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THE INFLUENCE OF BORDER REJECTIONS AND OFFICIAL CONTROLS ON THE MARKET ON ALERT NOTIFICATIONS IN THE RASFF

WPŁYW ODRZUCEŃ NA GRANICY I KONTROLI URZĘDOWYCH NA RYNKU NA POWIADOMIENIA ALARMOWE W SYSTEMIE RASFF

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Abstract: The Rapid Alert System for Food and Feed (RASFF) was created in 1979 and allows for quick response to risks for public health. Alert notifications within the RASFF are sent when the product, which presents a serious risk, is already on the market and a rapid action is required. The explicit increase of alert notifications can be noticed since 1999 and particularly since 2003/2004, when official controls on the market began to be noted. While a decrease of alert notifications can be observed since 2008, when border rejections in the RASFF began to be noted. The influence of border rejections and official controls on the market (as two variables) on the number of alert notifications in the RASFF in 1999-2014 was examined with regard to products categories, hazards categories and the European Union (EU) countries, using multiple regression. In the case of the EU countries also the influence of additional variables was examined: the number of food audits, import of food, drinks and tobacco, average total population and total agriculture production of food in the gross production value. The variable official controls on the market was statistically significant and the relationship was very high or high in case of: bivalve molluscs and products thereof, dietetic food, food supplements, fortified food, fish and fish products, herbs and spices and soups, broths, sauces and condiments (products categories) and: allergens, composition, food additives and flavourings, heavy metals, migration, mycotoxins and pathogenic micro-organism (hazards categories). The variable number of border rejections was statistically significant and the relationship was very high or high in case of: dietetic food, food supplements, fortified food (products categories) and: allergens, composition, food additives and flavourings and mycotoxins (hazards categories). In the case of the EU countries the very high or high relationship was not found in models with the two variables and was high in case of France and Latvia in models with six variables. It can be assumed that variability of the number of alert notifications in the RASFF (especially within the EU countries) also can depend on other factors, such as: the amount of food on the market, the scope of food control, the level of preparedness of controllers or movement of people. However, it is difficult to quantify these factors (and take as variables) or the adopted variables would cause collinearity.

Keywords: Rapid Alert System for Food and Feed (RASFF), alert notifications, official controls, border rejections, multiple regression.

Streszczenie: System Wczesnego Ostrzegania o Niebezpiecznej Żywności i Paszach (RASFF) powstał w 1979 roku. Umożliwia on szybkie reagowanie na zagrożenia dla zdrowia publicznego. Powiadomienia alarmowe w ramach systemu RASFF są przesyłane wówczas, gdy produkt prezentujący poważne ryzyko już znajduje się na rynku i konieczne jest natychmiastowe działanie. Wyraźny wzrost powiadomień alarmowych można zauważyć od roku 1999, a szczególnie od roku 2003/2004, kiedy zaczęto odnotowywać urzędowe kontrole na rynku. Natomiast spadek powiadomień alarmowych można zaobserwować od roku 2008, kiedy w systemie RASFF zaczęły być odnotowywane odrzucenia na granicy. Wpływ odrzuceń na granicy i urzędowych kontroli na rynku (jako dwóch zmiennych) na liczbę powiadomień alarmowych w systemie RASFF w latach 1999–2014 został zbadany w odniesieniu do kategorii produktów, kategorii zagrożeń i krajów Unii Europejskiej (UE), z wykorzystaniem regresji wielorakiej. W przypadku krajów UE zbadano także wpływ dodatkowych zmiennych: liczbę auditów żywności, import żywności, napojów i tytoniu, przeciętną populację całkowitą i całkowitą produkcję żywności w rolnictwie w produkcji brutto. Zmienna urzędowych kontroli na rynku była statystycznie istotna, a zależność bardzo wysoka lub wysoka w przypadku: małży i produktów pochodnych, żywności dietetycznej, suplementów diety, żywności wzbogaconej, ryb i produktów rybnych, ziół i przypraw korzennych, zup, bulionów, sosów i przypraw (kategorie produktów) oraz: alergenów, składu, dodatków do żywności i środków aromatyzujących, metali ciężkich, migracji, mykotoksyn i mikroorganizmów patogennych (kategorie zagrożeń). Zmienna odrzucenia na granicy była statystycznie istotna, a zależność bardzo wysoka lub wysoka w przypadku: żywności dietetycznej, suplementów diety, żywności wzbogaconej (kategorie produktów) oraz: alergenów, składu, dodatków do żywności i środków aromatyzujących i mykotoksyn (kategorie zagrożeń). W przypadku krajów UE zależność bardzo wysoka lub wysoka nie wystąpiła (w modelach z dwiema zmiennymi), jednak zależność wysoka wystąpiła w modelach z sześcioma zmiennymi w przypadku Francji i Łotwy. Zmienność liczby powiadomień alarmowych w systemie RASFF (szczególnie w ramach krajów UE) może także zależeć od innych czynników, jak np.: ilość żywności na rynku, zakres kontroli żywności, poziom przygotowania inspektorów czy ruch ludności. Jednak trudno byłoby skwantyfikować te czynniki (i przyjąć jako zmienne) lub też przyjęte zmienne powodowałyby współliniowość.

Słowa kluczowe: System Wczesnego Ostrzegania o Niebezpiecznej Żywności i Paszach (RASFF), powiadomienia alarmowe, kontrole urzędowe, odrzucenia na granicy, regresja wieloraka.

1. INTRODUCTION

Because of globalisation of food chains, food safety problems may move quickly around the world [Marvin et al. 2013]. Logistics is a part of supply chain within the food safety management – see Overbosch and Blanchard [2014]; see also Van Asselt et al. [2010]. During the last decade increased demands for operators in the food chain and an importance of food safety and quality controls [Delcour et al. 2015]. The food chain may in fact consist of five or six levels of companies and processors

– see Zach et al. [2012] and besides the logistic systems used to transport the products vary – see Uyttendaele et al. [2014].

Zach et al. [2012] stated the food chain should be included by implementation of rapid alert system. Zhang et al. [2011] mentioned that pre-warning analysis results and information from the abnormal logistic units may be linked to the pre-warning database by the response system. Kleter et al. [2009] recommended the Rapid Alert System for Food and Feed (RASFF) database as a tool to identify hazards – see also Banach et al. [2016].

The RASFF was created in 1979 [European Commission 2015c]. Yet, the current legal basis for the RASFF is the Regulation (EC) No 178/2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety [European Parliament and Council 2002] and in the Commission Regulation (EU) No 16/2011 laying down implementing measures for the Rapid Alert System for Food and Feed [European Commission 2011].

The members of the RASFF are: 28 European Union (EU) countries, European Commission, European Food Safety Authority (EFSA), European Free Trade Association Surveillance Authority (ESA), Norway, Iceland, Liechtenstein and Switzerland. They can exchange information on risks in food [European Commission 2015c].

The RASFF allows for quick response to risks for public health detected in the food chain before they could become harmful to consumers. Alert notifications are sent when the product (food or feed), which presents a serious risk, is already on the market and a rapid action (e.g. recall of the product) is required [European Commission 2015c].The number of alert notifications began to rise from 1999; however explicit increase can be noticed since 2003/2004, when official controls on the market began to be noted in the RASFF [Pigłowski 2015]. Official controls in 46% of cases led to alert notifications – see [European Commission 2015c]. In turn, a decrease of alert notifications can be observed since 2008, when border rejections in the RASFF began to be noted. Here, however, we can talk about indirect influence. This concurrence may in fact point out to the use of imported food to food production in the EU. Taylor et al. [2013] noted, that border notifications are a reflection of actions taken by the EU countries (intelligence within the market, response to information from other countries) and most notifications were made by Italy, Germany, the United Kingdom and Spain.

These changes in the number of alert notifications were connected with the implementation of a few law acts. The basic obligations on official controls were laid down in the mentioned Regulation (EC) No 178/2002. However, in 2004 was issued the Regulation (EC) No 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption – see [European Parliament and Council 2004a] and the Regulation (EC) No 882/2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules – see

[European Parliament and Council 2004b]. Then, in 2009 the Commission issued the Regulation (EC) No 669/2009 implementing Regulation (EC) No 882/2004 as regards the increased level of official controls on imports of certain feed and food of non-animal origin and amending Decision 2006/504/EC – see [European Commission 2009]. Hoffbauer et al. [2012] stated that the implementation of the Regulation (EC) No 669/2009 was effective.

Maleszka and Matuszak [2008] and Maleszka [2009] believed that the number of alert notifications in the RASFF may be affected by: population, the number of tourists, size of food trade, volume of food production, the amount of funds for research. Maleszka [2008] added that it could be also taken into account: import, geographical circumstances, public awareness, legislation and its enforcement. Whereas Matuszak [2010] also mentioned that in the RASFF new categories of hazards appeared and that other countries joined this system. Some of these factors can be quantified in the form of variables, referring them to the EU, i.e., population, volume of imports, volume of food production and also food audits, which were not mentioned above. However, the other factors would be difficult or impossible to quantify; they could also cause collinearity with border rejections and official controls on the market or between each other.

Therefore, the basic aim of the article was to examine what was the influence of the number of border rejections and official controls on the market on the number of alert notifications in the RASFF in three areas: products categories, hazards categories and the EU countries. However, the additional aim in the case of the EU countries was to examine the influence of food audits, border rejections, official controls on the market, import of food, drinks and tobacco, average total population and total agricultural production of food on alert notifications in the RASFF.

2. DATA AND METHODS

The study covered the period 1999–2014 (hence the population size n was 16) in three areas: products categories, hazards categories and the EU countries. The multiple regression analysis was used, taking as independent variables: the number of border rejections BR and the number of official controls on the market CN. Border controls (consignment detained, released and under customs) were not taken into account, because the result of these controls are border rejections. Thus, adopting the variables related to border controls caused collinearity with border rejections. As the dependent variable the number of alert notifications in the RASFF was adopted – see [European Commission 2015c]. If as the food origin several countries were indicated, the first of them was adopted.

Moreover, in the case of the EU countries multiple regression models were expanded and included other independent variables: the number of food audits carried out by the Food and Veterinary Office (FVO) AD – see [European

Commission 2015b], import of food, drinks and tobacco from all countries of the world (billions €) by the Standard International Trade Classification (SITC) *IM*, average total population (millions) *PP* – see [European Commission 2015a] and total agriculture production of food in the gross production value (current billions US$) *PR* – see [Food and Agriculture Organization 2015]. The different character of these variables made it possible to use them only in models for the EU countries.

The scope of the audits (earlier food inspections) – see variable *AD* is different than in the case of food controls. These audits often concern other food categories and even issues related to food safety, e.g.: food of animal origin, food of non-animal origin, general follow-up, system audits, plant health/ animal welfare (by main area) or general follow-up and systems audits, meat including horse meat/milk/dairy, animal welfare (by sector) – see [European Commission 2014].

In the case of import (variable *IM*) aggregated values of two products groups of SITC0_1 were adopted, i.e.: food and live animals (SITC0) and beverages and tobacco (SITC1) – see [European Commission 2015a]. The values of import for Croatia in 1999, 2000, 2001 and 2014 were not provided, therefore they were extrapolated using simple linear regression (where as the independent value *X* time with the value from 1 for 1999 to 16 for 2014 was adopted). The values of population (variable *PP*) for 2014 were also extrapolated in a similar manner, except Slovakia, where the average value was calculated, because the variable *X* in model of regression for this country was not statistically significant.

The data on agricultural production given by Eurostat was divided into groups (crops, poultry, milk, livestock) and subgroups, not as aggregated values – see [European Commission 2015c]. Therefore, the values of agricultural production (variable *PR*) from Food and Agriculture Organization (FAO) database (as the aggregated values) were adopted – see [Food and Agriculture Organization 2015]. However, the values from the FAO database were given up to 2012, so the values of variable *PR* for 2013 and 2014 were also extrapolated using simple linear regression. The total agricultural production in 1999 for Belgium and Luxembourg was given as the total value, therefore it was extrapolated in a similar manner. It should be added that the character of variables *IM* and *PR* allowed avoiding collinearity (imported foods were unlikely to be used for agricultural production).

3. RESULTS AND DISCUSSION

The parameters of models with two variables (the number of official controls on the market *CN* and the number of border rejections *BR*) for products categories were presented in Table 1. The value of the adjusted determination coefficient $\overline{R}^2$ was very high or high in the case of five products categories, i.e.: bivalve molluscs and products thereof (0.86), dietetic food, food supplements, fortified food (0.80), fish and fish products (0.82), herbs and spices (0.96) and soups, broths, sauces and condiments (0.83). While the moderate relationship was visible in the case of: alcoholic beverages (0.71), crustaceans and products thereof (0.64), gastropods (0.77), honey and royal jelly (0.74), meat and meat products (other than poultry) (0.66), natural mineral water (0.77), nuts and nut products and seeds (0.66), other food products / mixed (0.65) and poultry meat and poultry meat products (0.69). In all these products categories the variable number of official controls on the market CN was statistically significant, however, the variable number of border rejections BR was statistically significant only in the case of: alcoholic beverages, crustaceans and products thereof, dietetic foods, food supplements, fortified food (the only category in which the relationship was high), gastropods and natural mineral water.

Table 1. Parameters of multiple regression models for products categories (two variables)

Tabela 1. Parametry modelu regresji wielorakiej dla kategorii produktów (dwie zmienne)

Products categories	$\overline{R}^2$	F [1)]	p [2)]	p_{BR}	p_{CN} [3)]
Alcoholic beverages	0.71	**19.2490**	**0.0001**	**0.0034**	**0.0014**
Animal nutrition – (obsolete)[4)]	-	-	-	-	-
Bivalve molluscs and products thereof	0.86	**48.0070**	**0.0000**	0.4880	**0.0000**
Cephalopods and products thereof	0.30	**4.2355**	**0.0383**	0.6790	**0.0301**
Cereals and bakery products	0.54	**9.8190**	**0.0025**	0.7026	**0.0018**
Cocoa and cocoa preparations, coffee and tea	0.49	**8.0820**	**0.0052**	0.6188	**0.0020**
Confectionery	0.38	**5.5480**	**0.0181**	0.2986	**0.0061**
Crustaceans and products thereof	0.64	**14.3730**	**0.0005**	**0.0263**	**0.0003**
Dietetic foods, food supplements, fortified foods	0.80	**31.1210**	**0.0000**	**0.0041**	**0.0000**
Eggs and egg products	0.19	2.8060	0.0970	0.7820	**0.0341**
Farmed crustaceans and products thereof – (obsolete)[4)]	-	-	-	-	-
Farmed fish and products thereof (other than crustaceans and molluscs) – (obsolete)[4)]	-	-	-	-	-
Fats and oils	-0.02	0.8840	0.4366	0.2099	0.8983
Fish and fish products	0.82	**34.4950**	**0.0000**	0.8587	**0.0000**
Food additives and flavourings	0.18	2.6909	0.1052	0.0569	0.6615
Food contact materials[4)]	-	-	-	-	-
Fruits and vegetables	0.35	**4.9490**	**0.0252**	0.7035	**0.0121**
Gastropods	0.77	**26.6159**	**0.0000**	**0.0072**	**0.0000**
Herbs and spices	0.96	**201.4060**	**0.0000**	0.0968	**0.0000**
Honey and royal jelly	0.74	**22.4970**	**0.0001**	0.1039	**0.0000**
Ices and desserts	-0.02	0.8600	0.4461	0.7602	0.2358
Meat and meat products (other than poultry)	0.66	**15.2530**	**0.0004**	0.2301	**0.0001**
Milk and milk products	0.46	**7.2910**	**0.0075**	0.4027	**0.0022**
Molluscs and products thereof – (obsolete)[4)]	-	-	-	-	-
Natural mineral water	0.77	**26.2936**	**0.0000**	**0.0418**	**0.0000**
Non-alcoholic beverages	0.30	**4.2570**	**0.0378**	**0.0332**	**0.0299**
Nuts, nut products and seeds	0.66	**15.4920**	**0.0004**	0.1426	**0.0001**
Other food product / mixed	0.65	**14.9890**	**0.0004**	0.2592	**0.0193**

cont. Table 1

Poultry meat and poultry meat products	0.69	**17.8770**	**0.0002**	0.9404	**0.0001**
Prepared dishes and snacks	0.48	**7.7910**	**0.0060**	**0.0140**	**0.0399**
Soups, broths, sauces and condiments	0.83	**36.3380**	**0.0000**	0.8232	**0.0000**
Water for human consumption (other)	0.59	**11.8396**	**0.0012**	0.2030	**0.0004**
Wild caught crustaceans and products thereof – (obsolete)[4)]	-	-	-	-	-
Wild caught fish and products thereof (other than crustaceans and molluscs) – (obsolete)[4)]	-	-	-	-	-
Wine[4)]	-	-	-	-	-
Variables statistically significant				7	24
All products categories	0.86	**48.2990**	**0.0000**	0.0860	**0.0000**

Notes: [1)] critical statistics $F_{\alpha;k;n-k-1}$ was 3.8056 (significance level α of 0.05, the number of independent variables k was 2, population size n was 16), in models statistically significant the statistics value F was bolded; [2)] in models statistically significant the probability value p was below 0.05 and was bolded; [3)] variables denotation: the number of border rejections BR, the number of official controls on the market CN; [4)] no data for variable BR.

Source: own study.

In Table 2 presented parameters of models with two variables (the number of official controls on the market *CN* and the number of border rejections *BR*) for hazards categories. The value of the adjusted determination coefficient $\overline{R}^2$ was very high or high in the case of seven hazards categories, i.e.: allergens (0.97), composition (0.90), food additives and flavourings (0.97), heavy metals (0.95), migration (0.95), mycotoxins (0.90) and pathogenic micro-organisms (0.85) and moderate in case of: organoleptic aspects (0.78) and parasitic infestation (0.69). In all the mentioned categories the variable number of official controls on the market *CN* was statistically significant. Whereas the variable number of border rejections *BR* was statistically significant in the case of: allergens, composition, food additives and flavourings, mycotoxins and organoleptic aspects.

Table 2. Parameters of multiple regression models for hazards categories (two variables)

Tabela 2. Parametry modelu regresji wielorakiej dla kategorii zagrożeń (dwie zmienne)

Hazards categories	$\overline{R}^2$	F [1)]	p [2)]	p_{BR}	p_{CN} [3)]
Adulteration / fraud	0.56	**10.5660**	**0.0019**	**0.0285**	**0.0006**
Allergens	0.97	**261.1380**	**0.0000**	**0.0003**	**0.0000**
Biocontaminants	0.18	2.5890	0.1131	0.3519	0.1034
Biotoxins (other)	0.22	3.0860	0.0800	0.9197	**0.0293**
Chemical contamination (other)	0.37	**5.4580**	**0.0190**	0.1270	**0.0135**
Composition	0.90	**69.4060**	**0.0000**	**0.0031**	**0.0000**
Feed additives	0.14	2.2538	0.1444	0.7802	0.0617
Food additives and flavourings	0.97	**272.6970**	**0.0000**	**0.0000**	**0.0000**
Foreign bodies	0.58	**11.4310**	**0.0014**	0.7494	**0.0005**
GMO / novel food	0.31	**4.3520**	**0.0357**	0.0890	**0.0179**
Heavy metals	0.92	**81.9420**	**0.0000**	0.3827	**0.0000**

cont. Table 2

Industrial contaminants	-0.07	0.5220	0.6051	0.3405	0.5196
Labelling absent/incomplete/incorrect	-0.08	0.4680	0.6364	0.3606	0.5743
Migration	0.95	**134.9950**	**0.0000**	0.9665	**0.0000**
Mycotoxins	0.90	**66.8440**	**0.0000**	**0.0337**	**0.0000**
Non-pathogenic micro-organisms	0.57	**10.8240**	**0.0017**	**0.0019**	**0.0076**
Not determined / other	0.02	1.1310	0.3524	0.5204	0.1617
Organoleptic aspects	0.78	**27.8670**	**0.0000**	**0.0080**	**0.0000**
Packaging defective / incorrect	0.29	**4.0730**	**0.0423**	0.9508	**0.0138**
Parasitic infestation	0.69	**17.8350**	**0.0002**	0.0910	**0.0023**
Pathogenic micro-organisms	0.85	**42.0010**	**0.0000**	0.0739	**0.0000**
Pesticide residues	-0.15	0.0500	0.9511	0.9729	0.7607
Poor or insufficient controls	0.34	**4.7720**	**0.0279**	0.3181	**0.0086**
Radiation	0.53	**9.4850**	**0.0029**	**0.0407**	**0.0018**
Residues of veterinary medicinal products	0.48	**7.9490**	**0.0056**	0.3378	**0.0026**
TSEs 4)	-	-	-	-	-
Variables statistically significant				8	19
All hazards categories	0.86	**48.2190**	**0.0000**	0.0862	**0.0000**

Notes: 1) critical statistics $F_{\alpha;k;n-k-1}$ was 3.8056 (significance level α of 0.05, the number of independent variables k was 2, population size n was 16), in models statistically significant the statistics value F was bolded; 2) in models statistically significant the probability value p was below 0.05 and was bolded; 3) variables denotation: the number of border rejections BR, the number of official controls on the market CN; 4) no data for variable BR.

Source: own study.

Particular attention should be paid to seafood. Schröder [2008], Kleter et al. [2009], Wan Norhana et al. [2010] and Jami et al. [2014] pointed out that seafood was often reported in the RASFF. For instance, Boxman [2010] mentioned viruses in oysters and shellfish. Anacleto et al. [2015] noted notifications relating to toxic elements in bivalve molluscs. Noël et al. [2011] mentioned cadmium in crustaceans. Figueroa [2008] found, however, that the notifications in the RASFF on cadmium in fish products related mainly to product from the developing countries. Hoffbauer et al. [2012] also mentioned heavy metals in fish in the RASFF reports. In turn, He [2015] noted that the RASFF reports indicated that seafood from China was often rejected by imports. Little et al. [2012] pointed to microbiological contamination and veterinary products in the Vietnamese pangasius and Noseda et al. [2013] pointed out bacteria in frozen fish from Vietnam. Phu et al. [2015] mentioned chemical residues and pathogens in catfish from Vietnam, but pointed out that the RASFF reports can be now applied for improvement. This trend was also noticed by De Silva [2012].

The second, important products group, which can be treated together in the RASFF was: fruits and vegetables, nuts, nut products and seeds and herbs and spices – see also Kleter et al. [2009] and Pereira et al. [2014]. Attention was often paid to mycotoxins, e.g. in: peanuts and tree nuts [Van der Fels-Klerx et al. 2010], nuts

[García-Cela et al. 2012], dried fruits [Campone et al. 2015], nuts, dried fruits and spices [Van de Perre et al. 2015]. Hoffbauer et al. [2012] referred to pesticide residues in vegetables and fruits. Van Boxstael et al. [2013] also pointed to already mentioned mycotoxins, pesticide residues, and bacterial pathogens in vegetables and fruits and herbs and spices. Sango et al. [2014] drew attention to microbial pathogens in the RASFF notifications, too.

Among other products categories, Petroczi et al. [2011] pointed out to the RASFF notifications on dietetic foods, food supplements, fortified food and Jansen et al. [2015] drew attention to meat and meat products and poultry meat and poultry meat products. In contrast Poms et al. [2010] referred to the RASFF notifications in hazards category: allergens.

The parameters of models with two variables (the number of official controls on the market CN and the number of border rejections BR) for particular EU countries were presented in Table 3.

Table 3. Parameters of multiple regression models for countries (two variables)
Tabela 3. Parametry modelu regresji wielorakiej dla krajów (dwie zmienne)

Countries	$\bar{R}^2$	F 1)	p 2)	p_{BR}	p_{CN} 3)
Austria	0.11	1.9600	0.1802	0.8350	0.1031
Belgium	0.56	**10.7040**	**0.0018**	**0.0244**	**0.0022**
Bulgaria	0.65	**14.6430**	**0.0005**	0.9759	**0.0151**
Croatia	0.44	**6.9720**	**0.0088**	**0.0032**	0.0706
Cyprus	0.16	2.4618	0.1240	0.0707	0.1421
Czech Republic	0.47	**7.5650**	**0.0066**	0.3434	**0.0019**
Denmark	0.22	3.1140	0.0785	0.0545	0.0732
Estonia	-0.10	0.3470	0.7131	0.9535	0.4221
Finland	0.06	1.4490	0.2704	0.2703	0.7011
France	0.78	**27.7240**	**0.0000**	0.6835	**0.0000**
Germany	0.50	**8.4210**	**0.0045**	0.7912	**0.0013**
Greece	0.31	**4.3870**	**0.0350**	0.1815	**0.0156**
Hungary	0.51	**8.9440**	**0.0036**	0.5135	**0.0011**
Ireland	0.20	2.8360	0.0951	0.4179	0.1137
Italy	0.38	**5.4980**	**0.0186**	0.0899	**0.0088**
Latvia	0.09	1.7270	0.2162	0.1289	0.3232
Lithuania	0.28	**3.9150**	**0.0467**	0.2546	**0.0173**
Luxembourg	-0.14	0.1030	0.9031	0.7477	0.8443
Malta	0.05	1.4129	0.2785	0.1805	0.1712
Netherlands	0.54	**9.8630**	**0.0025**	**0.0330**	**0.0009**
Poland	0.34	**4.9160**	**0.0257**	0.7006	**0.0180**
Portugal	0.27	3.7380	0.0522	**0.0492**	0.2568
Romania	0.25	3.4480	0.0629	0.0846	0.7185
Slovakia	0.61	**12.6310**	**0.0009**	**0.0344**	**0.0002**
Slovenia	0.26	3.6666	0.0546	**0.0294**	0.5849
Spain	0.58	**11.5250**	**0.0013**	0.3472	**0.0004**

cont. Table 3

Sweden	0.18	2.5860	0.1134	0.2792	0.0699
United Kingdom	0.68	**16.6220**	**0.0003**	0.2580	**0.0001**
Variables statistically significant				6	14
All countries	0.86	**48.2190**	**0.0000**	0.0862	**0.0000**

Notes: [1)] critical statistics $F_{\alpha;k;n-k-1}$ was 3.8056 (significance level α of 0.05, the number of independent variables k was 2, population size n was 16), in models statistically significant the statistics value F was bolded; [2)] in models statistically significant the probability value p was below 0.05 and was bolded; [3)] variables denotation: the number of border rejections BR, the number of official controls on the market CN.

Source: own study.

There was no very high or high value of the adjusted determination coefficient $\overline{R}^2$ in any country, however, the moderate relationship was noticed in the case of: Bulgaria (0.65), France (0.78), Slovakia (0.61) and the United Kingdom (0.68) with the variable number of official controls on the market CN statistically significant in each of these countries. The variable number of border rejections BR was also statistically significant in the case of Slovakia.

The parameters of models with six variables (the number of official controls on the market CN, the number of border rejections BR and additionally: the number of food audits carried out by FVO AD, import of food, drinks and tobacco from all countries of the world (billions €) by SITC IM, average total population (millions) PP and total agriculture production of food in the gross production value (current billions US$) PR) for particular EU countries were presented in Table 4.

Increasing of variables number to six caused increase in the value of the adjusted determination coefficient $\overline{R}^2$ in the case of 20 among 28 EU countries (compare this value in Table 4 with the value in Table 3). The value of $\overline{R}^2$ became high in the case of France (0.87) and Latvia (0.80) and was moderate in the case of Bulgaria (0.77), Finland (0.76), Germany (0.66), the Netherlands (0.66), Slovakia (0.75), Slovenia (0.63), Spain (0.66) and the United Kingdom (0.70). However, the variable number of official controls on the market CN was statistically significant in the case of: Czech Republic, France, Hungary, Slovakia and the United Kingdom, and the variable number of border rejections BR in the case of: Croatia, Finland, France, Portugal and Slovakia. Statistical significance can also be pointed out in the case of variables: the number of food audits carried out by FVO AD in Finland (only in this one country, which can indicate low effectiveness of food audits), import of food, drinks and tobacco from all countries of the world (billions €) by SITC IM in Cyprus, Latvia Luxembourg, Portugal and Slovenia, average total population (millions) PP in Austria, Cyprus, Germany, Ireland, Italy, Latvia, Luxembourg, Portugal and Slovenia and total agriculture production of food in the gross production value (current billions US$) PR in Latvia and Slovenia.

Table 4. Parameters of multiple regression models for countries (six variables)
Tabela 4. Parametry modelu regresji wielorakiej dla krajów (sześć zmiennych)

Countries	$\overline{R}^2$	F 1)	p 2)	p_{AD}	p_{BR}	p_{CN}	p_{IM}	p_{PP}	p_{PR} 3)
Austria	0.39	2.5690	0.0984	0.6589	0.5338	0.8548	0.0670	**0.0228**	0.9306
Belgium	0.57	**4.2710**	**0.0259**	0.4522	0.9516	0.1331	0.2926	0.7274	0.4509
Bulgaria	0.77	**9.3710**	**0.0019**	0.7150	0.2026	0.0527	0.3362	0.9751	0.8048
Croatia	0.54	**3.9420**	**0.0326**	0.6708	**0.0426**	0.1104	0.3461	0.2835	0.8728
Cyprus	0.16	1.4785	0.2868	0.5546	0.1518	0.9024	**0.0059**	**0.0162**	0.8745
Czech Republic	0.48	3.3380	0.0514	0.5501	0.6436	**0.0325**	0.7639	0.2753	0.4146
Denmark	-0.03	0.9400	0.5118	0.4012	0.2594	0.2062	0.9861	0.9933	0.9114
Estonia	-0.34	0.3730	0.8786	0.7030	0.5828	0.8070	0.4027	0.1172	0.1169
Finland	0.76	**8.8753**	**0.0023**	**0.0176**	**0.0171**	0.7356	0.8160	0.6631	0.8352
France	0.87	**17.5220**	**0.0002**	0.5207	**0.0150**	**0.0014**	0.3563	0.9609	0.8860
Germany	0.66	**5.8710**	**0.0096**	0.9384	0.5060	0.0512	0.0930	**0.0247**	0.3338
Greece	0.08	1.2240	0.3766	0.8736	0.3987	0.3604	0.6523	0.8465	0.4630
Hungary	0.53	**3.7720**	**0.0369**	0.7301	0.7866	**0.0133**	0.8247	0.9471	0.2479
Ireland	0.19	1.5740	0.2593	0.5191	0.4709	0.9094	0.9733	**0.0002**	0.7700
Italy	0.38	2.5300	0.1019	0.1675	0.6369	0.0788	0.0921	**0.0000**	0.7920
Latvia	0.80	**11.0960**	**0.0010**	0.7799	0.3207	0.1805	**0.0000**	**0.0011**	**0.0002**
Lithuania	0.32	2.1740	0.1420	0.6907	0.0547	0.1564	0.6081	0.9360	0.1294
Luxembourg	0.15	1.4274	0.3028	0.1649	0.3674	0.5838	**0.0041**	**0.0000**	0.2550
Malta	0.01	1.0186	0.4704	0.2994	0.4938	0.1688	0.6030	0.1112	0.2819
Netherlands	0.66	**5.9020**	**0.0095**	0.4752	0.0648	0.4701	0.2645	0.0571	0.9162
Poland	0.55	**4.0440**	**0.0303**	0.2522	0.8819	0.9860	0.9021	0.5087	0.4922
Portugal	0.47	3.2380	0.0557	0.9882	**0.0440**	0.6824	**0.0118**	**0.0000**	0.6595
Romania	0.39	2.5650	0.0987	0.0924	0.4201	0.7289	0.5133	0.8645	0.7344
Slovakia	0.75	**8.4430**	**0.0028**	0.0737	**0.0162**	**0.0019**	0.0903	0.8011	0.0601
Slovenia	0.63	**5.1693**	**0.0145**	0.7252	0.5808	0.4155	**0.0108**	**0.0001**	**0.0177**
Spain	0.66	**5.7480**	**0.0103**	0.4215	0.0976	0.4579	0.9136	0.3915	0.7442
Sweden	0.16	1.4580	0.2930	0.6102	0.1727	0.0743	0.1521	0.1512	0.4316
United Kingdom	0.70	**6.8940**	**0.0056**	0.3466	0.2084	**0.0010**	0.5697	0.8310	0.4817
Variables statistically significant				1	5	5	5	9	2
All countries	0.97	**69.2750**	**0.0000**	0.0866	**0.0004**	**0.0002**	0.1994	0.2825	0.0873

Notes: 1) critical statistics $F_{\alpha;k;n-k-1}$ was 3.3738 (significance level α of 0.05, the number of independent variables k was 6, population size n was 16), in models statistically significant the statistics value F was bolded; 2) in models statistically significant the probability value p was below 0.05 and was bolded; 3) variables denotation: the number of food audits AD, the number of border rejections BR, the number of official controls on the market CN, import of food, drinks and tobacco from all countries of the world IM, average total population PP, total agriculture production of food in the gross production value PR.

Source: own study.

However, despite the fact that these variables were statistically significant, the value of the adjusted determination coefficient $\overline{R}^2$ was not moderate.

For total population the value of the adjusted determination coefficient $\overline{R}^2$ in the three examined areas (products categories, hazards categories and the EU countries) was the same and amounted up to 0.86 (high relationship). The variable number of official controls on the market CN was statistically significant (and the variable number of border rejections BR was not). However, the value of $\overline{R}^2$ in the model with six variables (for all the EU countries) was 0.97 (very high relationship). In this model both mentioned variables were statistically significant (and no other variable was statistically significant).

4. CONCLUSIONS

In the article there was presented the influence of the number of border rejections and official controls on the market on the number of alert notifications in the RASFF in three areas: products categories, hazards categories and the EU countries, using multiple regression.

In all products categories, hazards categories and the EU countries, where the relationship was at least moderate, the variable number of official controls on the market CN was statistically significant. However, the greatest attention should be paid to categories, where the relationship was very high or high, i.e.: bivalve molluscs and products thereof, dietetic food, food supplements, fortified food, fish and fish products, herbs and spices and soups, broths, sauces and condiments (in the case of products categories) and: allergens, composition, food additives and flavourings, heavy metals, migration, mycotoxins and pathogenic micro-organism (in the case of hazards categories).

The only products category with high relationship, where the second variable (the number of border rejections BR) was statistically significant, was: dietetic food, food supplements, fortified food. However, in the case of hazards categories this variable was statistically significant and the relationship was very high in the case of: allergens, composition, food additives and flavourings and mycotoxins.

In the case of the EU countries the very high or high relationship was not found in models with the two mentioned variables. The addition of variables (the number of food audits carried out by FVO AD, import of food, drinks and tobacco by SITC IM, average total population PP and total agriculture production of food PR) allowed obtaining the high relationship for France and Latvia. It should, however, also be noted that the moderate relationship occurred then in other EU countries: Bulgaria, Finland, Germany, the Netherlands, Slovakia, Slovenia, Spain and the United Kingdom.

The variability of the number of alert notifications in the RASFF (especially within the EU countries) can also depend on other factors, such as: the amount of food on the market, the scope of food control, the level of preparedness of controllers or movement of people. However, it is difficult to quantify these factors (and take as variables) or the adopted variables would cause collinearity.

Because of many operators in the food chain the role of logistics increases – see D'Amico et al. [2014], Dabbene et al. [2014]. The RASFF can be considered as a part of traceability related to dangerous food products. It should, however, also accurately and clearly indicate the origin and quantity of products, as well as logistics operator. This information could be used by countries (for controls planning), importers (when concluding trade agreements), consumers as well as for scientific research.

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