The effects on European importers' food safety controls in the time of COVID-19

Abstract

COVID-19 has highlighted the fragility of the global economic system. In just a few months, the consequences of the pandemic have left their mark on the affected countries at all levels and without exception. This article analyses the profile of food safety notifications reported by European countries in the first five months of 2020. The aim was to detect possible changes in food safety regulations imposed by control authorities that could aggravate the economic impacts of the pandemic. While COVID-19 does not appear to be a foodborne disease, some outbreaks have been linked to imported food, which might have affected the food control behaviour of importing countries. In this study, contingency tables and clustering were used to assess differences between years and notification characteristics and to detect homogeneous groups to help identify how the reported notifications might have changed. In the period considered in this study, the volume of notifications on most imported foodstuffs decreased considerably. This decrease was a direct consequence of the fall in international trade, which might have increased countries' reliance on domestic sources. The COVID-19 crisis has not caused a substantial change in the profile of European countries' in terms of the characteristics of reported notifications (product category and risk decision). However, the worst affected countries have replaced border rejections with alerts, which may indicate greater reliance on intra-EU markets.

Keywords: COVID-19; food notifications; contingency tables; cluster analysis

1. Introduction

The rapid transmission of COVID-19 has caused an unprecedented global health crisis, creating potential risks to food security and nutrition, particularly in certain countries. Border closures, restrictions on movement and social distancing to curb infection have disrupted supply chains (Aday & Aday, 2020; Rizou et al., 2020; Nakat & Bou-Mitri; 2021). These disruptions have led to the loss of perishable foods, including agricultural produce, fish, meat and dairy. Food is part of the essential infrastructure of any economy, along with other core areas such as health care, energy supply and communications. In the time of COVID-19, it is paramount for both international trade and retail distribution to continue to function normally (Nakat & Bou-Mitri, 2021). This paper assesses the safety of food imports in the first five months of the pandemic.

The globalisation of international food trade raises concerns about the spread of infectious diseases, with coronavirus placing countries in a situation of extreme weakness (Lüth et al., 2019). The pandemic is expected to alter trade policies substantially, tightening food safety regulations at the borders and challenging the globalisation of the food system (Barichello, 2020; Kerr, 2020). Unnecessary fear among the public is greater when health risks are unknown (Faour-Klingbeil et al., 2021).

This article analyses how the COVID-19 crisis may have affected food controls by European importing countries, expressed in terms of notifications reported in the Rapid Alert System for Food and Feed (RASFF). The aim of this research was to detect possible differences in the patterns of food safety measures. The study did not attempt to show a direct link between COVID-19 and food safety. Instead, it assessed whether the controls carried out by European importing countries might be affected by two possible causes. The first is the increased uncertainty about the way that the health conditions of the food chain might have facilitated transmission of the disease, at least in the initial period of the

pandemic. The second is the way that the weakened agri-food export supply chains (in the context of disrupted logistics) might have influenced food quality, leading to stricter controls by import authorities.

To detect food safety risks in an effective manner, European countries have developed the RASFF. This system provides reliable information on health hazards associated with food imports, enabling rapid response when incidents are detected. It offers a portal to an interactive online database storing all food and feed notifications reported on a daily basis (RASFF, 2016). It therefore provides a powerful tool for the exchange of information between European countries. This tool has enabled tracking of the risks that could affect the food chain and endanger public health (Kleter et al., 2009; Banach et al., 2016; Pigłowski, 2015, 2017, 2019, 2020; D'Amico et al., 2018; Postolache et al., 2020). In this paper, RASFF data are used to explore the impact of the COVID-19 health crisis and the subsequent disruption of the food value chain, which might lead to the relaxing or tightening of food controls at the border. While COVID-19 does not appear to be a foodborne disease, some outbreaks have been related to imported food, such as the outbreak in Beijing in July 2020.

This study examined the first five months of 2020, at which time COVID-19 was severely affecting Europe. Comparative analysis with the two previous years was conducted.

The article is divided into the following sections. Section 2 describes the research context, the use of the RASFF to monitor food safety controls and the main research hypotheses. Section 3 explains the method and sample for the empirical analysis. Section 4 presents the results. Finally, Section 5 summarises the main conclusions and contributions of the study.

2.   Research context and background

2.1. COVID-19 and food safety

The analysis of health crises such as Ebola (West Africa, 2014), SARS (East Asia, 2003), HIV (Africa, 1990s and 2000s), the plague (South Asia, 1994) and cholera (Latin America, 1991) can serve as a reference for decision makers when dealing with the imminent consequences of COVID-19 for food safety and security. Authors such as Shiau et al. (2020) have reported that the interaction between HIV and COVID-19 highlights food insecurity among those living with HIV.

The effects of COVID-19 are comparable to those of other diseases such as Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS-CoV), all of which cause acute respiratory problems and can circulate among animals (Das, 2020, Rodriguez-Morales et al., 2020, ECDC, 2020). One line of research focuses on controlling their spread and determining the optimal treatment to cure these diseases. Cheng et al. (2007) confirmed that exotic animals such as horseshoe bats are carriers of SARS-CoV and that ingesting these animals may cause the virus to propagate. Supporting this theory, Jalava (2020) linked the origin of COVID-19 to the Huanan Seafood Market, where bats, snakes, pheasants and other animals prone to transmitting the virus are sold. The consumption of these exotic animals, which is common in China, is believed to have spread the virus.

Galimberti et al. (2020) highlighted that food safety is a global issue and that the unsafe nature of local food markets such as that of Wuhan can have a severe global impact. In the time of COVID-19, several measures within the food system have been explored for prophylaxis and prevention. These include the use of functional foods, bioactive ingredients and nutraceuticals (Galanakis et al., 2020), food safety practices within workplaces and restaurants (Gomes de Freitas & Stedefeldt, 2020), and tools and

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instruments to facilitate the transition of the food industry to the new normal (Nakat & Bou-Mitri, 2021). Efforts are also being made to devise instruments capable of detecting and analysing the possible transmission of the virus through the food supply chain (Rizou et al., 2020).

There are several reasons for control authorities to tighten their regulation of food safety in times of COVID-19. The first is to regain consumers' confidence in the food chain. Consumer attitudes may be affected by several factors, such as health properties (Galanakis, 2015), minimal processing (Barba et al., 2015; Zinoviadou et al., 2015) and food additives (Galanakis, 2018; Galanakis et al., 2018; Wu et al., 2013). At the same time, trust in the authorities and reliable scientific information are essential to reduce misperceptions of food risk. The opinions of consumers affect the motivation of food control agencies. According to Jonge et al. (2008), consumer confidence is conditioned by the degree of transparency and openness of food safety authorities. However, Ha et al. (2020) reported that acquiring information on food incidents has a negative effect on confidence in institutions.

A second reason is that the food supply chain is a possible transmission route. This was not the case with MERS or SARS-CoV. However, in the case of COVID-19, there are conflicting opinions. While the United States Food and Drug Administration (FDA) does not rule out this possibility, the World Health Organization (WHO) and FAO consider it very unlikely. They have nevertheless issued guidance to ensure food safety (FDA, 2020; FAO/WHO, 2020a). The spread of the virus in fresh or packaged food could be due to the handling of such food by infected people. According to Galanakis (2020), food safety systems must be able to detect the presence of the virus in the environments where food is produced, processed and delivered.

Third, international agencies such as the FAO and the WHO have warned that the lockdown might have altered national and international food safety control systems, with the lack of personnel and the need to telecommute making it difficult to operate as normal (FAO/WHO, 2020b).

Finally, this crisis provides an opportunity for food fraud. The recession accompanying the pandemic has allowed criminal organisations to increase their profits through falsified labelling or the lack of proper documentation (Beia et al., 2020). For example, there is evidence that cheese has been sold during the lockdown as Parmesan without proper documentation, without health guarantees and with misleading labelling in relation to weight (European Commission, 2020a).

2.2. The use of the RASFF for tracking food safety controls

The European Commission has been forced to support the agri-food sector by providing a package of exceptional measures, including private storage aid, flexibility for market support programmes and temporary derogation of EU competition rules (European Commission, 2020b). In this context, analysis of the strictness of security measures during the pandemic is important. Their effectiveness lies in the existence of clearly identified points of detection and contact in the European Commission, the European Food Safety Authority (EFSA) and the European Free Trade Association Surveillance Authority (EFTA), as well as the member states at the national level. The RASFF has been in operation since 1979, but its current legal basis was established in Commission Regulation EU No 178/2002. This regulation stipulates the general principles and requirements of food law, as well as creating the EFSA and establishing food safety procedures. Subsequently, Commission Regulation EU No 16/2011 provided the implementing measures for the RASFF.

The RASFF provides the basis to explore the extent to which food border controls in some European importing countries changed during the initial months of the pandemic. For more than a decade, RASFF notifications have been studied from different perspectives. Kleter et al. (2009) identified the new trends in food safety hazards between 2003 and 2007. Kallummal et al. (2013) measured the impact of European notifications on Asian exports. Jaud et al. (2013) analysed notifications to 146 exporting countries, assessing the geographical focus of EU agri-food imports. Tudela-Marco et al. (2017) examined possible similarities between six EU member states in their implementation of food safety standards for fruit and vegetable imports. D'Amico et al. (2018) sought to detect the most important instances of non-compliance affecting seafood, exploring the possible relationships between the variables characterising the products that received notifications. Pigłowski (2019) studied notifications on micro-organisms reported by European and national institutions to ensure food and feed safety. Several studies have focused on specific products. For example, Xiong (2017) contributed to the understanding of food imports and food safety by analysing the demand for pistachios in the EU. García-Alvarez-Coque et al. (2020) analysed notifications on border controls of aflatoxin levels in tree nuts and peanuts. Postolache et al. (2020) analysed the status of notifications on milk and milk products between 2000 and 2020. Pigłowski (2015, 2017) used cluster analysis to explore the dependence between food safety notifications and product characteristics. The same author (Pigłowski, 2020) offered an overview of the paradigm of food safety, reviewing the literature on notifications by hazard category from 1996 to 2018.

2.3. Research hypotheses

RASFF notifications are used in this paper to test the following three hypotheses related to the effects of COVID-19 on food controls carried out by European importing countries:

H1

Variation in an importing country's wealth is a key factor in safety controls when food is purchased in international markets.

H2

The effects of the COVID-19 crisis have altered the monitoring characteristics (product category, type of notification and risk decision) of European importing countries in the period studied with respect to the same months in previous years.

H3

European importing countries have reacted consistently in terms of their notification behaviour over the three years covered by the study.

3.   Methodology

The study was designed to test these three hypotheses. Correlation coefficients and graphical analyses were used to address the first hypothesis. Using the Chi-square (χ^2) test and the contingency coefficient (calculated from contingency tables), the possible differences between notifications in the same months in 2018, 2019 and 2020 and the variables referring to product category, type of notification, notifying country and risk decision were identified to address the second hypothesis. Finally, two cluster analyses of similar groups of countries (one based on product category and one based on type of notification) were used to address the third hypothesis.

Contingency tables provide essential information to demonstrate associations between qualitative variables. Food safety has been investigated using the χ^2 test of cross-tabulation to identify relationships between variables (Al-Shabib et al., 2017; D'Amico et al., 2018; Walaszczyk & Galinska, 2020). Cluster analysis was used to group EU countries according to their notification behaviour with respect to product category or notification type. This method was useful to explore possible changes in notification behaviour and thereby achieve the research aims. Pigłowski (2015, 2017, 2020) used cluster analysis to explore the dependence between food safety notifications and product characteristics. However, that study was conducted in a different environment because of the absence of the effects of COVID-19. The data for the first five months of 2020 were compared with data on notifications in the previous two years. The short-term impact of COVID-19 on food controls was thus evaluated.

Contingency tables enable the analysis of categorical data using tables. These tables can help identify the existence and strength of possible associations between row and column variables. In this research, the number of contingency tables corresponds to the number of criteria. The columns represent the year of notification j (2018 to 2020), and the rows correspond to the variables of each criterion i. The criteria are product category, type of notification, region of notifying country and risk decision. The tables show the number of notifications for a given year and variable, known as the observed frequency. The general structure is illustrated in Table 1.

Table 1. General structure of contingency tables of observed frequencies

Criterion i	2018	2019	2020	Total
Variable 1	$n_{1,2018}$	$n_{1,2019}$	$n_{1,2020}$	$n_{1,\bullet}$
Variable 2	$n_{2,2018}$	$n_{2,2019}$	$n_{2,2020}$	$n_{2,\bullet}$
…..	…..	…..	…..	…..
Variable h	$n_{h,2018}$	$n_{h,2019}$	$n_{h,2020}$	$n_{h,\bullet}$
Total	$n_{\bullet,2018}$	$n_{\bullet,2019}$	$n_{\bullet,2020}$	N

Based on the data in Table 1, the expected frequencies are calculated using the following expression:

$$\text{E}_{ij} = \frac{n_{i\cdot} \cdot n_{\cdot j}}{N} \tag{1}$$

where N is the total number of observations in the table, $n_{i,\bullet}$ is the number of observations in row i, and $n_{\bullet j}$ is the number of observations in column j.

Both the observed and expected frequencies are necessary to perform the χ^2 test showing whether the variables considered in the study are independent or not. The results of the χ^2 test confirm whether the levels of a qualitative variable influence those of another nominal variable. Thus, the results of the χ^2 test in this study indicate whether the identifying variable for the year in which the notifications were reported is independent of product category, type of notification, region of notifying country and risk decision. The χ^2 test is defined by the following expression:

$$\chi^2 = \frac{\sum_{i=1}^{h} \sum_{j=1}^{k} (n_{ij} - E_{ij})^2}{E_{ij}} \tag{2}$$

where n_{ij} is the observed frequency and E_{ij} is the expected frequency.

The null hypothesis is that there is independence between factors. The alternative hypothesis is that there is dependence between factors.

The measures of association, which provide information only about the degree of association (not the direction of association), are calculated using the contingency coefficient as follows:

$$\text{Contingency coefficient} = \sqrt{\frac{\chi^2}{N + \chi^2}} \qquad (3)$$

where N is the total number of observations.

The values of the contingency coefficient are always positive and range between 0 and 1. A value of 0 indicates a weak association.

Cluster analysis was also performed. Product category and type of notification were used to group the countries in the sample into homogeneous clusters in terms of number of notifications. This multivariate statistical technique enables the grouping of elements to maximise not only within-group homogeneity but also between-group difference. In the first stage, an agglomerative hierarchical clustering algorithm was applied, starting with a situation where each observation constituted its own cluster. In successive steps, clusters were then merged until the optimal number of clusters was reached. The squared Euclidean distance between clusters was used as the clustering criterion. This technique provided the optimal number of clusters for the sample. A priori, this number is unknown. For this study, Ward's method was chosen from the available hierarchical algorithms. According to Kuiper and Fisher (1975), this powerful classification technique merges different elements while seeking to minimise within-cluster variance.

4. Results and discussion

4.1. RASFF Data

The empirical analysis was carried out by classifying the notifications by product category, notification type, region of the notifying country and risk decision (Table 2).

**Table 2. Classification of notifications by category**

Product category	*Food of vegetal origin*	Cereals, cocoa, fruits and vegetables, herbs, honey, nuts
	Food of animal origin	Egg, fats, gastropods, meat, milk, poultry meat
	Seafood	Bivalve molluscs, cephalopods, crustaceans, fish
	Other food	Alcoholic and non-alcoholic beverages, confectionary, dietetic food, additives, ices, natural water, prepared dishes, soups, water, wine and other
Type of notification	*Alert*	Sent when a food or feed presenting a serious health risk is on the market and when rapid action is required.
	Border rejection	Concerns food and feed consignments that have been tested and rejected at the external borders of the EU (and the European Economic Area – EEA) when a health risk has been found.
	Information for attention	Released if the product is only present in the notifying country, if it is no longer on the market or if it has not even been placed on the market.
	Information for follow-up	Related to a product that is or may be placed on the market in another country.
European region of notifying country (*)	*Northern*	Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Norway, Sweden, United Kingdom
	Eastern	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia
	Southern	Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, Spain
	Western	Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland
Risk decision	*Not serious*	Minimum degree of risk
	Serious	Maximum degree of risk
	Undecided	Decision cannot be made

Source: Authors (based on RASFF data). (*) According to the United Nations classification (UN, 2016)

The sample consisted of notifications reported between 1 January and 20 May in the three years covered by the study. A total of 3,629 observations (32.7% in 2018, 38.8% in 2019 and 28.4% in 2020) were obtained from the RASFF database. The distribution of the notifications shows a decrease of more than 25% between 2019 and the same period in

2020. This decrease can be attributed to the reduction in trade activity in those months (OECD Statistics indicate a 4% reduction in EU imports between January 2019 and January 2020). It is also worth analysing the possible differences in the number of notifications based on the categories in Table 2.

**Fig. 1. Distribution of notifications by product category**
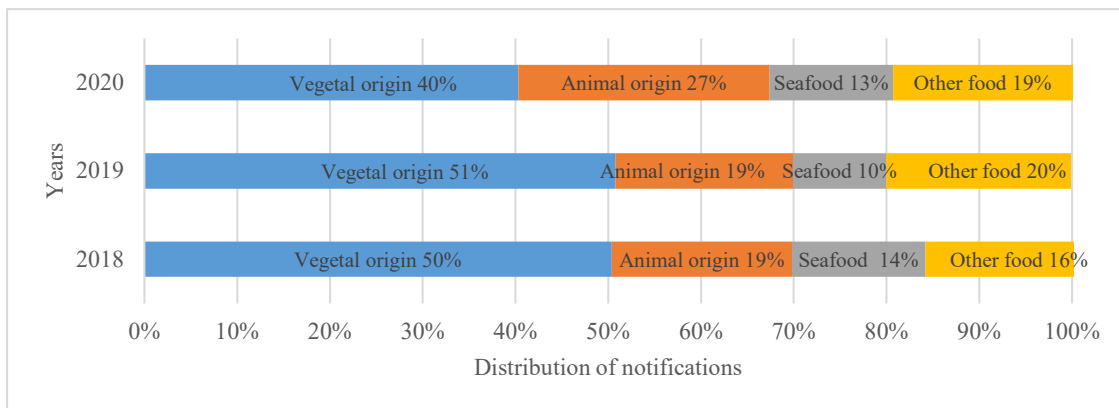
Source: Authors (based on RASFF data)

The vegetal products category has the largest share of notifications in the three years covered by the study (Fig. 1). In 2018 and 2019, nuts, nut products and seeds were the subject of approximately 23% of all notifications, decreasing to 14.1% in 2020. This was followed by fruits and vegetables, where no major differences were observed, remaining around 15% throughout the period studied. The second most important group of products was food of animal origin, with most notifications relating to poultry meat. There were notable differences over time, from 108 notifications in 2018 to 178 in 2020. However, this trend cannot be directly attributed to the pandemic. It reflects steady growth over the last decade, as confirmed by Konoiuk and Karwowka (2017) for the period 2011 to 2015. Also, notifications on meat and meat products (61 and 58 notifications in 2018 and 2020, respectively) and milk and milk products (35 and 28 notifications in 2018 and 2020, respectively) were common among notifications on foods of animal origin. The third most

common type of notification, other food, mainly included dietetic food, prepared dishes and confectionery, with 81, 43 and 22 notifications in 2020, respectively. Since 2018, the number has decreased for the first two categories, while confectionery has increased by 72%. The least important group, seafood, did not follow a clear overall trend. However, the change became evident following analysis by individual types of foods. The sharpest declines were for fish and fish products (94 in 2018 to 68 in 2020) and crustaceans and products thereof (14 in 2018 to 9 in 2020). This trend cannot be attributed to COVID-19. D'Amico et al. (2018) reported a decrease over the period 2011 to 2015. Notifications for other products such as bivalve molluscs and products thereof remained stable, with 58 notifications in 2018 and 2020.

**Fig. 2. Distribution of notifications by type of notification**
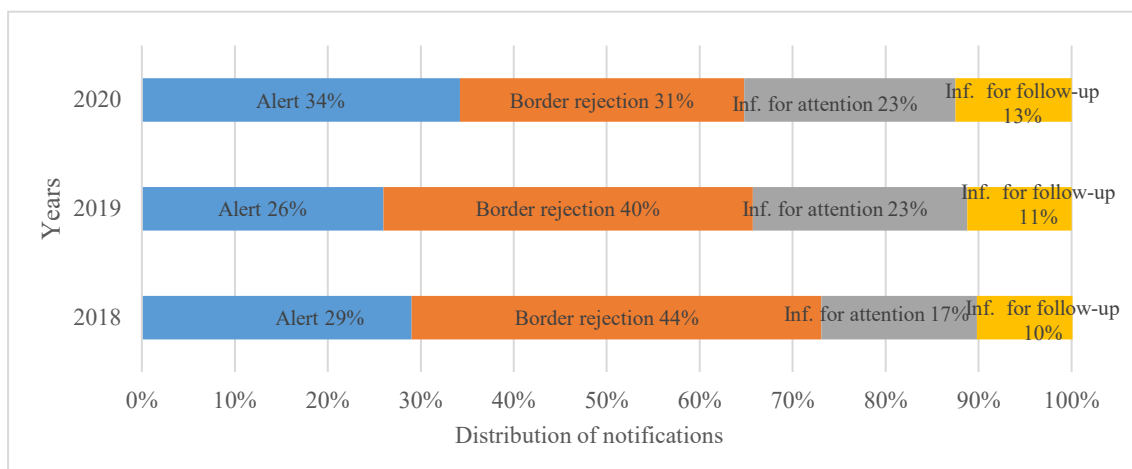
Source: Authors (based on RASFF data)

The data reveal that border rejection (due to inspection of the product at the border) was the most common type of notification, representing 44% in 2018 and decreasing by 13 percentage points in 2020 (Fig. 2). The next most important type of notification was an alert. An alert is made when a product is detected that may constitute a serious risk in the market, requiring rapid action to withdraw the product and reduce the chances of

contamination. There was no clear trend with this notification type, although it was the most common type in 2020. Similarly, there was no clear trend for information for attention and information for follow-up, which represented 23% and 13%, respectively, of all notifications in 2020. These notifications are less important because they affect only one country (attention) or do not require rapid action (follow-up). However, in both cases, they represent a potential risk for consumers.

Fig. 3. Distribution of notifications by region of notifying country
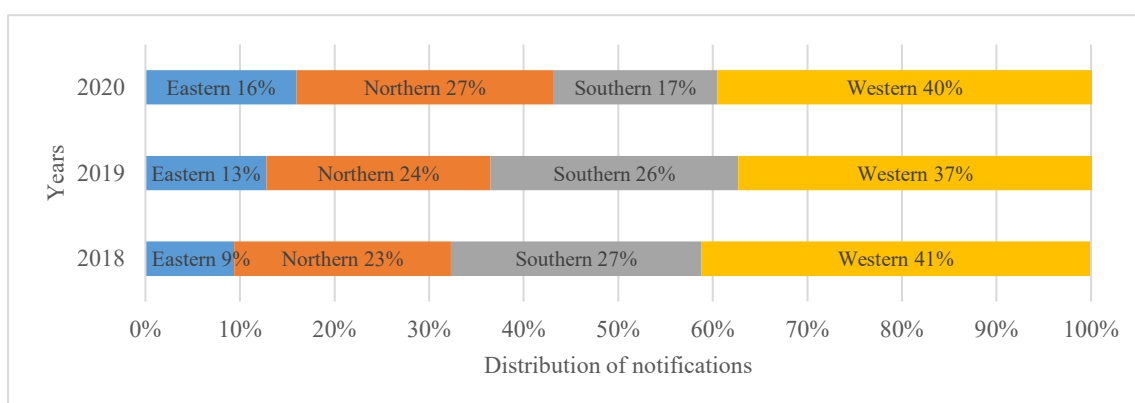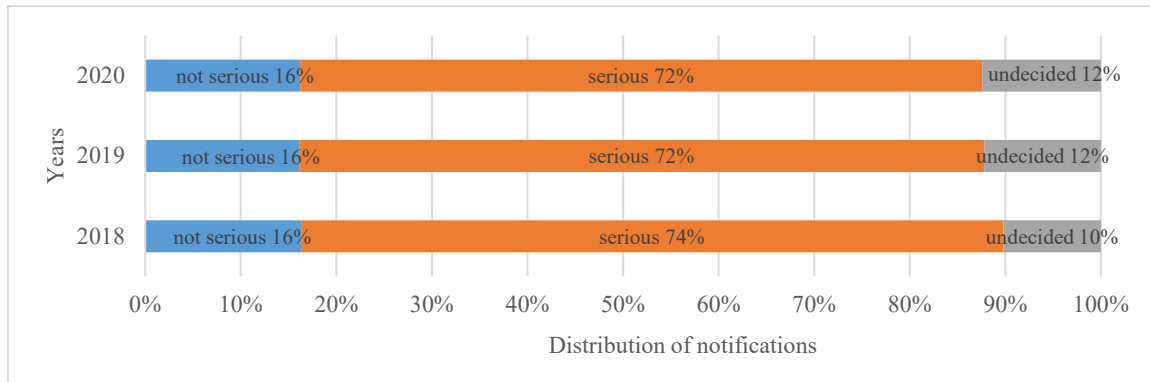

Source: Authors (based on RASFF data)

According to the literature, although the number of notifications reported by European countries varies greatly, five RASFF members have been cited as the most active on several occasions: Germany, Netherlands and France from the Western region, Italy from the Southern region and the United Kingdom from the Northern region (Giorgi & Lindner, 2009; Petróczi et al., 2010; Taylor et al., 2013; Konoiuk & Karwowka, 2017). The intense notification activity of these countries may be due not only to their high level of imports and population density but also to the efforts of their national food surveillance systems, which are crucial to ensure the effective identification of the potential risks inherent in imported foods (Lüth et al., 2019). In the period studied, the Western region was the most active region, with 130, 112 and 78 notifications in 2020 by the Netherlands,

Germany and France, respectively, although this was slightly less than in previous years (Fig. 3). In 2020, notifications reported by countries from the Northern region increased with respect to those in the Southern region. This trend may be attributed to the uneven spread of the pandemic, which required particularly aggressive self-isolation measures in Spain and Italy. According to OECD statistics, imports from Spain fell by 37.5% and those from Italy fell by 32.0% in May 2020 compared to the same period in the previous year.

Fig. 4. Distribution of notifications by risk decision

Source: Authors (based on RASFF data)

The RASFF database also registers notifications by the predicted level of risk of the product (serious, not serious or undecided). There may be substantial differences in the risk decision depending on the food (Fig. 4). For example, Postolache et al. (2020) focused solely on notifications for milk and milk products over the period 2000 to 2020, finding that undecided risk was the most commonly reported risk decision. Overall, however, no significant changes were observed between 2018 and 2020. There was only a slight decrease in those classified as serious, coinciding with the downward trend in previous years, as reported by Čapla et al. (2019) for the period 2016 to 2018.

4.2. Results of the statistical analysis

The empirical analysis addressed three hypotheses. The aim was to detect possible variations in the notifying behaviour of European countries to flag these issues to those responsible for food safety.

H1: *Variation in an importing country's wealth is a key factor in safety controls when food is purchased in international markets.*

A change in the number of notifications should be attributed to two factors: restrictive policies during the most virulent months of the pandemic and the decline in trade flows resulting from the drop in the purchasing power of individuals in the affected countries (Fig. 5).

Fig. 5. GDP per capita growth rate versus the growth rate of notifications (Q1 2020*)
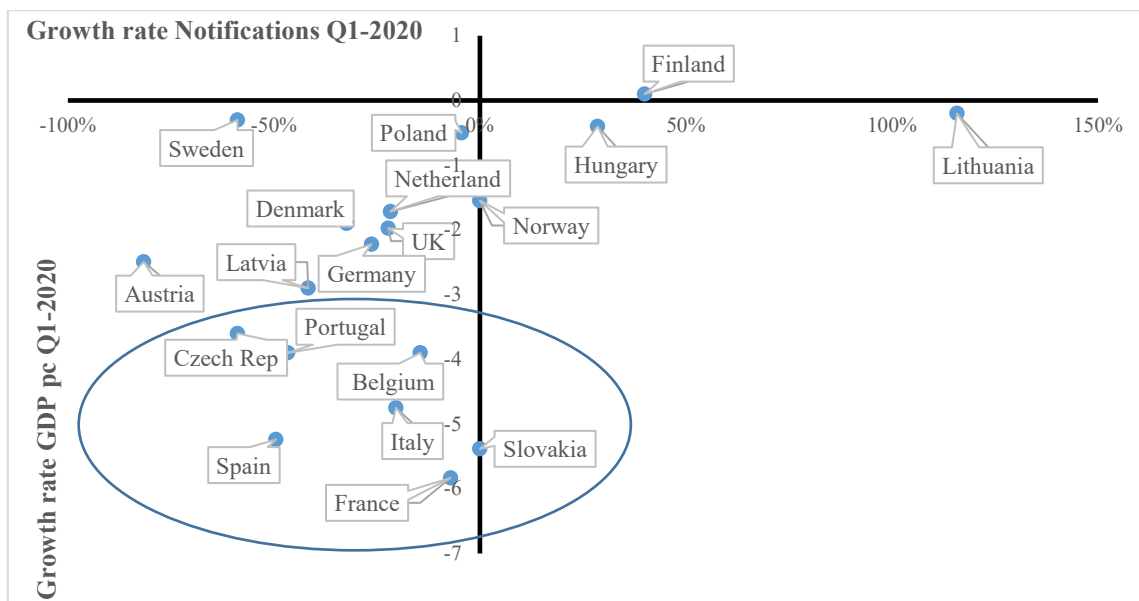
(*) The first quarter was used because of data availability.
Source: Authors (based on OECD and RASFF data)

Fig. 5 shows the countries that experienced the greatest recession in Q1 2020 (Portugal, Czech Rep, Belgium, Italy, Spain, France and Slovakia). There was considerable variability in the volume of notifications (from a 58.8% drop in Czech Republic to no change in Slovakia). In the Netherlands and Germany, which are the biggest reporters of notifications in Europe, there were moderate reductions in notifications (21% and 26%, respectively), and GDP per capita shrank by around 2%. It is also worth noting the behaviour of Finland, Hungary and Lithuania. In these countries, border notifications grew substantially, and they experienced a slight recession. Together, these results indicate that the correlation between wealth and food safety is non-existent or very weak. Hence, it may be concluded that the authorities are capable of ensuring trade in agri-food products with notification patterns that are independent of the economic cycle.

H2: The effects of the COVID-19 crisis have altered the monitoring characteristics (product category, type of notification, risk decision) of European importing countries in the period studied with respect to the same months in previous years.

Based on the notifications recorded in the RASFF database, contingency tables were produced to identify whether the level of monitoring by importing countries changed due to stricter or weaker food safety controls between 2018 and 2020 (Table 3). Following the approach of Pigłowski (2020), feed was omitted in the study. The analysis focused exclusively on food because it was the most frequently notified product category in the RASFF from 1979 to 2017 (89.5% of all notifications).

Table 3. Contingency tables

Product category	2018	2019	2020	Total
Food of vegetal origin	598	717	415	1,730
Food of animal origin	226	270	279	775
Seafood	171	143	137	451
Other food	192	281	200	673
Total	1,187	1,411	1,031	3,629

χ^2 test: 54.359 (p value: 0.000)
Contingency coefficient: 0.121 (p value: 0.000)

Notification type	2018	2019	2020	Total
Alert	344	367	353	1,064
Border rejection	523	560	315	1,398
Information for attention	198	326	234	758
Information for follow-up	122	158	129	409
Total	1,187	1,411	1,031	3,629

χ^2 test: 58.220 (p value: 0.000)
Contingency coefficient: 0.126 (p value: 0.000)

Region of notifying country	2018	2019	2020	Total
Eastern	112	180	165	457
Northern	272	334	279	885
Southern	315	369	179	863
Western	488	528	408	1,424
Total	1,187	1,411	1,031	3,629

χ^2 test: 50.599 (p value: 0.000)
Contingency coefficient: 0.117 (p value: 0.000)

Risk decision	2018	2019	2020	Total
Not serious	193	227	167	587
Serious	873	1012	736	2621
Undecided	121	172	128	421
Total	1,187	1,411	1,031	3,629

χ^2 test: 3.486 (p-value: 0.480)
Contingency coefficient: 0.031 (p-value: 0.480)

Source: Authors (based on RASFF data)

Based on the χ^2 test, the contingency tables for product category, type of notification and region of notifying country show that the year of notification conditioned each of these criteria (*p* value < 0.05; rejection of the null hypothesis of independence between

variables). These results imply that the specific circumstances in the periods considered in this study affected the differences in the number of notifications. However, the contingency coefficient indicates a weak relationship between the period and the characteristics of the notification (approximately 0.1 in all cases).

In the first few months of 2020, COVID-19 had the greatest impact on European countries. At that time, there was a clear decrease in notifications, regardless of the focus of the analysis. This decrease was an undeniable consequence of the changes in countries' economic activity. However, logistical issues related to the spread of the pandemic might have affected trade volumes and the corresponding controls at border inspection points. The analysis nonetheless shows that the risk decision was not significant (p value: 0.480) and can therefore be considered independent of the events each year.

H3: *European countries have reacted consistently in terms of their notification behaviour over the three years covered by the study.*

In line with the research aims, the final step consisted of identifying whether European countries reacted similarly in their notification patterns or whether their responses varied. Cluster analysis was used to identify homogeneous groups of countries in terms of their reporting behaviour, based on both product category and type of notification.

In summary, the analysis of notifications confirms that COVID-19 has not been perceived as a food safety issue. The COVID-19 crisis has not been a key factor for countries to change their behaviour in terms of border notifications on food imports. This is regardless of whether food notifications have been influenced by changes in trade and economic conditions, which have been heavily affected by the COVID-19 crisis.

a. Clustering by product category

As explained in Section 2, cluster analysis was carried out for each year. Ward's method was used to group countries according to their similarity by product category (Fig. 6). For the three years covered by this study, the ideal number of clusters was three, based on the specification of the corresponding dendrogram. The results show a clear difference between Cluster 1 and the other two clusters. Cluster 1 consisted of many countries that reported few notifications, whereas Clusters 2 and 3 contained fewer countries that were more active in reporting notifications (Table 1A in the Appendix).

Fig. 6. Mean value of each product by cluster
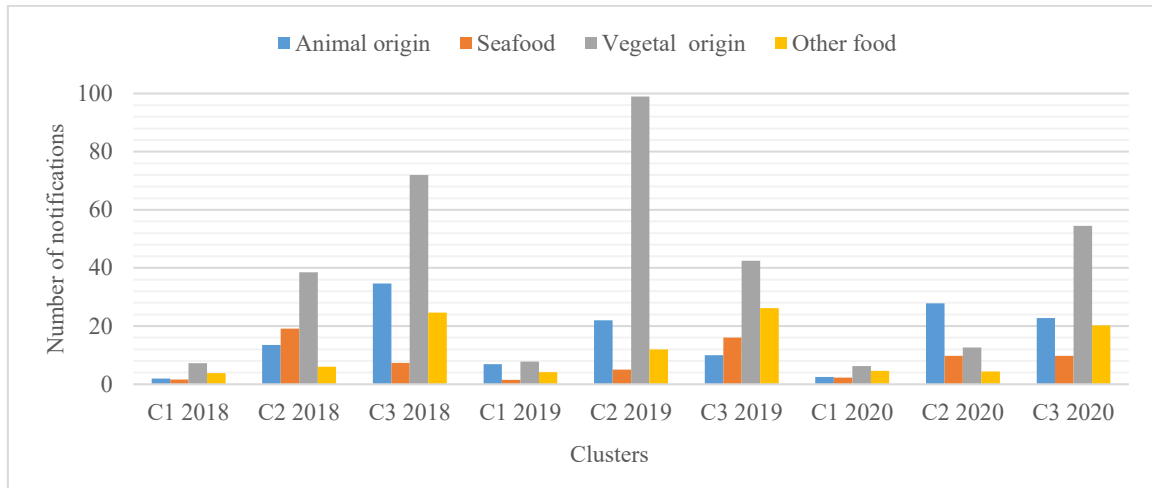
Source: Authors (based on RASFF data). Note: C1 = Cluster 1; C2 = Cluster 2; C3 = Cluster 3

As shown in Fig. 6, the number of notifications on products of vegetal origin was at its highest in all clusters in 2018 and 2019. This result is complemented by the data in Table 4. The table shows the countries that reported the most notifications by product, each country's cluster for each year and the differences between the quantities of each group, supported by Table 3.

Table 4. Main notifying countries by product category and cluster

Product category	2018 Country/Notifications/Cluster			2019 Country/Notifications/Cluster			2020 Country/Notifications/Cluster		
Vegetal origin	Netherlands	102	C3	Netherlands	113	C2	Netherlands	73	C3
	Germany	71	C3	Germany	92	C2	Germany	54	C3
Animal origin	Netherlands	45	C3	Netherlands	30	C2	Lithuania	36	C2
	UK	31	C3	Germany	34	C2	Italy	54	C2
Seafood	Italy	71	C2	Italy	46	C2	Italy	32	C2
	Spain	19	C2	Spain	27	C2	France	13	C2
Other food	UK	36	C3	UK	75	C2	UK	44	C3
	Germany	21	C3	Sweden	45	C2	Germany	54	C3

Source: Authors (based on RASFF data)

By product category, the notifying countries for food of vegetal origin, seafood and other food remained constant over time. No variation due to the presence of COVID-19 in Europe was observed. For example, Spain and Italy have been particularly heavily affected by the pandemic. According to statistics from the European Centre for Disease Prevention and Control, in May 2020, there were 5,116.6 confirmed cases of COVID-19 per million people in Spain and 3,848.1 in Italy, compared to 2,186.4 in Germany. However, they have continued to report more notifications on seafood, although the volume decreased significantly. Similarly, since 2018, the Netherlands and Germany have reduced their notifications on food of vegetal origin by 28.4% and 23.9%, respectively. The most notable changes were in food of animal origin. In 2020, Lithuania and Italy were the most active countries, with 36 and 54 notifications, respectively. Italy exceeded the levels of the Netherlands, Germany and the United Kingdom in 2018 and 2019.

In summary, the clusters based on the number of notifications by product category did not vary over time. Despite having an impact on many areas of the economy, the COVID-

19 health crisis was not a key factor in forcing countries to change their behaviour in terms of border notifications on food imports.

b. *Clustering by type of notification*

The cluster analysis by type of notification was carried out in a similar way to the analysis by product category. The technique was applied to the three samples corresponding to the years covered by the study. The observations were the notifying countries and the variables used to define the homogeneous groups. In this case, these variables were the types of notification. In the RASFF database, the types of notification are alert, border rejection, information for attention and information for follow-up.

The dendrograms show that the ideal grouping corresponds to three homogeneous clusters of countries. Again, Cluster 1 is characterised by a large number of countries reporting a small number of notifications each. Cluster 2 consisted of countries that reported fewer notifications. Finally, Cluster 3 contains the most active countries (Table 2A in the Appendix). Fig. 7 shows the average number of notifications for each cluster by category.

Fig. 7. Mean value of each notification type by cluster
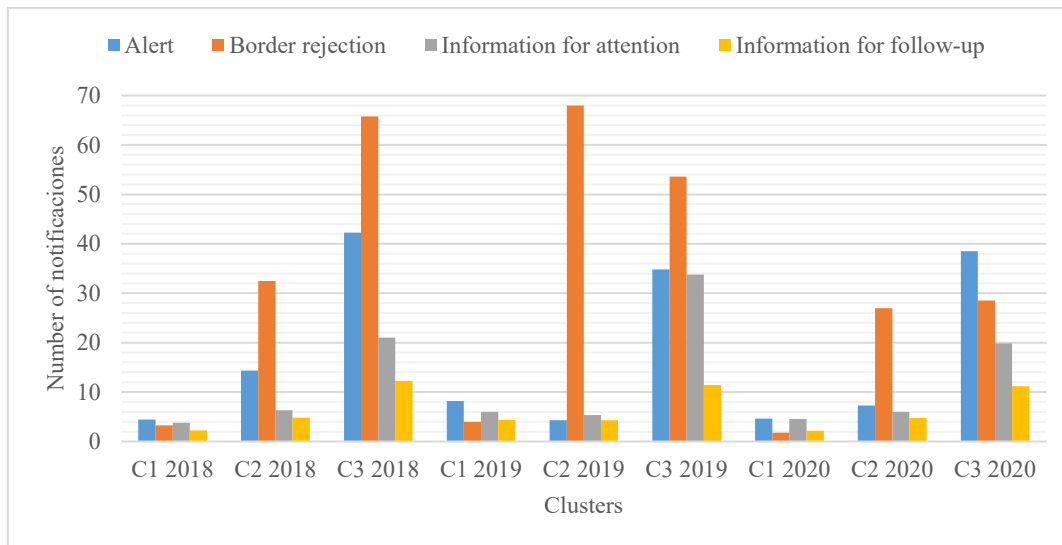
Source: Authors (based on RASFF data). Note: C1 = Cluster 1; C2 = Cluster 2; C3 = Cluster 3

Border rejection was the predominant notification type in Cluster 2 for the three years covered in this study and in Cluster 3 for 2018 and 2019. This situation changed in 2020. For 2020, Cluster 3 contained a set of countries that, according to statistics from the European Centre for Disease Prevention and Control (Belgium, Italy, France and the United Kingdom) have been heavily affected by the pandemic. These countries most often used the alert as a notification type. Although Cluster 1 contained the most member states, it also contained the least active countries over the period studied. Table 5 shows the countries that reported the most notifications.

Table 5. Main notifying countries by notification type, cluster and year

Type of notification	2018			2019			2020		
	Country/Notifications/Cluster			Country/Notifications/Cluster			Country/Notifications/Cluster		
Alert	Netherlands	46	C3	Netherlands	42	C3	Netherlands	49	C3
	Italy	55	C3	Germany	54	C3	Germany	50	C3
Border rejection	Netherlands	99	C3	Greece	90	C2	Netherlands	56	C3
	UK	65	C3	Spain	62	C2	UK	49	C3
Information for attention	Italy	30	C3	UK	57	C3	UK	37	C3
	UK	20	C3	Netherlands	54	C3	Italy	20	C3
Information for follow-up	Italy	23	C3	Italy	24	C3	Italy	19	C3
	Netherlands	12	C3	Germany	18	C3	Germany	22	C3

Source: Authors (based on RASFF data)

The most active countries, regardless of the year and type of notification, were in Cluster 3. The exception was 2019, when the countries in Cluster 2 reported more border rejections than those in any other cluster. Regarding the notifying nations, there were slight variations between 2018 and 2020. The Netherlands reported the most alerts and border rejections, except for 2019, when Greece reported the most border rejections. Italy and the United Kingdom were the most active in information for follow-up and for attention.

Therefore, in response to H3, the analysis showed a change in the most common type of notification. Border rejections were the most common notifications in 2018 and 2019 in Cluster 3. These were replaced by alerts as the most common notifications in 2020. In addition, the clusters were similar in all three years, with Cluster 3 containing the most active countries and Cluster 1 the least active countries. Again, there was no change in the notification behaviour. The active group essentially consisted of six European countries over the period studied: the Netherlands, the United Kingdom, Germany, Spain, Italy and Greece.

The impact of the COVID-19 pandemic is being felt in different areas of the economy. Agricultural trade is no exception. According to Lamichhane and Reay-Jones (2021), the restrictive measures taken to curb the disease have limited the production and supply of plant protection products, affecting crop systems worldwide. In theory, however, agricultural trade should be less affected than other sectors because of the lower income elasticity of demand for these products. Nevertheless, a decrease of 12% to 20% in the value of world trade is expected.

Recently, Barichello (2020) performed a preliminary assessment of the expected effects in Canada. The conclusion was that the results in the cereal sector are likely to be better than others, because income elasticity is lower and because the large exporters are expected to impose restrictions on the international sale of some products such as wheat. These restrictions will raise prices and benefit Canada as a wheat exporter. However, with other products such as livestock, fruit and vegetables, Canada will face a decline in trade due to the loss of purchasing power in several importing countries, in addition to the imposition of greater restrictions on imports for sanitary, phytosanitary and food security reasons.

This research did not detect substantial changes in behaviour patterns for food controls because, in Europe, food safety controls are fully integrated into countries' domestic policies. However, this practice cannot be extended worldwide. Hossain (2020) showed that in the short, medium and long term, food safety challenges due to COVID-19 have varied among the member countries of the Asian Productivity Organization. Similarly, Gregorioa and Ancog (2020) concluded that, in Southeast Asia, the experience of this pandemic should be drawn upon to ensure food safety by treating it as a coordinated problem between the public and private sectors. In a study carried out in Bangladesh, Nur-E-Alam et al. (2020) recommended meeting citizens' food needs with local supplies

to minimise the risk of impacts on food safety. By drawing on Internet survey data of 1,373 residents in China, Min et al. (2020) found that consumers' food safety knowledge has a significant and positive effect on their food safety behaviour.

4. Conclusions

One of the features of the COVID-19 pandemic is its severe consequences not only for people's health but also at all levels of economic and social activity. In an attempt to curb the rapid transmission of the virus, the vast majority of countries closed their borders and confined the population. These measures have caused huge disruptions in local and global value chains. International food trade has been no exception, suffering considerably from these restrictive measures. This situation could have detrimental effects on consumers' and governments' confidence in food safety. Specifically, this situation could have serious effects in relation to the risk that imported products do not comply with health and quality standards, even though there is a lack of evidence that COVID-19 can spread directly through food and the human digestive system (Duda-Chodak et al., 2020).

In short, this paper provides valuable insight into the possibility of enhanced food control notifications during the initial period of the pandemic in Europe. At that time, countries had to deal with a multitude of economic and social problems. Thus, it is plausible to expect that they might have relaxed or tightened their actions in certain key areas, such as the detection of anomalies in the international food trade.

The present article makes several novel contributions to the analysis of food safety notifications. First, it covers a wide geographical area, assessing variation in food control behaviour across a large sample of European countries. Second, it provides in-depth analysis of the relationship between the COVID-19 pandemic and food control behaviour,

expressed in terms of the frequency of notifications reported in a given period. In the period of 2020 considered in this study, the volume of notifications on most imported foodstuffs, specifically seafood and food from agriculture, decreased considerably. This decrease was a direct consequence of the fall in international trade in the first five months of 2020, which could have increased importing countries' reliance on domestic sources.

Third, this paper characterises the profile of reported food notifications according to their timing of communication and other key characteristics. The COVID-19 crisis has not been a key factor for countries to change their profile in terms of the product categories and risk decisions of reported notifications. This stability is a positive sign within the domain of food safety for human consumption, giving some reassurance to the agri-food industry.

As a fourth and final contribution, the analysis identifies similarities between countries in terms of the products and the incidents they report. The analysis shows that the consequences of the pandemic have not substantially affected the behaviour of the notifying authorities. Italy, France, Spain, the Netherlands, Germany and the United Kingdom have been the most active countries, regardless of the year or product. However, in relation to the reported type of notification, the countries that the spread of the virus has affected the most have changed their profile by replacing border rejections with alerts. This change can again be linked to a higher reliance on intra-EU sources.

The research covers a short period. The use of contingency tables to analyse relationships between variables does not provide information on the strength of the influence of these relationships. Providing this insight could be an interesting aim for future investigations using other econometric techniques. It would also be of interest to identify patterns of notifications in post-COVID-19 periods spanning two or more years. Finally, the analysis

could be extended to a wider sample of countries, particularly those less equipped to perform strict food safety controls during pandemics.

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Appendix

Table 1A. Results of the cluster analysis by product category

Notifying country	Cluster 2018	Notifying country	Cluster 2019	Notifying country	Cluster 2020
Austria	1	Austria	1	Austria	1
Luxembourg	1	Luxembourg	1	Luxembourg	1
Ireland	1	Ireland	1	Greece	1
Switzerland	1	Belgium	1	Spain	1
Portugal	1	Switzerland	1	Ireland	1
Sweden	1	Portugal	1	Belgium	1
Denmark	1	Denmark	1	Switzerland	1
Norway	1	Norway	1	Portugal	1
Slovakia	1	Slovakia	1	Sweden	1
Estonia	1	Estonia	1	Denmark	1
Malta	1	Malta	1	Norway	1
Cyprus	1	Cyprus	1	Slovakia	1
Finland	1	Finland	1	Estonia	1
Czech Republic	1	Czech Republic	1	Malta	1
Romania	1	Romania	1	Cyprus	1
Slovenia	1	Slovenia	1	Finland	1
Lithuania	1	Lithuania	1	Romania	1
Croatia	1	Croatia	1	Slovenia	1
Latvia	1	Latvia	1	Croatia	1
Poland	1	Poland	1	Latvia	1
Hungary	1	Hungary	1	Hungary	1
Greece	2	Greece	2	Italy	2
Spain	2	Netherlands	2	France	2
Belgium	2	Germany	2	Czech Republic	2
Italy	2	Spain	3	Lithuania	2

France	2	Italy	3	Poland	2
Bulgaria	2	United Kingdom	3	United Kingdom	3
United Kingdom	3	Sweden	3	Netherlands	3
Netherlands	3	France	3	Germany	3
Germany	3	Bulgaria	3	Bulgaria	3

Table 2A. Results of the cluster analysis by type of notification

Notifying country	Cluster 2018	Notifying country	Cluster 2019	Notifying country	Cluster 2020
Austria	1	Austria	1	Austria	1
Luxembourg	1	Luxembourg	1	Luxembourg	1
Ireland	1	Ireland	1	Ireland	1
Switzerland	1	Belgium	1	Switzerland	1
Portugal	1	Switzerland	1	Portugal	1
Sweden	1	Portugal	1	Sweden	1
Denmark	1	Sweden	1	Denmark	1
Norway	1	Denmark	1	Norway	1
Slovakia	1	Norway	1	Slovakia	1
Estonia	1	Slovakia	1	Estonia	1
Malta	1	Estonia	1	Malta	1
Cyprus	1	Malta	1	Cyprus	1
Finland	1	Cyprus	1	Finland	1
Czech Republic	1	Finland	1	Czech Republic	1
Romania	1	Czech Republic	1	Romania	1
Slovenia	1	Romania	1	Slovenia	1
Lithuania	1	Slovenia	1	Lithuania	1
Croatia	1	Lithuania	1	Croatia	1
Latvia	1	Croatia	1	Latvia	1
Hungary	1	Latvia	1	Hungary	1
Greece	2	Poland	1	Greece	2
Spain	2	Hungary	1	Spain	2
Belgium	2	Greece	2	Poland	2
France	2	Spain	2	Bulgaria	2
Poland	2	Bulgaria	2	Belgium	3
Bulgaria	2	Italy	3	Italy	3
Italy	3	United Kingdom	3	France	3
United Kingdom	3	Netherlands	3	Germany	3
Netherlands	3	France	3	United Kingdom	3
Germany	3	Germany	3	Netherlands	3