIN) published by Notre Dame University, Indiana, USA, as part of the Notre Dame Adaptation Initiative project [36]. This index is a free, open-source index that shows a country's current vulnerability to climate disruptions and assesses its readiness to mobilize public and private investments to adaptations. It brings together over 74 variables to form 45 core indicators to measure the vulnerability and readiness of 192 UN countries from 1995 to 2018. The ND-GAIN index measures overall vulnerability by considering six life-supporting sectors of food, water, health, ecosystem service, human habitat and infrastructure; see Chen et al. [7].

A country's ND-GAIN index score is composed of a vulnerability score and a readiness score. The first one measures a country's exposure, sensitivity and ability to adapt to the negative impact of climate change, while the second one considers three components—economic readiness, governance readiness and social readiness. The final score returns results by subtracting the vulnerability score from the readiness score for each country, and scales the scores to give a value between 0 and 100, by using the formula:

$$ND\text{-Gain score} = (Readiness\ score - Vulnerability\ score + 1) * 50 \quad (11)$$

The index has a descending value orientation, i.e., a lower score indicates lower vulnerability. A higher vulnerability score means higher vulnerability ("worse") and a higher readiness score means higher readiness ("better") [7].

3.8.2. Vulnerability to Extreme Meteorological Events

The next quantitative parameter used in the analysis is the long-term Climate Risk Index (CRI), which analyzes the quantified level of exposure and vulnerability to more frequent and severe climatic events for which countries should prepare, both in terms of fatalities and economic losses. The CRI is available for the period of 1998–2018; the most recent data used for this paper are available from 2018. The index is constructed as annual averages of the events in the analyzed period. The CRI had

been developed and is used by Germanwatch [8], based on data from the Munich RE NatCatSERVICE German reinsurance company, providing one of the world's most comprehensive databases for analyzing and evaluating natural catastrophes. The CRI examines both absolute and relative impacts to create an average ranking of countries in four indicating categories, with a stronger emphasis on the relative indicators. The CRI 2020 data are based on the loss figures of 181 countries from the period 1999 to 2018. Each country's index score has been derived from its average ranking in all four indicating categories, according to the following weighting: death toll, 1/6; deaths per 100,000 inhabitants, 1/3; absolute losses in purchasing power parity (PPP), 1/6; losses per GDP unit, 1/3. The index has an ascending valuation, so countries with the highest values are the ones most impacted [8].

3.9. Political Stability and Governance Quality

An absence of political stability is also considered to be directly linked with higher output volatility. It is in part due to its impact on economic and investment activities but also because they also create economic uncertainties in parallel with political ones. To measure the influence of this factor, the study uses the methodology of the World Bank Policy Research Group. It is known as World Governance Indicators (WGI), prepared by the team of Kaufmann et al. [37] with results regularly published by the World Bank in its Data Catalog [22]. The World Bank uses in its WGI aggregate and individual governance indicators six dimensions of governance: voice and accountability; political stability and absence of violence or terrorism; government effectiveness; regulatory quality; rule of law; and control of corruption.

Of these indicators, four are used in this study—political stability and absence of violence or terrorism; government effectiveness; regulatory quality; and rule of law—as they are considered important factors regarding the vulnerability of the economy's trade relations. The index of **political stability and absence of violence/terrorism** measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means. It is expressed in the percentile rank, which indicates the country's rank among all countries covered by the aggregate indicator, with 0 corresponding to the lowest rank, and 100 to the highest rank. An upper percentile rank refers to the upper bound of a 90 percent confidence interval for governance, expressed in percentile rank terms.

The next indicator used in the study is the **government effectiveness**, which captures perceptions of the quality of public services, the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimates give a country's score on the aggregate indicator in units of standard normal distribution, i.e., ranging from approximately -2.5 to 2.5 .

The **rule of law** indicator quantifies perceptions of the extent to which citizens have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police and the courts, as well as the likelihood of crime and violence. Estimates give a country's score on the aggregate indicator in units of standard normal distribution, i.e., ranging from approximately -2.5 to 2.5 .

The **regulatory quality** indicator reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimates give a country's score on the aggregate indicator in units of standard normal distribution, i.e., ranging from approximately -2.5 to 2.5 .

The final resulting **WGI** factor is then calculated as the arithmetic mean of the above-mentioned four state management quality indicators. The resulting parameter is part of the final evaluation of the domestic policy impact on the vulnerability of individual economies in the ascending direction in the range from -2.5 to 2.5 in four groups.

To these indicators of political character, two more added in the form of **dummy variables**, which are important for the character of international relations, especially on the European continent, namely NATO membership and Eurozone (EZ). This parameter is gauged as a dummy variable for the value of NATO/EZ membership (1) or non-membership (0).

4. Results

The study comprehensively assessed the vulnerability of the agricultural sector trade within the EU on two levels, as aggregated data at the level of the whole EU and at the level of individual economies according to several groups of indicators as follows:

1. Macro-economically, where the focus is on key parameters in this area, such as GDP, GDP per capita and openness of the economy (see Table A1);
2. Position of the agricultural sector in the economies of EU countries (Table A2);
3. Basic quantitative characteristics of foreign trade in EU countries (Table A3);
4. Basic qualitative indicators of foreign trade in EU countries (Table A4);
5. Indicators on agro trade of EU countries in the intra- and extra-territorial trade of the EU (Table A5);
6. Indicators of environmental vulnerability (Table A6);
7. Indicators of political stability (Table A7).

4.1. Aggregated EU Results

The total results of EU foreign trade present that the EU as a whole is not facing some crucial risks dealing with vulnerability in its agricultural trade. But there are some risks generated in this sphere coming from its growing openness of its trade in general presented in Table 1, particularly connected to its high integration to global value chains. The coronavirus crisis in 2020 showed some serious negative features of this participation.

Table 1. EU Trade openness 1970–2018.

Year	Trade(% of GDP)
1970	39.48
1975	44.47
1980	51.22
1985	56.82
1990	52.89
1995	56.54
2000	71.16
2005	73.38
2010	78.54
2015	87.44
2018	90.75

Source: World Bank national accounts data, and OECD National Accounts data files [22]. License CC BY- 4.0.

The shape of the openness of the economy can be identified by some indicators such as export and import structure, balance of trade, active or passive balance of payments, and the convertibility of national currency and its exchange rate volatility. For comparison, the commodity structure (using HS 4-digit classification coding) of EU foreign trade in 2018 was as follows [26]:

The structure of imports to the EU (28) in the year 2018 included the following principal commodities representing a higher share than 1% of the total import volume (Table 2).

Table 2. Structure of EU imports in 2018 with share higher than 1%.

Commodity Group	HS Code	Share in %
Petroleum oils and oils obtained from bituminous minerals, crude	2709	11.9
Radio, television, reception, recording or reproducing apparatus	8525	3.75
Petroleum oils, other than crude	2710	3.5
Automatic data processing machines and units	8471	3.1
Petroleum gases and other gaseous hydrocarbons	2711	2.68
Motor cars and other motor vehicles	8703	2.33
Turbo-jets, turbo-propellers and other gas turbines	8411	2.09
Medication	3004	1.64
Electronic integrated circuits and micro-assemblies	8542	1.41

Source: authors' calculations, UN Comtrade data [26].

The structure of exports from the EU (28) in 2018 included the following principal commodities representing a higher share than 1% of the total export volume (in accordance with HS 4-digit classification) (Table 3):

Table 3. Structure of EU exports in 2018 with share higher than 1%.

Commodity Group	HS Code	Share in %
Motor cars and other motor vehicles	8703	6.53
Medication	3004	5.18
Petroleum oils, other than crude	2710	4.14
Other aircraft; spacecraft; suborbital and spacecraft vehicles	8802	2.77
Human and animal blood, vaccines and similar products	3002	2.62
Parts and accessories of the motor vehicles	8708	2.35
Turbo-jets, turbo-propellers and other gas turbines	8411	2.16
Gold (including gold plated with platinum)	7108	1.62
Machines and mechanical appliances, not specified	8479	1.19

Source: authors' calculations, UN Comtrade data [26].

On a global level, we can see that according to Steingress [26] the EU as a whole does not reach a sensitive threshold of 1% in its agricultural trade (at the level of HS 4-digit decomposition) in any item.

Total (extra- and intra-) EU agricultural imports (SITC 0–2, 4) of EU member countries in 2018 represented the sum of 1,133,752 billion EUR, out of which 904,945 billion EUR were the external trade, i.e., trade with non-member countries (58.6%). The composition of the EU's agricultural imports was as follows: foodstuffs accounted for one third (32.0%) of the value of EU imports, crops were nearer to one half (47.8%) and animals and animal products accounted for about one fifth (20.2%).

The EU food trade data according to SITC (2-digit aggregation) are as follows: total (extra- and intra-EU) agricultural exports (SITC 0–2, 4) of EU member countries in 2018 represented the sum of EUR billion 1,102,385, out of which EUR billion 637,538 were the external trade, i.e., trade with non-member countries (57.8%). The export structure of agricultural goods was as follows: foodstuffs accounted for a majority (57.4%) of the agricultural goods exported from the EU in 2018. The values of crop and animal and animal product exports from the EU were very similar, at about EUR 29.6 billion and EUR 29.0 billion, respectively.

The trade balance was negative in a total sum of EUR billion –31,367 (i.e., a 2.8% share of all agriculture exports only). These data present the fact that on the aggregate level the EU as a whole has in its foreign trade profile no agro trade commodities, creating a dependency or an extensive vulnerability, both in the exports and in the imports.

The dynamic measure of the EU food vulnerability (unfortunately according to data up to 2014 only) gauged by the ND-GAIN vulnerability component for the food sector is shown in Figure 3 below. A higher value score in the vulnerability score means higher vulnerability (i.e., from a dynamic point of view the situation is getting “worse”). Figure 3 documents an overall increase in the vulnerability of the agricultural sector in the last decade.

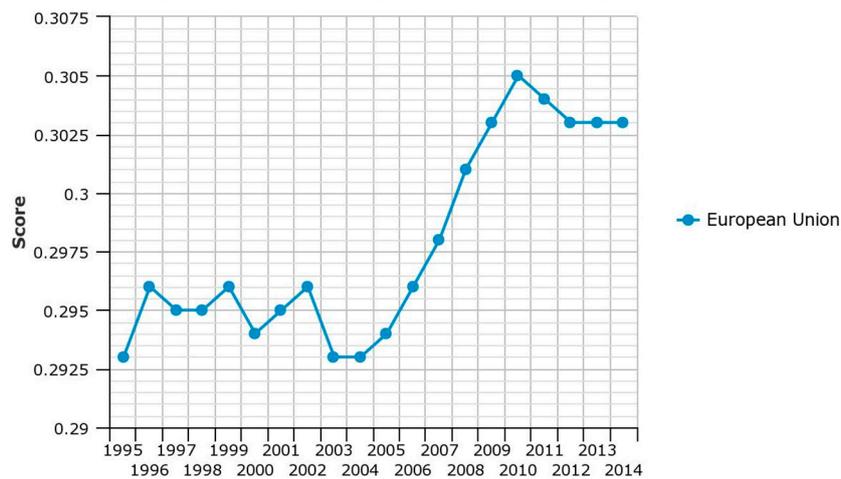


Figure 3. Notre Dame Global Adaptation Index (ND-GAIN) index development between 1995–2014. Source: Notre Dame (<https://gain-visualization.crc.nd.edu>).

The following Figure 4 presents the vulnerability factors composition of the EU food sector, where the food imports dependency reaches the highest level. The indicator is relative and is focused on the EU only, not comparing the values of other countries or country groupings. At any rate it is a piece of important information, which will be explained in the next comment providing characteristics of the situation in individual EU member countries.

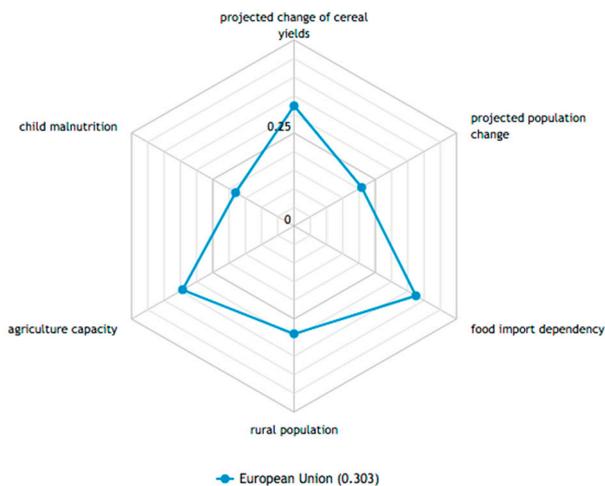


Figure 4. ND-GAIN composition in 2014. Source: Notre Dame (<https://gain-visualization.crc.nd.edu>).

4.2. Individual Country Results

A different situation can emerge at the level of some member countries. In this context it is necessary to say that the biggest share of the negative trade balance of agricultural products was generated in 2018 by the United Kingdom, which is since 1.2.2020 no more a EU member, which will substantially increase the agricultural self-sufficiency and resilience of the EU as a whole. However, this does not mean that vulnerability in the field of agribusiness does not arise at the level of individual member states.

A summary of the data from individual EU member countries is presented in seven group indicators in Appendix A (Tables A1–A7) together with the scaling used for the final assessment in Appendix B (Table A8) and Table 4 (page 21) and Table 5 (page 22). The color of respective data in tables correspond to the level of influence of each indicator to vulnerability, as showed on the bottom of each table in the section Vulnerability.

Table A1 shows the basic macroeconomic data as GDP per capita characterizing the level of economic development, the absolute value of GDP defining the size of the economy (economic dimension of the country) and trade openness by Equation (1) in the above-mentioned chapter of this paper. The table defines its legend the scaling of different parameters and the direction of valuation (upside or downside). The scaling does not reflect the numerically increasing or decreasing values of the parameters, but rather their influence at the vulnerability of the particular economy, which in many cases can have the opposite meaning. Membership in the Eurozone (EZ) is used as a dummy variable (1;0), as a specific factor influencing the price volatility of member countries' trade, even if its contribution to it is not one-way-oriented, as it allows to trigger the terms of trade shocks in the case of extra-EU trade and reduces in intra-EZ trade. Its impact is reflected in the final valuation with a +/- one-point difference.

Table A2 presents data defining the position and performance of the agriculture sector (AGC) in individual countries. The indicators used for final evaluation are the share of the agriculture sector of the GDP (AGC/GDP in %), the productivity of the sector measured by the difference between the share of the sector of GDP creation and its share of employment in percentage points (pp). The logic of calculating this parameter is based on the fact that if the share of the sector in GDP is lower than the share of its employment in the economy, then the country has a productivity gap in this sector, given by the difference between these two indicators. The sector's openness to trade is defined as the share of the trade (with agricultural products as the output of the agricultural sector). It is assumed that the growing trade openness has a double effect: it allows eliminating internal shocks (crop failure, extreme natural influences such as drought, floods etc.). On the other hand, it can act as a trigger for the transmission of external shocks within the economy (by changing price relations, terms of trade, declining supply, etc.). In this study, overall trade openness is not considered to be a factor reducing the vulnerability of the EU economies as a whole, but rather as a factor acting as a starter for transmission in individual economies, especially for countries outside the Eurozone.

Table A3 characterizes the EU's trade position in world trade on the basis of the total exports and imports of member countries, their trade balance (BOT) and its share of exports using the BOT Coverage Index (BCI). This indicator shows the sensitivity and dependence of the economy on the development of its foreign trade because it indicates the extent to which the country is able to cover its import needs, which are manifested by a surplus or deficit of the trade balance through its own exports. The scaling indicates a relatively high or low vulnerability of the economy caused by dependence on its own foreign trade, or the need to finance imports with another balance of payments items (services or foreign capital—credit; portfolio investments or in the form of Foreign Direct Investments—FDI).

Table A4 focuses on some qualitative trade indicators such as concentration indices and terms of trade volatility, which aim to provide deeper characteristics of foreign trade relations of member countries. The characteristics of the trade concentrations use the Hindefall–Hirschman partners concentration index of export. The absence of similar import index usage in the evaluation can be explained by small differences between these two indices (only in one country was there a difference in scaling). The terms of trade indicator is very volatile, so its annual value in the year 2018 was of no importance. Its volatility and the impact on trade shocks can be discovered in longer periods only. That was the reason why the five-year period's average (2014–2018) was analyzed, and its volatility is described by statistical mean and variation coefficients.

Table A5 provides characteristics of intra- and extra-EU agro trade of individual member countries. In addition to exports, imports and the trade balance, the share of the trade balance result in exports both internally and externally to the EU is added as an evaluated indicator. These indicators should document the degree of self-sufficiency and, in opposition to it, also the vulnerability of the agricultural sector. The third indicator of agricultural trade vulnerability is the FAO food trade security index (4). It also indicated that approx. 1/3 of member countries have too high a dependence on food imports. The results show that the self-sufficiency and thus the vulnerability are greater in intra-EU trade than in extra-EU trade. However, in light of the current crisis, the situation is not very good, and there is a

distinct trade deficit in the analyzed trade items. It is necessary to state that the low level of agricultural self-sufficiency of the UK plays a dominant negative role in this aspect. Brexit in 2020 will radically improve the overall position of the whole EU from this point of view.

Table A6 is the first of the data set presenting the role of non-economic parameters. As already stated above, environmental changes and climate change play a growing role in the global economy, with reactions to new policies proposed by the Intergovernmental Panel on Climate Change IPCC [38] and UNCTAD [39]. This development is an increasingly respected fact also in politics. The EU is currently looking for new approaches to the problem of environmental protection, especially in the field of the climate change mitigation. It is one of the factors directly connected with its agriculture, the vulnerability of this sector and particularly trade. The growing importance of climate change for the subject of research of this study is due to the fact that the evaluation includes two indicators, i.e., the ND-Gain Index and the Climate Risk Index, illustrating the problem from two sides: both in terms of the overall vulnerability of economic and social systems and in terms of the environmental risks of individual countries. Both indicators have a set of indices calculated according to their own methodology; summative scaling allows their comparability and gives the possibility of comparable evaluation of their impact.

Table A7 records indicators of the stability of internal and external policy of member countries. It is calculated as a statistical mean of four indicators used by the World Bank Institute [37] while evaluating the quality of governance systems in individual countries.

Of the six indices used by the World Bank, the study works with four as follows: political stability and absence of violence/terrorism (marked as PSI); government effectiveness (marked as GE); regulatory quality (marked as RQ); and rule of law (marked as ROL). They characterize the stability and quality of the governance system in individual EU member states. The statistical mean is used as the final parameter of all four indices as a measure of the national policy; because the foreign trade is also under the influence of the foreign policy of member countries and eventually they align, an additional parameter for the evaluation of foreign policy stability and performance in the form of a dummy variable was added, i.e., membership in NATO. The final valuation of the political environment of the foreign trade is consequently, similarly to the climate risks, evaluated by two criteria.

4.3. The Final Scoring Model

The basic idea of the study was to examine what role does the development of agro trade play in the transmission of external shocks, and to what extent other factors may affect the economic volatility of EU countries. The volatility of the parameters then determines the vulnerability of the agriculture sector of individual EU countries to these shocks. Given that the economic theory does not provide a clear-cut answer, the empirical statistical analysis should help to disclose the direction and extent of the processes influencing the proportion between trade openness and self-sufficiency of the agricultural sector within EU and its individual member countries. To gauge this effect, this paper uses a linear model of vulnerability with the following specification:

$$Vs = \sum_{i=1}^n (\alpha (AXi, t + \sigma) + \beta Vhhi, t + \gamma (Tsh i, t) + \delta (ToT avg, i, t + VC ToT, i, t) + \mathbf{Y} i, t + \varepsilon (\mathbf{Z} i, t + \theta) \quad (12)$$

where the subscript i denotes a respective EU country and t is the relevant time period; Vs represents the final vulnerability score, AX is a set of control macroeconomic variables including the absolute and relative level of GDP and GDP per capita, agriculture sector position and performance within the country's economy and trade openness; $Vhhi_{i,t}$ is the HH concentration index, Tsh is the trade shape defining the role of agribusiness in the extra- and intra-EU trade of individual EU countries, $ToT_{avg, i, t}$ are the average terms of trade for the evaluated period, $VC_{tot_{i,t}}$ is the volatility of terms of trade, $Y_{i,t}$, are the climate risks volatility factors (set of climatic volatility parameters for the evaluated period), and $Z_{i,t}$ is the political stability index (average of the WGI indices set constructed by the World Bank

plus NATO). Coefficients α , β , γ , δ and ε reflect the weight of individual parameters in relation to their relevance for trade and economic vulnerability.

At this stage of the study, their value is used as 1, but in future deeper analysis they are planned to depend on the correlations between their development and measures of the vulnerability indices. σ and θ are dummy variables putting the value 1 as EZ and NATO membership, as an indicator of the stability of monetary and foreign relations of the EU member countries, and 0 is for non-member countries in both groupings. As their impact is not considered here as too important, their scale valuation is reduced to ± 1 point in final result.

4.4. Presentation of Final Results

Table A8 provides a basic summarization of the results of the model, allowing to create the basic final scoring of all countries and allowing their groupings in accordance with agro trade vulnerability. The table shows the summary results of the position of individual countries within the individual evaluated criteria in terms of their frequency in the given groups.

Indicators are sorted according to the scale in which they were included in the evaluation within the individual groups of indicators with the corresponding score for each group. Individual groups defined according to scales (from 1 to 4) and distinguished by color were then evaluated by the number of points, which increases by one degree when assigned to a higher group. The colors used within the groups of individual parameters are the same used for sorting into the final groupings presented in Table 5.

Table 5 presents the summary statistics of the correlation matrix, with the sum of the scoring points presented in Table A8. The results are broadly in line with expectations, confirming the correlations between vulnerability and the most relevant parameters. The grouping of member countries is done based on the final ranking of each country score.

The formation of the groups represents the individual quartiles (nQ where n = 1–3). Consequently the first Q, then the median (the second Q) and the third Q are calculated for the entire set of EU member countries used in the analysis. The values of the individual thresholds are rounded to whole numbers as in the Table 4. below:

Table 4. Values of country groupings creation.

Quartiles	Values	Thresholds
1 Q	36.75	37
2 Q	42.50	43
3 Q	48.00	48

Source: authors' own calculations.

The final result in the form of individual countries evaluation and the groupings is presented in the Table 5. below (detailed calculation in Appendix B). The colors of individual groups in the Scoring evaluation in the Table 5. respond to the valuation given by thresholds in the Table 4.

In this set, the timeframe and distance are quite broad, which confirms the introductory hypothesis of heterogeneity of the EU member states economies not only in the sphere of macroeconomics, economic development, size and general trade, but also in the sphere of trade with agricultural products and its vulnerability.

Table 5. Final country groupings.

Nr. of Points	Country Groupings		
63	Malta		
54	Bulgaria		
52	Croatia		
51	Luxembourg		
50	Romania	Ireland	
48	Portugal	Lithuania	
47	Greece	Cyprus	Latvia
44	Poland	Slovenia	
43	Hungary		
42	Czech Republic	Finland	
41	Slovakia	Estonia	
40	Sweden	Austria	
37	Italy		
36	Spain		
35	Denmark	Belgium	
33	France	Netherlands	
30	UK		
29	Germany		
Scoring evaluation:			
	high vulnerability	48–63	
	vulnerable	43–47	
	less vulnerable	38–42	
	low vulnerability	29–37	

Source: authors' own calculations.

5. Discussion

The comprehensive statistical analysis results provide data indicating differentiated levels of vulnerability of EU member states' agro trade. The partial data, as well as the final results of the study, reflect some correlations between trade vulnerability and the traditionally known economic parameters. These correlations could be explained by the following reasons:

- (a) The lower stage of economic development is characterized by a narrower trade pattern specialization, which generates higher sensitivity to changes in export and import prices and the development of ToT;
- (b) The impact of external shocks and the vulnerability of the economy decrease in relationship with the economic development level, as its higher value is usually connected with better shock-absorbing ability;
- (c) The impact of macroeconomic fluctuations on less-developed countries are more highly correlated with the exogenous shocks affecting the sectors (including agriculture) in which they specialize;
- (d) The level of economic development is not an exclusive, but an influential factor of higher vulnerability; the other factors, such as the size and openness of the economy to trade, its shape and concentration profile and geographical location, also play an important role in sensitivity to external and exogenous shocks and the ability to adapt and build some stage of resilience in the short and long term view;
- (e) One of the interesting conclusions of the study is that the fact that fundamentally different groups of countries (such as some LDCs) are more vulnerable to external shocks, is also observable (albeit in a modified form) in the group of EU countries;
- (f) The resilience towards external or exogenous shocks is partially correlated with political factors, such as political stability, the rule of law and regulation quality, allowing the introduction of regionally orchestrated responsible policies supporting sustainability and the protection of all components of the natural environment;

- (g) The factor of comprehensive environmental development, and particularly climate change, is of growing importance in recent years but also in the near future. The sensitivity to the impact of those risks and vulnerability to climate change depends in general on the level of economic development, which determines the capacity to adapt. However, the 2018 heatwaves and consequent long-term droughts, as well as the COVID-19 crisis in 2020 also proved that even high-income countries can feel climate change impacts (or eventually other similar factors like some diseases pandemics) more intensively than ever before. Effective climate change mitigation is therefore in the self-interest of all countries worldwide, including EU member countries.

All of these theses are based on the results of the study presented in this paper. The study was built on the relatively simple linear model of mutual interlinks between economic, trade, environmental and political factors identified by different authors, their studies, papers and expert estimates of the authors of this study. They need deeper verification and discussions using more sophisticated statistical tools and methods than the descriptive statistics used here. These include statistical interference methods like correlation analysis, hypothesis testing and goodness of fit. Some recent situations reflecting the COVID-19 pandemic, the expected subsequent crisis and the follow-up data describing its impact on the trade with food and other agricultural commodities in more depth will reveal in a more detailed way the real vulnerability of the EU and individual member countries in this sphere.

6. Conclusions

The study was based on the hypothesis that although the EU as an economic and customs union has a certain degree of dependence on food imports, this phenomenon as a whole does not pose a major threat to its resilience to external and exogenous shocks. On the other hand, it assumed a specific heterogeneity and a differentiated degree of vulnerability of individual member states in the field of agro trade.

The analysis performed on the data from 2018 (or in some cases even on a broader time horizon) confirmed that both hypotheses were correct. The EU demonstrates a considerable degree of independence on external agro trade, even though it has an overall smaller negative trade balance, which does not reach critical values, especially given its relationship to its total export volumes. However, the hypothesis of a differentiated level of vulnerability and the possibility of the emergence of economic, but also social or environmental, impacts of exogenous shocks at the level of individual member states has been proven as well. As in other areas, the heterogeneity of the EU is also traceable in the field of the vulnerability of their agricultural sector and its foreign trade. Such a vulnerability that may be borne by, among others, foreign trade in agricultural products will require some political measures, especially under the new conditions borne by the post-COVID-19 crisis era, which is expected to emerge in the next years.

A more comprehensive view of the issue of vulnerability presented by the study showed that there are certain general features suggesting this differentiation. These include the size of the economy, geographical location, maturity of the economy, productivity of the agricultural sector, etc. It can be expected that these features will also be reflected in the renewed EU budget for the upcoming years in the search for ways to strengthen resilience in individual economies with higher vulnerability.

The conclusions of this study can be considered preliminary due to some simplified methodological procedures; they will require further specification of the methodology and data used, especially in the search for correlations between individual parameters and their influence on determining their significance and therefore weight in the scoring model. Nevertheless, it can be stated that even this preliminary output confirmed the hypothesis of EU heterogeneity in terms of vulnerability in the field of agro trade.

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Appendix A

Table A1. General macroeconomic data in 2018. EZ: Eurozone.

EU Country	GDP per Capita	GDP	Trade Open	EZ Member
	EUR	mil.EUR	%	Y/N
Belgium	40,240	459,820	170.0%	1
Bulgaria	7980	56,087	107.3%	0
Czech Republic	19,530	207,570	157.9%	0
Denmark	52,010	301,341	59.6%	0
Germany	40,340	3,344,370	72.0%	1
Estonia	19,740	26,036	117.7%	1
Ireland	66,670	324,038	71.4%	1
Greece	17,210	184,714	47.4%	1
Spain	25,730	1,202,193	51.9%	1
France	34,980	2,353,090	45.1%	1
Croatia	12,620	51,625	74.8%	0
Italy	29,220	1,765,421	50.5%	1
Cyprus	24,290	21,138	63.5%	1
Latvia	15,130	29,151	10.2%	1
Lithuania	16,160	45,264	130.8%	1
Luxembourg	98,640	60,053	56.9%	1
Hungary	13,690	133,782	156.6%	0
Malta	25,490	12,379	63.9%	1
Netherlands	44,920	774,039	150.2%	1
Austria	43,640	385,712	83.1%	1
Poland	12,920	496,361	90.9%	0
Portugal	19,830	203,896	65.3%	1
Romania	10,510	204,641	73.4%	0
Slovenia	22,080	45,755	160.0%	1
Slovakia	16,470	89,721	176.0%	1
Finland	42,490	234,370	55.8%	1
Sweden	46,310	471,208	60.5%	0
UK	36,480	2,423,737	40.5%	0
EU (28)		15,907,511	73.4%	19
1 QUARTIL	16,393	54,971	59.0%	
2 Q MEDIAN	24,890	206,105	72.7%	
3 QUARTIL	40,878	477,496	121.0%	
Vulnerability:				
high	<12,000	<60k	>120%	N/A
relevant	12,000–25,000	60k–206k	73%–120%	N/A
less	25,000–40,000	206k–480k	59%–72.9%	0
low	>40,000	>1,000k	<59%	1

Source: Eurostat, World Bank, authors' own estimates.

Table A2. Position of agriculture in the economy.

EU Country	AGC/HDP	AGC/empl.	Productivity	AGR/GDP	Agro OPEN
	%	%	pp		%
Belgium	1.77%	1.20	0.6%	0.4	20.79
Bulgaria	7.53%	17.10	-9.6%	2.9	4.56
Czech Republic	2.46%	2.50	-0.04%	0.8	8.08
Denmark	3.37%	2.10	1.3%	0.7	5.87
Germany	1.55%	1.30	0.2%	0.5	7.21
Estonia	3.10%	2.30	0.8%	0.8	10.29
Ireland	2.67%	4.60	-1.9%	0.8	5.02
Greece	5.58%	10.60	-5.0%	2.7	2.57
Spain	4.24%	3.70	0.5%	2.3	3.41
France	3.17%	2.50	0.7%	1.4	3.08
Croatia	4.39%	5.30	-0.9%	1.9	5.02
Italy	2.96%	3.40	-0.4%	1.8	3.32
Cyprus	3.35%	3.30	0.05%	1.6	4.22
Latvia	4.04%	5.20	-1.2%	1.1	11.32
Lithuania	5.73%	6.70	-1.0%	1.5	7.16
Luxembourg	0.66%	0.70	-0.04%	0.2	26.65
Hungary	6.21%	3.60	2.6%	2.3	3.81
Malta	0.93%	1.10	-0.2%	0.5	14.01
Netherlands	3.53%	2.10	1.4%	1.4	10.96
Austria	1.81%	3.00	-1.2%	0.8	9.03
Poland	5.03%	9.60	-4.6%	1.8	4.24
Portugal	3.67%	8.40	-4.7%	1.4	5.21
Romania	8.40%	22.80	-14.4%	4.1	1.73
Slovenia	3.00%	6.40	-3.4%	1.4	9.88
Slovakia	2.41%	1.90	0.5%	0.6	9.12
Finland	1.65%	2.50	-0.8%	0.3	7.18
Sweden	1.19%	1.20	-0.01%	0.3	11.23
UK	1.16%	1.10	0.1%	0.4	5.89
AVG	3.41%		-1.45%		-1.45%
1 Q	1.80%		-1.38%		4.24%
2 Q (MEDIAN)	3.17%		-0.11%		6.52%
3.Q	4.28%		0.51%		9.98%
Vulnerability:					
high	> 4.3%		< (-1.38%)		> 10%
relevant	3.2–4.29%		(-1.38%)–(-0.1%)		6.52%–9.9%
less	1.79–3.19%		(-0.1%)–0.5%		6.53%–4.23%
low	< 1.8%		> 0.5%		< 4.24%

Source: Eurostat, authors' own estimates and calculations.

Table A3. Position in world trade.

EU Country	EXP WORLD	IMP WORLD	BoT WORLD	BoT/EXP
	mil. EUR	mil. EUR	mil. EUR	%
Belgium	396,612.7	384,971.9	11,640.8	2.9%
Bulgaria	28,095.7	32,104.7	-4,008.9	-14.3%
Czech Republic	171,260.2	156,457.5	14,802.7	8.6%
Denmark	92,926.3	86,814.5	6,111.9	6.6%
Germany	1,320,732.4	1,087,431.3	233,301.1	17.7%
Estonia	14,424.3	16,228.2	-1,803.8	-12.5%
Ireland	139,831.2	91,560.2	48,271.0	34.5%
Greece	33,451.4	54,061.0	-20,609.6	-61.6%
Spain	293,458.8	330,635.8	-37,177.1	-12.7%
France	492,583.7	568,339.3	-75,755.7	-15.4%
Croatia	14,750.5	23,886.7	-9,136.2	-61.9%
Italy	465,325.4	426,045.7	39,279.7	8.4%
Cyprus	4,251.7	9,166.4	-4,914.7	-115.6%
Latvia	13,675.7	16,696.2	-3,020.5	-22.1%
Lithuania	28,271.0	30,942.6	-2,671.6	-9.4%
Luxembourg	13,824.9	20,344.7	-6,519.8	-47.2%
Hungary	106,498.4	103,057.4	3,441.1	3.2%
Malta	2,551.9	5,357.5	-2,805.6	-109.9%
Netherlands	615,600.7	546,826.7	68,773.9	11.2%
Austria	156,428.8	164,007.6	-7,578.8	-4.8%
Poland	223,213.1	227,796.4	-4,583.2	-2.1%
Portugal	57,806.5	75,363.9	-17,557.4	-30.4%
Romania	67,424.5	82,828.8	-15,404.3	-22.8%
Slovenia	37,423.0	35,803.3	1,619.8	4.3%
Slovakia	79,136.9	78,727.4	409.5	0.5%
Finland	64,235.8	66,577.0	-2,341.2	-3.6%
Sweden	140,551.8	144,489.0	-3,937.2	-2.8%
UK	412,055.5	570,546.8	-158,491.3	-38.5%
AVG	195,943.0			-17.5%
1.Q	28,227.2			-24.7%
2.Q	86,031.6			-11.0%
3.Q	240,774.5			3.5%
Vulnerability				
low	< 240k			> 0.1%
less	240k–86k			0%–(10%)
relevant	86k–28k			(-10%)–(-25%)
high	28k >			< (-25%)

Source: Eurostat, UN Statistical Yearbook 2018 [25], authors' own estimates.

Table A4. Qualitative parameters of EU world trade.

EU Country	HH INDEX X	HH INDEX M	ToT commod.	ToT Volatility	ToT Average	ToT Volatility
	2018	2018	2018	st.deviation	20013-18	coef. of var.
Belgium	0.083	0.074	102.38	0.9346	99.73	0.94%
Bulgaria	0.057	0.053	106.77	1.6930	99.03	1.71%
Czech Republic	0.101	0.125	116.62	0.6351	99.98	0.64%
Denmark	0.074	0.087	104.38	0.4286	99.46	0.43%
Germany	0.042	0.042	106.27	1.6369	99.83	1.64%
Estonia	0.067	0.055	114.95	0.6683	100.68	0.66%
Ireland	0.123	0.116	125.76	2.8371	97.58	2.91%
Greece	0.037	0.046	108.31	0.6608	99.00	0.67%
Spain	0.061	0.050	116.63	1.6390	99.06	1.65%
France	0.056	0.059	99.14	1.2878	98.34	1.31%
Croatia	0.072	0.073	102.99	1.2426	98.46	1.26%
Italy	0.050	0.056	95.51	1.8113	99.57	1.82%
Cyprus	0.056	0.065	126.53	1.2238	99.30	1.23%
Latvia	0.071	0.075	131.44	1.2552	100.62	1.25%
Lithuania	0.058	0.068	102.72	1.0333	99.57	1.04%
Luxembourg	0.116	0.145	124.85	1.9942	96.97	2.06%
Hungary	0.098	0.091	105.38	1.0567	100.72	1.05%
Malta	0.086	0.072	129.36	4.0556	96.11	4.22%
Netherlands	0.084	0.066	102.91	0.4794	99.75	0.48%
Austria	0.112	0.145	160.76	1.0678	99.10	1.08%
Poland	0.102	0.081	126.90	0.9384	99.07	0.95%
Portugal	0.134	0.106	120.11	1.2892	99.25	1.30%
Romania	0.084	0.075	100.22	1.0370	98.81	1.05%
Slovenia	0.080	0.067	117.25	0.7591	99.34	0.76%
Slovakia	0.090	0.072	103.94	1.3971	101.67	1.37%
Finland	0.056	0.071	122.14	1.5972	98.07	1.63%
Sweden	0.052	0.069	116.61	1.0783	98.78	1.09%
UK	0.053	0.058	89.43	1.0990	102.07	1.08%
AVG	0.077	0.077	113.581	1.316	99.3	1.30%
1 Q	0.056				98.8	0.94%
2 Q MEDIAN	0.073				99.3	1.16%
3 Q	0.092				99.8	1.63%
Vulnerability:						
low	< 0.049				> 100	< 1.00
less	0.050–0.099				99	1.00–1.5
relevant	0.100–0.249				98	1.5–2.0
High	< 0.25				< 97	> 2.00

Source: Eurostat, UN 2019 [25], authors' own calculations.

Table A5. Agricultural trade of EU in 2018.

EU country	EU External Trade		EU Internal Trade		FAOFAO
	BoT	BoT/EXP	BoT	BoT/EXP	food vulnerability
	mil. EUR	%	mil. EUR	%	
Belgium	-553.1	-1%	4,775.9	12%	10.7%
Bulgaria	-497.8	-9%	27.3	1%	14.7%
Czech Republic	-866.1	-8%	-374.2	-4%	5.5%
Denmark	5,689.1	27%	3,622.5	26%	20.3%
Germany	-29,185.5	-32%	-21,337.9	-30%	10.1%
Estonia	358.1	14%	122.7	6%	14.8%
Ireland	4,654.0	32%	2,467.9	23%	12.4%
Greece	-679.3	-9%	-1,002.2	-20%	36.4%
Spain	7,538.9	13%	14,355.1	35%	16.7%
France	5,321.2	8%	-4,855.3	-11%	17.4%
Croatia	-255.0	-8%	-942.3	-48%	28.2%
Italy	-12,034.8	-26%	-9,851.1	-33%	14.1%
Cyprus	-719.9	-147%	-646.9	-201%	90.1%
Latvia	1,009.3	23%	4.5	0%	28.2%
Lithuania	1,139.3	19%	167.8	4%	20.7%
Luxembourg	-2,402.7	-161%	-2,327.9	-162%	20.6%
Hungary	2,115.3	22%	1,663.3	20%	6.0%
Malta	-460.5	-176%	-580.8	-2525%	46.9%
Netherlands	29,834.4	29%	40,631.2	50%	11.0%
Austria	-1,769.2	-11%	-3,071.0	-25%	10.2%
Poland	8,443.5	25%	8,404.3	30%	9.7%
Portugal	-3,496.9	-38%	-3,033.6	-44%	21.5%
Romania	-1,563.9	-20%	-2,330.4	-46%	13.0%
Slovenia	-966.3	-28%	-736.2	-30%	9.5%
Slovakia	-2,341.3	-58%	-1,650.2	-43%	6.2%
Finland	-1,376.2	-17%	-2,178.1	-53%	12.3%
Sweden	-1,289.8	-7%	444.1	3%	17.5%
UK	-32,221.1	-94%	-26,559.1	-139%	27.1%
TOTAL EU	-26,576.3	-4%	-4,790.6	-1%	,
AVERAGE		-23%		-114%	20%
1 Q		-29%		-44%	11%
2 Q MEDIAN		-9.2%		-20%	15%
3 Q		15%		8%	21%
Vulnerability:					
low		> 0%		> 0%	< 10.9%
less		(-0.1%)–(-9.9%)		(-0.1%)–(-22%)	11%–15%
relevant		(-10%)–(-29%)		(-22%)–(-44%)	15%–20.9%
high		> (-30%)		> (-45%)	> 21%

Source: Eurostat, FAO [27], authors' own calculations.

Table A6. Climate risks vulnerability.

EU Country	GAIN INDEX	CRI Index
	2017	1999–2018
Belgium	61.7	63.83
Bulgaria	56.8	70.83
Czech Republic	63.7	79.67
Denmark	70.6	112.33
Germany	69.3	38.67
Estonia	62.4	148.83
Ireland	64.7	119.17
Greece	58.6	78.83
Spain	62.6	47.33
France	66.6	38.00
Croatia	56.0	48.33
Italy	60.7	43.67
Cyprus	58.0	129.67
Latvia	60.8	83.83
Lithuania	61.1	100.5
Luxembourg	68.7	97.17
Hungary	58.4	69.00
Malta	56.9	152.83
Netherlands	66.5	71.83
Austria	70.5	55.67
Poland	63.1	77.17
Portugal	61.6	38.83
Romania	52.8	53.17
Slovenia	65.5	54.33
Slovakia	58.1	108.00
Finland	72.0	155.67
Sweden	71.3	129.50
UK	69.1	65.00
Average	63.15	83.27
1 QUARTILE	58.55	53.75
2 Q (MEDIAN)	62.5	74.50
3 QUARTILE	67.125	109.08
Vulnerability:		
low	67 >	< 54.7
less	62–67	54.6–74.9
relevant	58–61	75–108.9
high	57 <	> 109

Source: ND-GAIN [36], Germanwatch [8].

Table A7. Governance and foreign policy indicators.

EU Country	PSI	ROL	RQ	GE	GW	NATO
Belgium	0.41	1.37	1.23	1.17	1.05	1
Bulgaria	0.42	-0.03	0.58	0.27	0.31	1
Czech Republic	1.04	1.05	1.26	0.92	1.07	1
Denmark	0.96	1.83	1.68	1.87	1.59	1
Germany	0.60	1.63	1.75	1.62	1.40	1
Estonia	0.60	1.24	1.56	1.19	1.15	1
Ireland	1.03	1.46	1.60	1.42	1.38	0
Greece	0.09	0.15	0.30	0.34	0.22	1
Spain	0.25	0.97	0.95	1.00	0.79	1
France	0.11	1.44	1.17	1.48	1.05	1
Croatia	0.77	0.32	0.45	0.46	0.50	1
Italy	0.31	0.25	0.67	0.41	0.41	1
Cyprus	0.54	0.75	1.02	0.92	0.81	0
Latvia	0.42	0.96	1.19	1.04	0.90	1
Lithuania	0.75	0.96	1.11	1.07	0.97	1
Luxembourg	1.37	1.81	1.76	1.78	1.68	1
Hungary	0.76	0.56	0.60	0.49	0.60	1
Malta	1.29	1.05	1.34	0.97	1.16	0
Netherlands	0.87	1.82	2.02	1.85	1.64	1
Austria	0.92	1.88	1.54	1.45	1.45	0
Poland	0.55	0.43	0.88	0.66	0.63	1
Portugal	1.14	1.14	0.89	1.21	1.09	1
Romania	0.06	0.33	0.45	-0.25	0.14	1
Slovenia	0.91	1.06	0.69	1.13	0.95	1
Slovakia	0.75	0.53	0.81	0.71	0.70	1
Finland	0.92	2.05	1.79	1.98	1.69	0
Sweden	0.91	1.90	1.80	1.83	1.61	0
UK	0.05	1.64	1.76	1.34	1.20	1
AVG	0.67	1.09	1.17	1.08	1.00	22
1. QUARTIL					0.70	
2 Q MEDIAN					1.03	
3 QUARTIL					1.38	
Vulnerability:						
high					< 0.7	N/A
relevant					0.71–1.03	N/A
less					1.03–1.38	0
low					> 1.39	1

Source: World Bank World Governance Indicators (WGIs) [22], authors' own estimates.

Appendix B

Table A8. Overall assessment of summarized criteria.

EU Country	1	2	3	4	TOTAL
Belgium	8	16	3	8	35
Bulgaria	2	12	12	28	54
Czech Republic	4	16	18	4	42
Denmark	8	14	9	4	35
Germany	12	8	9	0	29
Estonia	7	12	6	16	41
Ireland	3	12	15	20	50
Greece	8	0	15	24	47
Spain	7	14	15	0	36
France	8	16	9	0	33
Croatia	2	12	18	20	52
Italy	7	14	12	4	37
Cyprus	3	16	12	16	47
Latvia	4	10	21	12	47
Lithuania	2	18	12	16	48
Luxembourg	6	2	15	28	51
Hungary	6	12	9	16	43
Malta	2	12	9	40	63
Netherlands	10	12	3	8	33
Austria	3	22	15	0	40
Poland	5	12	15	12	44
Portugal	3	14	15	16	48
Romania	3	12	15	20	50
Slovenia	5	12	15	12	44
Slovakia	7	10	12	12	41
Finland	4	16	18	4	42
Sweden	4	20	12	4	40
UK	7	16	3	4	30
Average					42.93
1 quartile					36.75
2 q (median)					42.50
3 quartile					48.00
Stat. deviation					7.86

Source: authors' own calculations.

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