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Notifications in European Rapid Alert system for dangerous products (RAPEX)

Keywords

consumer safety, dangerous products, RAPEX, European Union, two-way joining cluster analysis

Abstract

The goal of the study was to analyse European Rapid Alert system for dangerous products (RAPEX) notifications, taking into account: year, product category, risk type, submitting country and origin country. The study covered the years 2005–2021 (the entire period of the RAPEX operation) and used two-way joining cluster analysis. The most significant risks were: chemical risks and choking in toys from China, injuries in motor vehicles from European Union (EU) countries, i.e. Germany, France, Italy, the United Kingdom, Spain, as well as the United States and Japan and choking, injuries and strangulation in clothing items from Turkey. The quick flow of information, cooperation between EU countries within the RAPEX and open access to data make an important contribution to improving consumer safety on the European market, and localising production in Europe (following the COVID-19 outbreak and the war in Ukraine) could further improve this safety.

1. Introduction

The European Rapid Alert system for dangerous products (RAPEX) is a system designed for dangerous consumer products, allowing the rapid exchange of information about these products. It does not cover food, pharmaceuticals and drugs. The basis for establishing the RAPEX was contained in the Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety (GPSD), which came into force on 15 January 2004 (European Commission, 2022a; European Parliament & Council, 2002).

The purpose of the Directive 2001/95/EC is to ensure that products placed on the European Union (EU) market are safe. According to this legislation, product means any product, including a service, which is intended for consumers or which, even if not intended for consumers, is reasonably foreseeable to be used by consumers, supplied or made available to them, whether for consideration or not, in the course of a commercial activity, whether new, used or reconditioned. The safe product means any product that, under normal or foreseeable conditions of use, including duration, putting into service, installation and maintenance requirements, does not present any risk or only a minimum risk associated with its use, considered acceptable and corresponding to a high level of protection safety and health of persons, taking into account in particular: the product characteristics, the effect on other products, the product presentation and categories of consumers at risk. Dangerous product means any product that does not meet the definition of a safe product. Producers are obliged to place only safe products on the market. In turn, a serious risk is any serious risk, including its subsequent consequences, requiring rapid intervention by public authorities. The RAPEX is essentially aimed at the rapid exchange of information in the event of a serious risk. If a member country adopts or decides to adopt measures or actions, it shall recommend or agree with producers and distributors, on a compulsory or voluntary ba-

sis, these measures or actions in order to prevent, limit or impose specific conditions on the possible placing on the market or use of products on its territory due to the serious risk, and immediately notify it to the European Commission trough the RAPEX. This can mean recall, i.e. any measure aimed at taking away a dangerous product from customers that has already been delivered to them or made available by the producer or distributor, or a withdrawal, i.e. any measure aimed at preventing the distribution, presentation or offering of a dangerous product to the consumer (European Parliament & Council, 2002).

The number of RAPEX notifications declined in 2015, but is still at a high level, i.e. around 2,000 notifications per year (Figure 1). The analyses carried out on the notifications reported in this system most common cover short periods and / or indicate only the selected risks. Therefore, the goal of the study was to analyse RAPEX notifications throughout entire period of system operation, taking into account: year, product category, risk type, submitting country and origin country.
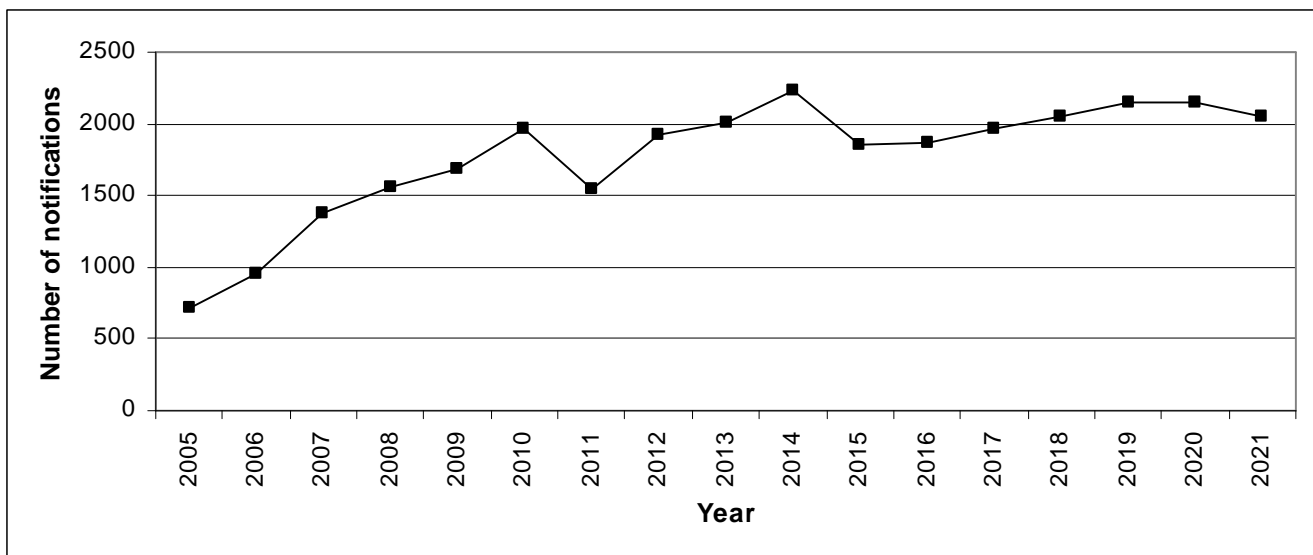
Figure 1. Number of notifications in the RAPEX in 2005–2021.

This chapter is organized into five sections: Introduction as Section 1, Data and methods as Section 2, Results as Section 3, Discussion as Section 4 and Conclusions as Section 5.

The Introduction provides the legal basis for the operation of the RAPEX and the basic definitions. The section Data and methods present the way of processing of data obtained from the RAPEX database, as well as the methods used, i.e. pivot tables, two-way joining cluster analysis and the Pearson's correlation coefficient. The Results section is devoted to showing the overall results of the research, as well as most frequently reported countries. In the Discussion section, research by other authors on the RAPEX was presented. Finally, in Conclusions, a short summary of the obtained results was made and attention was drawn to selected international conditions related to the reported risks.

2. Data and methods

The data was extracted from the RAPEX database to Microsoft Excel (Microsoft Corporation, Redmond, USA) files and covered the period from 2005 (the first year in the database) to 2021, i.e. 17 years (European Commission, 2022b). Due to the different year coding, each year was exported separately and then all files were merged. The resulting data table contained 26 columns. However, due to too much diversity in the data (or, in other cases, the lack of diversity, i.e. the same repeated value at each notification), as well as missing data, only the following five variables were selected for analysis: year, product category, risk type, submitting country and origin country.

Product categories with only a few notifications were changed to *other* and the names of some product categories were shortened (to fit in the figures):

- childcare articles (childcare articles and children's equipment),
- clothing items (clothing, textiles and fashion items),
- communication equipment (communication and media equipment),
- electrical appliances (electrical appliances and equipment), and
- gas appliances (gas appliances and components).

For some notifications, more than one type of risk was reported, which could significantly hamper the analysis, so only notifications with one type of risk were selected. Finally, a source table was obtained with data covering 25,659 notifications, which represented 85% of all notifications in 2005–2021.

The data was then processed using pivot tables. The initial analysis consisted of arranging the data according to the variables: year, product category, risk type, submitting country and origin country from highest to lowest number of notifications within each value of these variables.

Using the pivot tables and also transposition functions, data were then prepared for two-way joining cluster analysis, which allowed to indicate similarities in reported notifications. First, tables with product categories in the rows and year, risk type, submitting country and origin country in the columns were constructed. Due to the method used, the number of origin countries was limited to the thirty with the highest number of notifications. Then, pivot tables were also built for the origin countries against which the number of notifications above the mean value was reported, with the years in the rows and product categories, risk types and submitting countries in the columns. Empty cells (no notification) were filled with the value "0".

The two-way joining cluster analysis was performed in Statistica 13.3 (TIBCO Software Inc., Palo Alto, USA). It is used when values in columns and rows can be expected to simultaneously contribute to the discovery of meaningful cluster patterns. Although the structure of these clusters is by nature not homogeneous, it is believed that this method be a powerful tool for exploratory data analysis (TIBCO, 2022).

The results of the two-way joining cluster analysis were presented in the graphs using colours ranging from green (with various shades), yellow, orange, red to brown. However, the largest clusters were represented by the most distinct colours, i.e. after excluding green in aforementioned shades. Besides, to increase readability, the darkest shade of green colour has been faded out (swapped to white) as it would occupy the largest part of the graphs, but would not indicate significant clusters. Additionally, due to the significant number of notifications against toys originating from China, a Pearson's correlation coefficient was also calculated for the number of these notifications and imports of toys for particular EU countries (for the period 2005–2021). Data on imports from China were taken from the Eurostat database according to the Standard International Trade Classification – SITC, taking into account the sum of imports (in kg) from the following subgroups:

- 894.1 baby carriages and parts thereof, n.e.s. (not elsewhere specified),
- 894.2 tricycles, scooters, pedal car and similar wheeled toys; dolls' carriages; dolls; other toys; reduced-size ("scale") models and similar recreational models, working or not; puzzles of all kinds,
- 894.3 articles for funfair, table or parlour games (including pintables, billiards, special tables for casino games and automatic bowling-alley equipment) (Eurostat, 2022).

As data for 2020 and 2021 for the United Kingdom imports were already not available, these values were estimated based on a simple linear regression model generated in AcaStat 9.0.2 (AcaStat Software, Orange, USA).

3. Results

3.1. Overall results of studies

In Figures 2–5 presented number of notifications in the RAPEX by product category, risk type, submitting country and origin country, respectively. The mean value of the number of notifications was exceeded for the following variables in the case of:

- product categories (Figure 2): toys (27.0%), motor vehicles (16.0%), clothing items (16.0%), electrical appliances (9.0%), cosmetics (4.8%) and childcare articles (3.5%),
- risk type (Figure 3): injuries (26.7%), chemical (26.1%), chocking (13.9%), electric shock (12.1%) and strangulation (5.9%),

- submitting country (Figure 4): Germany (15.4%), Spain (8.6%), Hungary (8.1%), France (6.7%), the United Kingdom (6.1%), Bulgaria (5.6%), Cyprus (4.8%), Finland (4.6%), Poland (4.0%), Greece (3.9%) and Slovakia (3.5%),

- origin country (Figure 5): China (53.8%), unknown country (8.4%), Germany (5.8%), United States (3.2%), France (3.0%), Turkey (3.0%), Italy (2.6%), Japan (2.0%), the United Kingdom (1.9%), Poland (1.3%), India (1.3%) and Spain (1.3%).
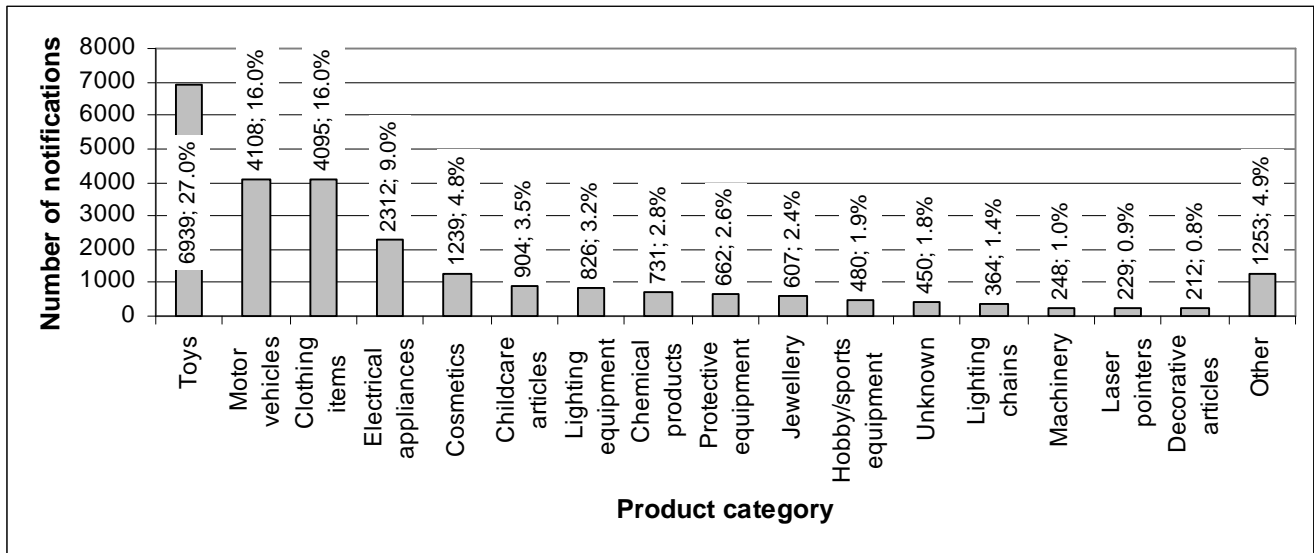

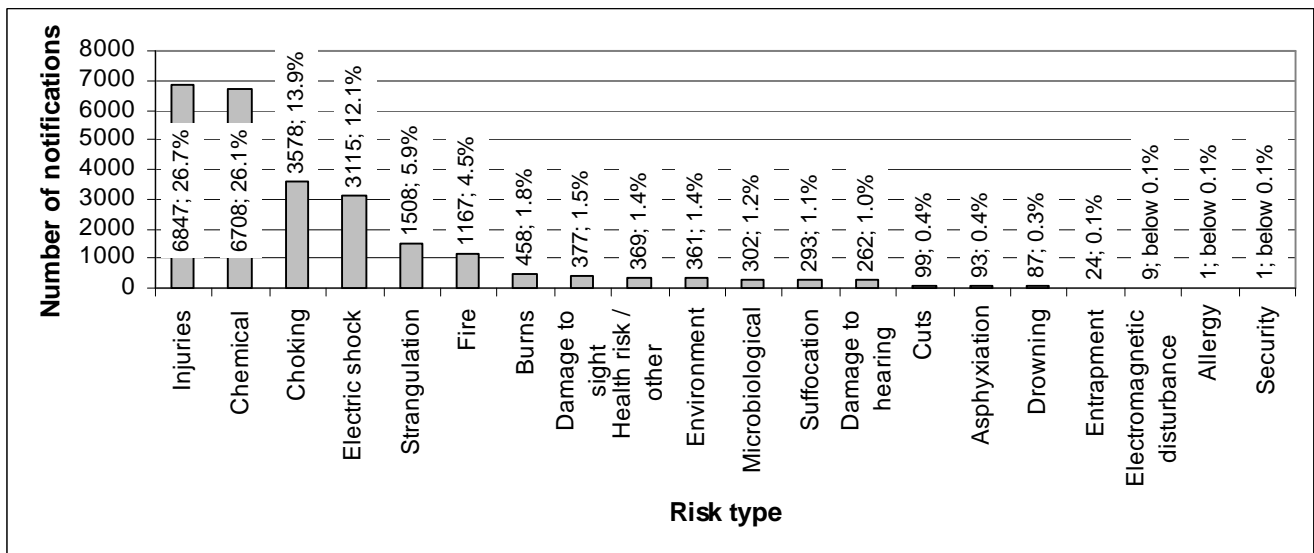**Figure 2.** Number of notifications in RAPEX in 2005–2021 by product category.

Figure 3. Number of notifications in RAPEX in 2005–2021 by risk type.
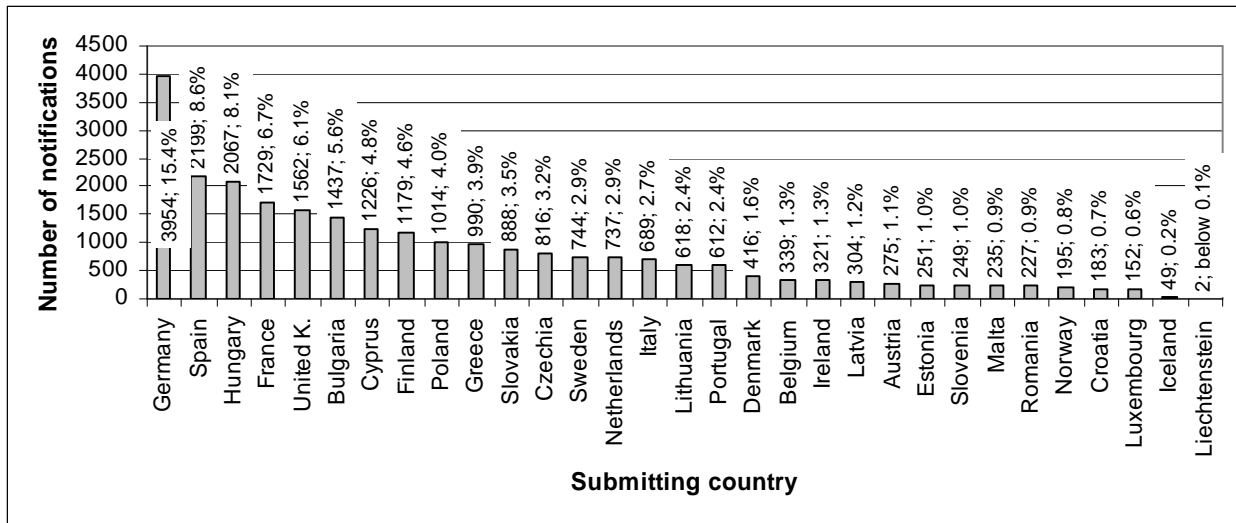
Figure 4. Number of notifications in RAPEX in 2005–2021 by submitting country.
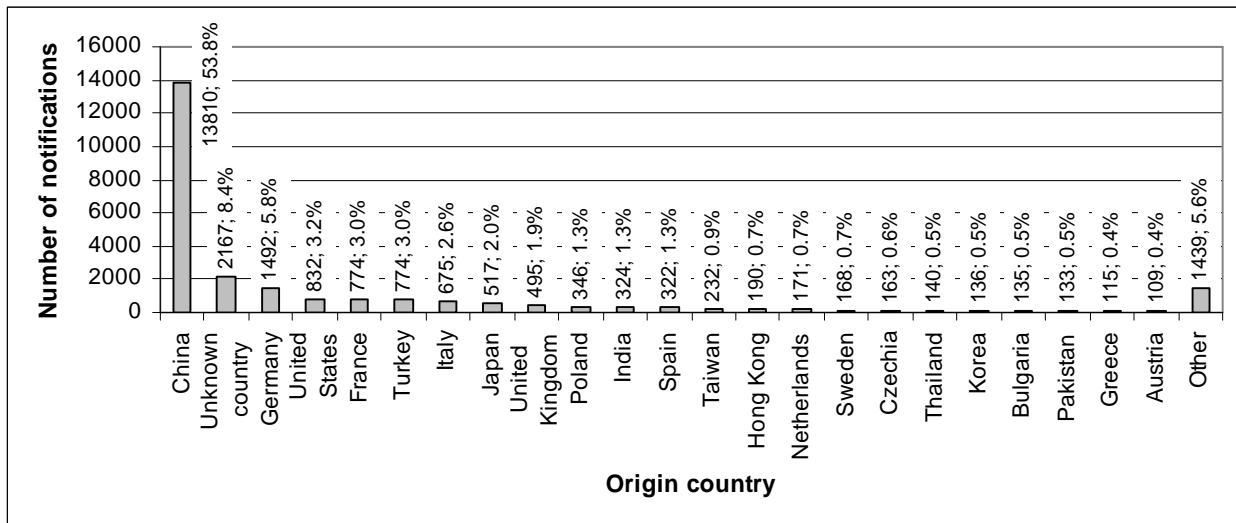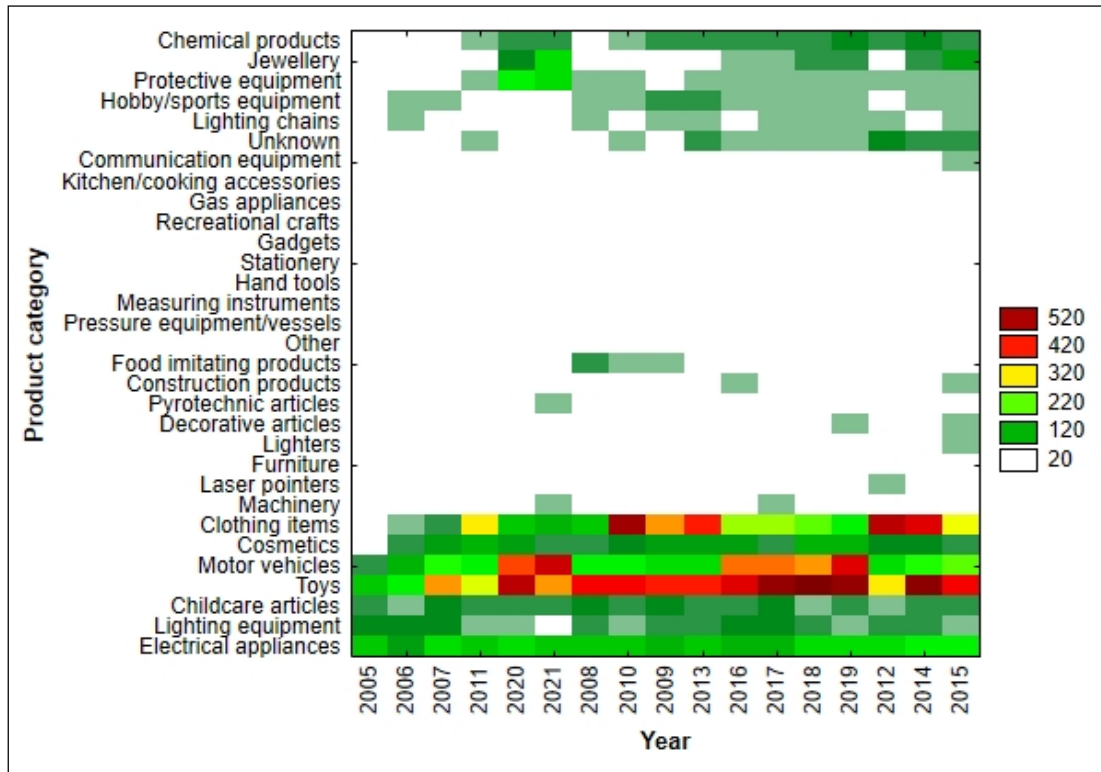

Figure 5. Number of notifications in RAPEX in 2005–2021 by origin country.

The use of two-way joining cluster analysis based on pivot tables with product categories in rows and years, risk types, submitting countries and origin countries in columns, respectively, allowed to obtain more detailed results (Figures 6–9).

Notifications against reported product categories with a number above the mean value, can be seen in every year of the period studied (bottom part of Figure 6). However, notifications in relation to toys (2007–2010, 2012–2021), motor vehicles (2016–2021) and clothing items (2009–2014) are the most notable.

For toys, the most frequently reported risk types were chemical and choking, for motor vehicles there were injuries, and for clothing items there were chemical, choking and injuries, although these were only expressed in green (Figure 7).

Toys were reported by many countries, although it is most evident in the case of Spain, motor vehicles were most frequently reported by Germany and clothing items by Bulgaria (Figure 8). With regard to the origin country, this is again most evident for toys (where this country was China), for motor vehicles there were Germany, France, the United Kingdom, Italy, the United States and Japan, and for clothing items it was also China, although for these two product categories this was, however, only expressed in green (Figure 9).The use of two-way joining cluster analysis based on pivot tables with product categories in rows and years, risk types, submitting countries and origin countries in columns, respectively, allowed to obtain more detailed results (Figures 6–9).

Figure 6. Results of two-way joining cluster analysis related to notifications in RAPEX in 2005–2021 considering product categories and years.
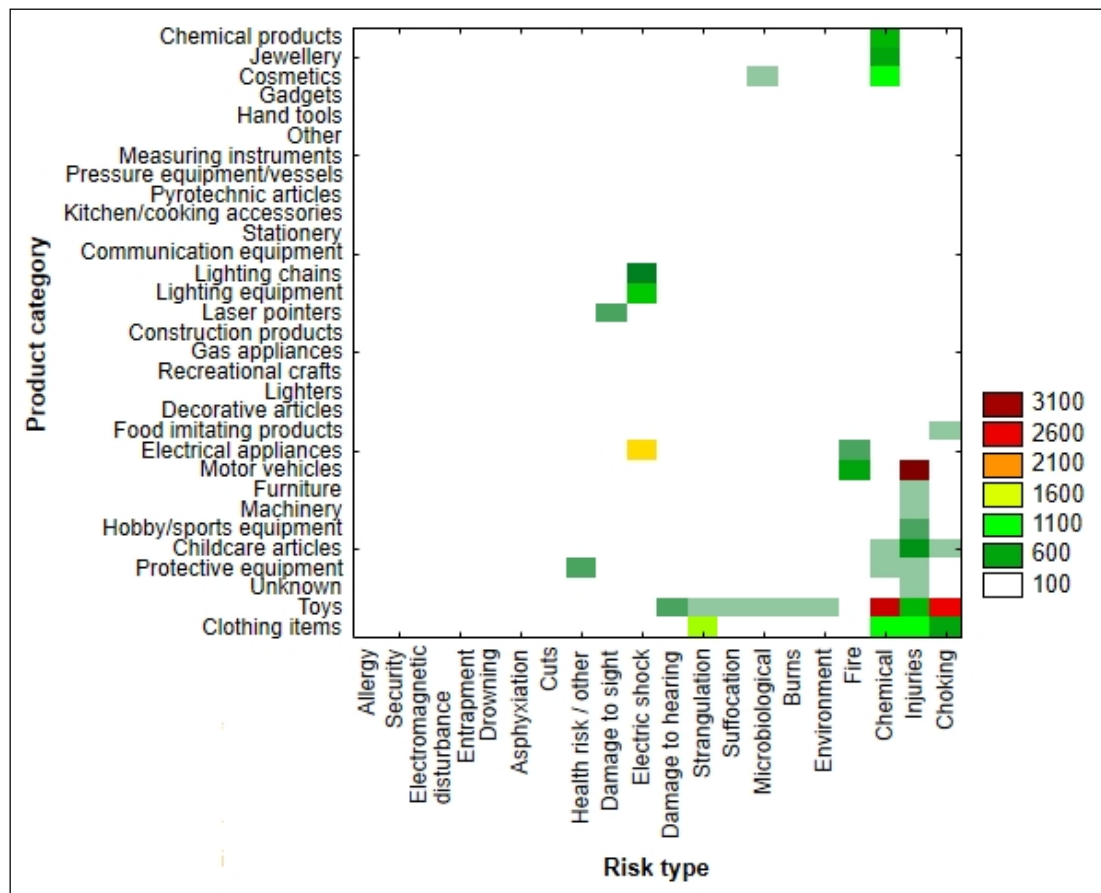
Figure 7. Results of two-way joining cluster analysis related to notifications in RAPEX in 2005–2021 considering product categories and risk type.
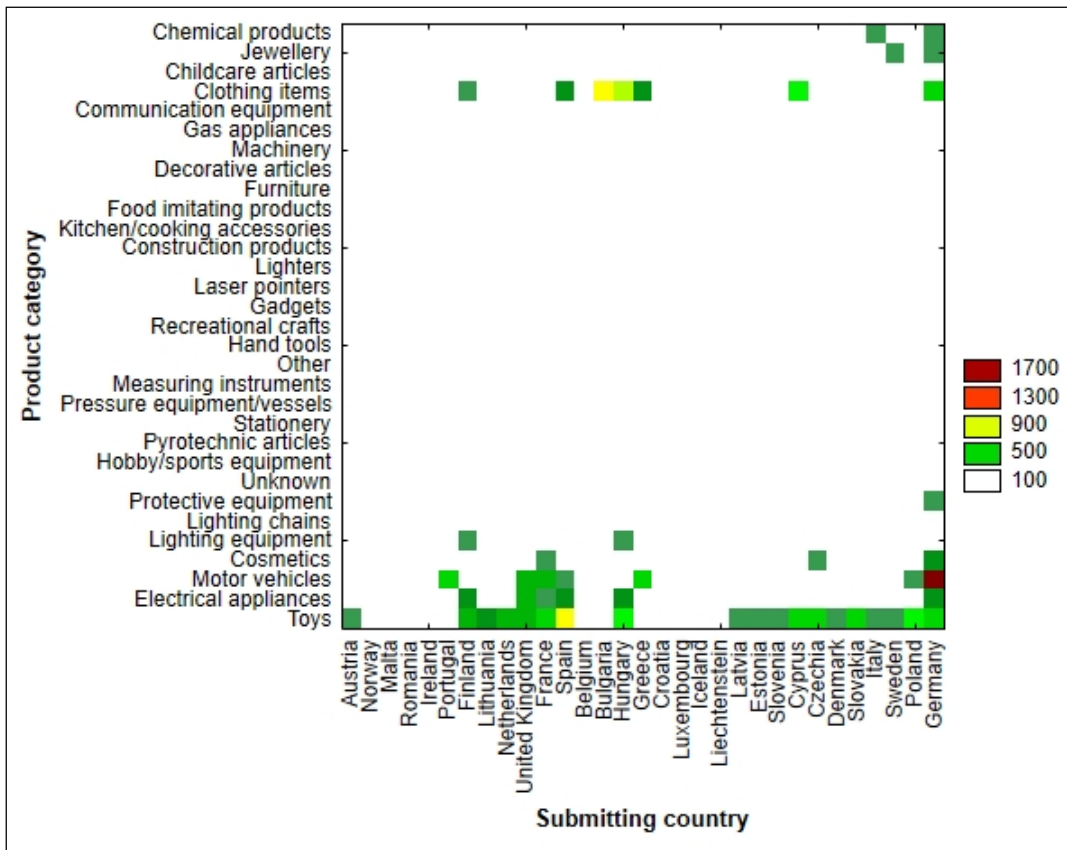
Figure 8. Results of two-way joining cluster analysis related to notifications in RAPEX in 2005–2021 considering product categories and submitting countries.

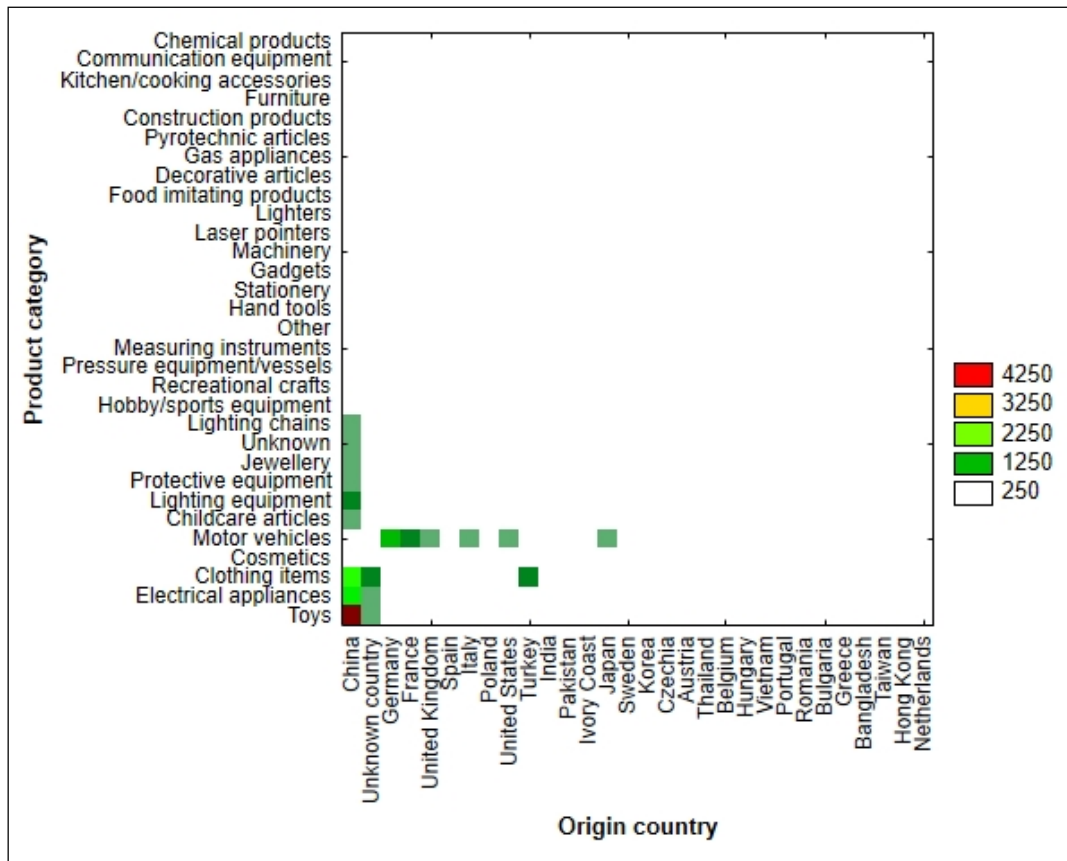**Figure 9.** Results of two-way joining cluster analysis related to notifications in RAPEX in 2005–2021 considering product categories and origin countries.

3.2. Most frequently reported countries

Notifications to products originating from China are therefore of particular attention. However, considering the origin country, the number of notifications above the mean value concerned as many as twelve countries, so examining them would give a much more complete view of the origin of the risks. A two-way joining cluster analysis was therefore conducted for each origin country separately, taking into account: year, product categories, risk types and notifying countries. These results were presented in Table 1. They were collected from graphs (not included in this chapter) considering the most distinct colours based mainly on product categories.

Table 1. Results of two-way joining cluster analysis for the most frequently reported origin countries in RAPEX in 2005–2021

| Origin country | Variable (clusters) | | | |
	Year	Product category	Risk type	Submitting country
China	2007–2010, 2012–2021	Toys	Chemical	Czechia, Germany, Spain
			Chocking	Spain
Unknown country	2010, 2012–2015	Clothing items	Chemical	Hungary
Germany	2016–2021	Motor vehicles	Injuries	Germany
United States	2012, 2018–2019	Chemical products	Chemical	Germany
	2015–2019, 2021	Motor vehicles	Injuries	
France	2016–2021	Motor vehicles	Injuries	France, Germany
Turkey	2010, 2012, 2017–2018, 2021	Clothing items	Chocking, Injuries, Strangulation	Bulgaria
Italy	2008–2009, 2011–2012, 2015–2021	Motor vehicles	Injuries	Germany, Greece
Japan	2007, 2010–2011, 2015–2016, 2018–2021	Motor vehicles	Injuries	Germany, Greece, Portugal
United Kingdom	2012, 2014–2020	Motor vehicles	Injuries	United Kingdom
Poland	2007–2008, 2014–2017	Childcare articles	Injuries	Germany, Slovakia
	2010, 2018–2019	Cosmetics	Chemical	Czechia, Lithuania
India	2009–2011, 2014, 2016	Clothing items	Chemical	Germany, Spain
Spain	2018–2021	Motor vehicles	Injuries	Germany

The most visible problem for more than the last 10 years were toys from China, reported mainly by the Czechia, Germany and Spain, where chemical and choking risks were identified. It was therefore examined whether there was a correlation between the number of notifications reported in the RAPEX by particular EU countries on products from China and imports of toys from China (Table 2). The value of these imports (expressed in kg) was adopted on the basis of the data from the Eurostat according to the Standard International Trade Classification – SITC (see details in section 2. Data and methods). The data for the examination of the correlation covered the entire period under study, i.e. 2005–2021.

It is worth noting that for all EU countries (the last row of Table 2) the correlation was moderate (i.e. between 0.5 and 0.7). Besides, it can be observed for only a few countries, i.e.:

- low correlation (i.e. between 0.3 and 0.5) for France – 0.43,
- moderate correlation for Germany – 0.54, Ireland – 0.64, Italy – 0.62,
- high correlation (i.e. between 0.7 and 0.9) for Poland – 0.81.

Another problem was clothing items originating from unknown countries and India (in earlier years) and Turkey (still an ongoing issue). In the case of clothing items from unknown countries, notifications were reported mainly by Hungary, and products from India by Germany and Spain (and these were chemical risks). In turn, clothing items from Turkey were notified mainly by Bulgaria, and the reported risks were chocking, injuries and strangulation.

Injury risks were notified in motor vehicles from Germany, France, Italy, the United Kingdom and Spain (with Germany, France and the United Kingdom reporting their own products). This risk

was also communicated to vehicles from the United States and Japan (mainly by Germany).

Table 2. Pearson's correlation coefficient for number of notifications in RAPEX to products from China and imports of toys (in kg) from China according to SITC by Eurostat in 2005–2021

Country	Coefficient	Test statistic
Austria	–	1.345
Belgium	–	1.085
Bulgaria	–	0.058
Croatia	–	-1.161
Cyprus	–	0.625
Czechia	–	0.799
Denmark	–	1.221
Estonia	–	0.537
Finland	–	1.286
France	0.43 (for α 0.10)	1.866
Germany	0.54 (for α 0.05)	2.479
Greece	–	-0.320
Hungary	–	-0.148
Ireland	0.64 (for α 0.05)	3.215
Italy	0.62 (for α 0.05)	3.025
Latvia	–	-0.533
Lithuania	–	1.613
Luxembourg	–	0.834
Malta	–	0.395
Netherlands	–	1.415
Poland	0.81 (for α 0.05)	5.439
Portugal	–	-2.109
Romania	–	1.388
Slovakia	–	0.486
Slovenia	–	0.450
Spain	–	0.601
Sweden	–	1.653
United Kingdom	–	1.013
EU countries	0.59 (for α 0.05)	2.804

Critical statistic is 2.131 / 1.753 (for $n - 2 = 15$ degrees of freedom and α 0.05 / 0.10 in 2-tailed T distribution).

Chemical risks in chemical products from the United States and in cosmetics from Poland were also reported, with notifications from Germany, the Czechia and Lithuania, respectively. Germany and Slovakia also reported injury risks in childcare articles from Poland. However, these two problems have not been as frequent in recent years.

4. Discussion

Ruohonen (Ruohonen, 2022) presenting a wide overview of notifications in 2005–2021 in the RAPEX indicated similar findings. Among the most frequently notified products were toys, clothing items, motor vehicles and electrical appliances. In turn, the most often reported risk types were injury, chemical, choking and electric shock. China was the most commonly reported country, followed by Germany. Meanwhile, the ten countries that most widely reported dangerous products were: Germany, Hungary, Spain, the United Kingdom, France, Bulgaria, Cyprus, Finland, Greece and Poland.

Some authors indicated specific risks reported through the RAPEX in individual products. When analysing notifications on toys, attention was drawn to cyclohexane (Tirendi et al., 2009), phthalates (McCombie et al., 2017) or chemical risks in general in 2015 (Guo et al., 2018). Chlorinated paraffins, in turn, have been reported in several product categories, i.e. in toys, sports equipment and clothing items (Guida et al., 2020) or, as noted by Babayemi (Babayemi et al., 2022) in toys, gymnastic mats and sports equipment.

Joo (Joo et al., 2018) posited that if an exporter fails to comply with the requirements of the Regulation 1907/2006 on the registration, evaluation, authorisation and restriction of chemicals (REACH), this could be reported in the RAPEX, resulting in a loss of entry into the EU market. Elsner (Elsner, 2017), meanwhile, referred to the Regulation 1272/2008 related to classification, labelling and packaging of chemical substances (CLP), stating that only a few cases of non-compliance with the requirements of this legislation reported in the RAPEX could indicate both high compliance and lack of adequate inspections.

In turn, Vincze (Vincze et al., 2019) pointed out the reporting of microbiological risks in toys, cosmetics and chemical products from 2005 to 2017 in the RAPEX. Notifications related to microbiological risks in cosmetics during different periods were also highlighted by other authors: 2005–2008 (Lundov & Zachariae, 2008), 2005–2018 (Michalek et al., 2019) and 2009–2014 (Stewart et al., 2016). Meanwhile, Salerno-Kochan (Salerno-Kochan & Kowalski, 2020), analysing notifications from the entire period of the RAPEX operation indicated risks such as suffocation, injury and choking in clothing items.

Other authors only mentioned the most frequently reported product categories, i.e.: toys, electrical appliances, motor vehicles, clothing items and childcare articles (Pose-Juan et al., 2016;

Mjakuškina & Lapiņa, 2018) or toys and cosmetics in 2018 (Marcelis et al., 2021).

Some authors highlighted notifications for individual product categories, i.e.: toys from 2009 to 2013 (Liepiņa & Korabļova, 2014), clothing items from 2010 to 2017 (Agrawal et al., 2021) or cosmetics (Gaudiano et al., 2010; Meng et al. 2017). Despite the fact that motor vehicles was the second most frequently notified product category in the RAPEX, it did not receive much attention. However, Winkle (Winkle, 2016, 2022), referring to motor vehicles, stated that the German Federal Motor Transport Authority uses the notifications reported in this system to analyse and evaluate risks from product defects after the launch of these products on the market (in terms of the necessity and urgency of product recalls).

Kjellén (Kjellén, 2009) noted that more than half of the products notified in the RAPEX were from China. Other authors have also noted this problem by even pointing to specific years, i.e.: 2008 (Tse & Tan, 2012), 2015 (Zhu et al., 2018), 2016 (Kosmol et al., 2018), 2017 (Yu & Hou, 2019). In turn, Tse (Tse et al., 2021) noted that of the products from China reported in the RAPEX in 2012, more than a one quarter were electronic devices.

5. Conclusion

The number of notifications in the Rapid Alert system for dangerous products (RAPEX) has remained at around 2,000 per year in recent years (2015–2021). The most significant problems have concerned toys from China (chemical risks and choking), motor vehicles from European Union (EU) countries: Germany, France, Italy, the United Kingdom, Spain, as well as the United States and Japan (injuries) and clothing items from Turkey (choking, injuries, strangulation).

There is a correlation between toy imports from China by the major EU countries (France, Germany, Italy and Poland) and the number of notifications made by these countries in the RAPEX. This is important because of the EU common market, where free movement of products is possible. Thus, the risks associated with toys from China may affect all other EU countries.

In the case of motor vehicles, the manufacturing countries have mostly notified themselves against these products. This demonstrates their sense of responsibility for consumer safety, as well as their ability to carry out recall actions efficiently at authorised service centres.

In turn, Bulgaria, as an EU country bordering Turkey, reported the highest number of notifications against clothing items originating from that country.

Notifications under the RAPEX, thanks to the rapid flow of information, cooperation between EU countries and open access to data, make an important contribution to improving consumer safety on the European market. In order to improve the safety of non-food products, their production should be relocated from Asia to Europe, where oversight of the design and production process is much more rigorous. Financial sanctions against those placing unsafe products on the market could also be considered. Consumer awareness of the risks that may be present in these products should also be raised through market campaigns and easier access to information on recalled products.

References

Agrawal, T.K., Vijay, K., Pal, R., Wang, L. & Chen, Y. 2021. Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry. *Computers & Industrial Engineering* 154(107130), 1–12.

Babayemi, J.O., Nnorom, I.C. & Weber, R. 2022. Initial assessment of imports of chlorinated paraffins into Nigeria and the need of improvement of the Stockholm and Rotterdam Conventions. *Emerging Contaminants* 8, 360–370.

Elsner, P. 2017. Classification of consumer products under the EU CLP Regulation: what to consider when caring for contact dermatitis patients: CLP classification of consumer products. *Contact Dermatitis* 78, 1–6.

European Commission. 2022a. *About European Rapid Alert System for Dangerous Products (RAPEX)*, https://joinup.ec.europa.eu/collection/rapex/about (accessed 17 Sep 2022).

European Commission. 2022b. *Safety Gate: the EU Rapid Alert System for Dangerous non-Food Products*, https://ec.europa.eu/safety-

gate-alerts/screen/search (accessed 17 Sep 2022).

European Parliament & Council. 2002. *Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety* (OJ L 11, 15.1.2002, 4–17).

Eurostat, 2022, *International Trade in Goods – Detailed Data. EU Trade Since 1999 by SITC* (DS-018995), https://ec.europa.eu/eurostat/web/main/data/database (accessed 29 Sep 2022).

Gaudiano, M.C., Lucente, D., Antoniella, E., Bertocchi, P., Muleri, N., Manna, L., Bartolomei, M., Alimonti, S., Valvo, L. & Rodomonte, A.L. 2010. "For export only" medicines come back to Europe: A RP-LC method for the screening of six glucocorticoids in illegal and counterfeit anti-inflammatory and lightening creams. *Journal of Pharmaceutical and Biomedical Analysis* 53, 158–64.

Guida, Y., Capella, R. & Weber, R. 2020. Chlorinated paraffins in the technosphere: A review of available information and data gaps demonstrating the need to support the Stockholm Convention implementation. *Emerging Contaminants* 6, 143–154.

Guo, X., Bai, H., Lv, Y., Xi, G., Li, J., Ma, X., Ren, Y., Ouyang, Z. & Ma, Q. 2018. Rapid identification of regulated organic chemical compounds in toys using ambient ionization and a miniature mass spectrometry system. *Talanta* 180, 182–192.

Joo, H.-Y., Seo, Y.-W. & Min, H. 2018. Examining the effects of government intervention on the firm's environmental and technological innovation capabilities and export performance. *International Journal of Production Research* 56(18), 6090–6111.

Kjellén, S.Z. 2009. Rapid alerts for crises at the EU level. S. Olsson (Ed.). *Crisis Management in the European Union*. Springer-Verlag, Berlin – Heidelberg, 61–82.

Kosmol, T., Reimann, F. & Kaufmann, L. 2018. Co-alignment of supplier quality management practices and cognitive maps – A neo-configurational perspective. *Journal of Purchasing and Supply Management* 24, 1–20.

Liepiņa, R. & Korabļova, L. 2014. Market surveillance of toys: Situation assessment and improvement. *Procedia – Social and Behavioral Sciences* 156, 360–364.

Lundov, M.D. & Zachariae, C. 2008. Recalls of microbiologically contaminated cosmetics in EU from 2005 to May 2008. *International Journal of Cosmetic Science* 30, 471–474.

Marcelis, Q., Gatzios, A., Deconinck, E., Rogiers, V., Vanhaecke, T. & Desmedt, B. 2021. Development and application of a novel method to assess exposure levels of sensitizing and irritating substances leaching from menstrual hygiene products. *Emerging Contaminants* 7, 116–123.

McCombie, G., Biedermann, S., Suter, G. & Biedermann, M. 2017. Survey on plasticizers currently found in PVC toys on the Swiss market: Banned phthalates are only a minor concern. *Journal of Environmental Science and Health, Part A* 52(5), 491–496.

Meng, X., Bai, H., Guo, T., Niu, Z. & Ma, Q. 2017. Broad screening of illicit ingredients in cosmetics using ultra-high-performance liquid chromatography – hybrid quadrupole – Orbitrap mass spectrometry with customized accurate-mass database and mass spectral library. *Journal of Chromatography A*, 1528, 61–74.

Michalek, I.M., John, S.M. & Caetano dos Santos, F.L. 2019. Microbiological contamination of cosmetic products – observations from Europe, 2005-2018. *Journal of the European Academy of Dermatology and Venereology* 33, 2151–2157.

Mjakuškina, S. & Lapiņa, I. 2018. Evaluation of market surveillance implementation and sustainability. J. Connell et al. (Eds.). *Global Value Chains, Flexibility and Sustainability. Flexible Systems Management*. Springer, Singapore, 257–269.

Pose-Juan, E., Fernández-Cruz, T. & Simal-Gándara, J. 2016. State of the art on public risk assessment of combined human exposure to multiple chemical contaminants. *Trends in Food Science & Technology* 55, 11–28.

Ruohonen, J. 2022. A review of product safety regulations in the European Union. *International Cybersecurity Law Review* 3, 345–366.

Salerno-Kochan, R. & Kowalski, M. 2020. Safety management of textile products in the European Union and estimation of its efficiency. Part 2. *Fibres and Textiles in Eastern Europe* 28(3), 12–17.

Stewart, S.E., Parker, M.D., Amézquita, A. & Pitt, T.L. 2016. Microbiological risk assessment for

personal care products. *International Journal of Cosmetic Science* 38, 634–645.

TIBCO. 2022. TIBCO Statistica® User's Guide. Available online: https://docs.tibco.com/pub/stat/14.0.0/doc/html/UsersGuide/ (accessed 21 Apr 2022).

Tirendi, S., Geiss, O., Barrero-Moreno, J. & Kotzias, D. 2009. Chemical emissions from toys – the case of stink blasters. *International Journal of Environmental Analytical Chemistry* 89(8–12), 929–938.

Tse, Y.K. & Tan, K.H. 2012. Managing product quality risk in a multi-layer global supply chain. *International Journal of Production Economics* 139, 49–57.

Tse, Y.K., Zhang, M., Zeng, W. & Ma, J. 2021. Perception of supply chain quality risk: Understanding the moderation role of supply market thinness. *Journal of Business Research* 122, 822–834.

Vincze, Sz., Al Dahouk, S. & Dieckmann, R. 2019. Microbiological safety of non-food products: What can we learn from the RAPEX database? *International Journal of Environmental Research and Public Health* 16(1599), 1–14.

Winkle, T. 2016. Development and approval of automated vehicles: Considerations of technical, legal, and economic risks. M. Maurer et al. (Eds.). *Autonomous Driving*. Springer, Berlin – Heidelberg, 589–618.

Winkle, T. 2022. Technical, legal, and economic risks. T. Winkle (Ed.). *Product Development within Artificial Intelligence, Ethics and Legal Risk*. Springer Vieweg, Wiesbaden, 67–123.

Yu, Y. & Huo, B. 2019. The impact of relational capital on supplier quality integration and operational performance. *Total Quality Management & Business Excellence* 30(11), 1282–1301.

Zhu, A.Y., von Zedtwitz, M. & Assimakopoulos, D.G. 2018. Introduction: Better safe than sorry. A.Y. Zhu et al. (Eds.). *Responsible Product Innovation. Innovation, Technology, and Knowledge Management*. Springer, Cham, 1–12.