ASSESSING THE EPIDEMICS AND PANDEMICS' IMPACT ON SUPPLY CHAINS IN THE AUTOMOTIVE INDUSTRY

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Abstract

Today, supply chains operate in a very uncertain global environment, so one of the basic tasks is to maintain a higher level of resilience. Great threats to the resilience of supply chains, which occur at time intervals, are labelled in literature as health crises. The appearance of diseases, due to their nature may cause epidemics and pandemics', which can greatly endanger stability and lead to interruptions in supply chain processes. A major problem cited in literature concerning the specifics of such situations relates to the limited ability to predict both the causes and consequences of such actions. Due to that, it is difficult to manage crisis situations, and as a logical consequence, there are immeasurable negative effects. The aim of this paper is to examine the negative effects of various epidemics and pandemics on production in the automotive industry. The analyses were employed with the aim of defining the extent to which an epidemic and a pandemic disrupt production activities in supply chains. In addition, it is important to consider the characteristic of viruses, as well as the differences in the average values of production in the years when the crisis occurred. In order to analyse the hypotheses, the authors used Wilcoxon's test to check the statistical significance of changes in production levels. To examine the significance of the difference in average changes in production for the duration of the epidemics and the pandemics, the authors used Friedman's test in SPSS.

Key words: supply chain, automotive industry, production, viruses, pandemic.

ПРОЦЕНА УТИЦАЈА ЕПИДЕМИЈА И ПАНДЕМИЈА НА ЛАНЦЕ СНАБДЕВАЊА У АУТОМОБИЛСКОЈ ИНДУСТРИЈИ

Апстракт

Данас ланци снабдевања функционишу у веома неизвесном глобалном окружењу, па је један од основних задатака одржавање већег нивоа отпорности. Претње које угрожавају отпорност ланаца јављају се у временским интервалима

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и у литератури су означене као здравствен екризе. Појава болести, које својим деловањем изазивају епидемије и пандемије, може у великој мери угрозити стабилност и довести до прекида процеса у ланцима снабдевања. Велики проблем који се наводи у литератури, а који се тиче специфичности оваквих ситуација, односи се на ограничену способност предвиђања како узрока тако и последица кризних ситуација. Из тог разлога је тешко управљати кризним ситуацијама, а немерљиви негативни ефекти представљају логичну последицу. Циљ овог рада је да испита негативане ефекте у производњи у аутомобилској индистрији узроковане појавама различитих епидемија и пандемија. Коришћене анализе имају за циљ да дефинишу у којој мери епидемије и пандемије ремете производне активности у ланцима снабдевања. Поред тога, важно је анализирати карактеристике вируса, као и разлике у просечним вредностима производње у годинама када је криза наступила. У циљу испитивања хипотеза, аутори су користили Вилкоксонов тест за проверу статистичке значајности промена нивоа производње. У циљу испитивања значајности разлике у просечним променама производње у годинама епидемија и пандемија, аутори су користили Фридманов тест у SPSS-у.

Кључне речи: ланац снабдевања, аутомобилска индустрија, производња, вируси, пандемија.

INTRODUCTION

The disasters caused by epidemic or pandemic outbreaks are different from other disasters due to two specific features: their long-term disruption and their increasing propagation (Dasaklis et al., 2012). The importance of addressing epidemic/pandemic outbreaks nowadays is even greater, as the general framework in which they may occur has dramatically changed during the last years (Dasaklis et al., 2012, p.393). The global cost of an epidemic/pandemic depends on the number of affected countries, and then on the required duration of lockdown policies (Sharma et al., 2020). A greater appreciation of the economy-wide impacts of epidemics/pandemics (i.e. to determine macro-economic trends towards a general equilibrium model, rather than effects on only one sector or market) is warranted (Smith et al., 2019). The extremely negative impact of epidemics/pandemic seriously jeopardises the business of the supply chain, preventing activities among partners.

The phrase 'Black Swan' is mentioned in London in the 16th century, and is based on the teachings of the Old World, which start with the assumption that all swans must be white, because all historical writings indicate this. In this sense, there is no possibility that black swans exist. After the black swan was discovered in Australia in 1697, the term 'Black Swan' began to be used as a synonym for denying something that was considered impossible. Facing the black swan caused a big surprise. The 'Black Swan' effect is defined by the following attributes: rarity - an event that is outside the scope of normal expectations; extreme impact and hindsight - despite its status 'outside the scope of

normal expectations'; and the fact that the occurrence of such an event must be explained, after it has been shown that such an event occurred and that it could have been predicted (Anđelković, 2015). The last pandemic to occur, as a risk factor of supply chain disruption, has all the characteristics of a black swan phenomena (Belhadi et al., 2021). Previous researches were focused on natural disasters, wars and terrorism, political environment, economic instability, economic downturns, and social and cultural problems (Ghadir et al., 2022), whereas pandemics were ignored.

Requirements are placed to researchers for a better understanding of supply chain phenomena in crisis conditions caused by epidemic/pandemic in order to help supply chain managers better prepare for the next crisis and foster translucency (i.e., the ability to simultaneously restore some processes and change – often radically – others) (Craighead et al., 2020, p.838). The situation related to the SARS-CoV-2(Severe Acute Respiratory Syndrome Corona virus 2) virus has greatly affected the business activities in supply chains, and a similar impact could be seen several times in the last 30 years. The corona virus (COVID-19) outbreak shows that an epidemic/pandemic can seriously wreak havoc on supply chains around the globe (Queiroz et al., 2020).

Global financial implications are likely to be felt across all industries. Companies in the tourism, transport of people and goods, hospitality, logistics, automotive and aviation sectors are particularly exposed (Mihajlović & Trajković, 2020).The final extent of losses is not yet known, but the development of economic models, combined with epidemiological models and network analysis techniques, can yield more realistic estimates and aid in selecting appropriate strategies in a timely manner (Yu & Aviso, 2020, p.183).

LITERATURE REVIEW

The interruptions that have occurred in chains in recent years were very often caused by threats arising from health crises. Although not highlighting epidemics or pandemics specifically, four of the five disruptions are clearly related to pandemic/epidemic disruptions (Golan et al., 2020, p.223). Emerging pandemics threaten global health and economies, and are increasing in frequency (Pike et al., 2014). One of the problems is the degree of transmission, which is very pronounced when it comes to viruses. Presently, global supply chains are widely believed to transmit the crisis across countries (Bonadio et al., 2020). Since supply chains currently operate in the global market, connections with international partners are the key to the realisation of business activities.

In the past three years, global supply chains, especially in the manufacturing sectors (i.e. automobile, electronics, pharmaceutical etc.) and service sectors (i.e. airline, retail suppliers, transportations etc.), have

been influenced by the serious effects of the SARS-Cov-2 virus, or the Covid-19 disease, spreading. Border closures and lockdowns around the world caused problems in supply. Global supply chains have been profoundly impacted due to their high dependency on their vulnerable suppliers. For example, around 200 firms listed as Fortune Global 500 firms work with factories in Wuhan, where the outbreak originated (Kilpatrick & Barter, 2020).

The automotive industry is especially important for a country's economy because of its contribution to the reduction of unemployment, and its contribution to the increase of gross domestic product. For example, the UK's annual turnover in the automobile industry is over £82bn, adding a significant £18.6bn to the economy while employing over 823,000 personnel across the wider automotive sector (Belhadi et al., 2021). Therefore, in crisis situations, the governments of countries make enormous efforts to ensure the survival of the automotive industry. Wuhan, China provinces, as a focal point of the SARS-CoV-2 virus, is the location of lot producers of components to global automobile manufacturers (Flegontova & Ponomareva, 2020, p.21). Closing producing capacities in Wuhan had a direct influence on global automotive production (Belhadi et al., 2021). The pandemic caused by the spread of the SARS-CoV-2 virus led to the closure of sales halls, as well as production plants. For example, the Mazda-Toyota joint-venture project was stopped, as was the project of Fiat Chrysler Automobiles in Detroit. Manufacturing plants for producing automobiles and their parts around the world slowed their work because of the protocols designed to increase security, such as temperature screening before entering the site, wearing medical-grade masks, and social distancing (Belhadi et al., 2021).

The outbreak in Wuhan was not the first time Asian economies were faced with the spread of viral infections. Countries from this continent have already experienced SARS-CoV (Severe acute respiratory syndrome corona virus) and MERS-CoV (Middle East respiratory syndrome corona virus), and the negative consequence of these diseases. The purpose of this paper is to summarise the impact of SARS, MERS, and SARS-CoV-2 on the automotive industry, with specific focus on some characteristics of these diseases. SARS-CoV-2 caused significant supply shocks due to non-pharmaceutical interventions, such as lockdowns, while SARS and MERS mainly caused demand shocks (Tanaka, 2022).

The onset of the disease, due to the spread of the SARS-CoV (Severe acute respiratory syndrome corona virus), MERS-CoV (Middle East respiratory syndrome corona virus) and SARS-CoV-2 viruses, destabilised supply chains to varying degrees. Connectivity among partners was also emphasised in previous epidemics such as SARS-CoV and MERS-CoV. SARS was a new disease in autumn of 2002, and it first occurred in Guangdong Province, China, and spread to 29 countries, with 8422 cases

and 916 fatalities (Cherry & Krogsrad, 2004). One study examined the impact of SARS on business activities in Canada. The outbreak of severe acute respiratory syndrome (SARS) in Toronto and other cities in 2003 showed a heightened sensitivity of places in the global economy to rapid changes brought on by the acceleration of social and ecological relationships (Keil & Harris, 2006, p.491).

Chou et al. (2004) examined the impact of SARS on Taiwan's economy. They reported that nearly 30% of international flights into Taiwan were cancelled during the outbreak, reducing passenger count by 122,000 in the second quarter of 2003 (Chou et al., 2004, p. 89).

Nearly ten years later, on the 13th of June, 2012, the first case of the Middle Eastern Respiratory Syndrome (MERS) disease was recorded in Jeddah, Saudi Arabia. Due to the virus' rapid transmission, the country that suffered the greatest losses was the Republic of Korea. The rapid and wide spread of the MERS-CoV infection in South Korea during the outbreak had a disastrous impact on the whole country, and highlighted our limited knowledge of MERS (Min et al., 2016). The MERS infection in the Republic of Korea has had a special impact on the labour market. More than half of the waged workers among young, middle aged and old people in Korea are non-regular workers (Lee & Cho, 2016).

According to IHS Markit Automotive, 11 of the Chinese provinces which were on strict lockdown account for more than two-thirds of the vehicle production in the country. Additionally, these provinces supply auto-parts to carmakers in the US, Europe, and South Korea (Ayittey et al., 2020, p.473). Automotive sectors are similarly international, with highly specialised suppliers that make short-term substitution difficult (Guan et al., 2020, p.583).

The authors of one study simulated the dependence between China and other markets at the begging of the pandemic. In addition, they looked at the spill-over effects on the rest of the world. With the spread of COVID-19 to highly developed western countries, labour and transportation constraints in Germany and many of the countries that supply auto parts and raw materials caused a decrease in production by the German automotive sector amounting to 28.8% (24.8% directly due to local containment, and 4.0% due to effects upstream) (Guan et al., 2020, p.583). Such decreases in German production rippled upstream to suppliers in Hungary, Spain, Italy and the United States, and downstream, with demand for German cars decreasing in the United States, China and Austria by 29.1%, 37.6% and 22.3%, respectively. In the case of a global spread, and more widespread and longer-term lockdowns, the output of the German automobile industries decreased by a further 0.9% (Guan et al.,2020, p.583).

According to Fortune (2020), more than 94% of the top 1000 companies have been negatively affected by this outbreak (El Baz & Ruel, 2021).Major automobile companies have been cutting jobs with decreas-

ing sales, owing to the ongoing pandemic (Belhadi et al.,2021). Apart from being a global health concern, COVID-19 continues to have major consequences on the world economy, and experts have predicted that COVID-19 will lower global gross domestic product growth in 2020 by one-half of a percentage point (from 2.9% to 2.4%) (Gupta et al., 2020).

In examining the impact of SARS-CoV-2 on supply chains, the authors Inoue and Todo examined Japan's connection with other regions. Therefore, this study examines the propagation of the economic effect of the lockdown of a city to prevent the spread of COVID-19 to other regions through supply chains (Inoue & Todo, 2020). In their study, the authors simulated the locking effect of large industrial cities. Due to its size and importance, they focused on Tokyo. When Tokyo is locked down, the value-added production of Tokyo immediately becomes almost zero. Because the daily production of non-essential sectors in Tokyo is estimated to be 309 billion yen, or approximately 2.9 billion US dollars, the total direct loss of production in Tokyo due to lockdown is 309 billion yen multiplied by the number of days in the lockdown period (Inoue & Todo, 2020).

RESEARCH METHODOLOGY

All business activities are currently preoccupied with the ongoing COVID-19 pandemic. The current impact of this outbreak on the manufacturing firms is already very severe, and medium-to-long-term impacts are predicted to be higher than that of any other previous major outbreaks such as the 2003 outbreak of SARS (Paul & Chowdhury, 2020, p.107). In order for the analysis to be complete, the authors of this paper will look at the current pandemic in relation to the two health crises in the last 30 years to have left somewhat greater consequences. In addition to the current crisis, the analysis will focus on data from the years 2003 and 2012, when the world, or at least some part of it, was faced with the SARS-CoV and MERS-CoV viruses. The focus of the analysis will be on production in order to see the impact of these viruses on business activities. The authors will examine whether the appearance of the virus causes a decrease in production in the automotive industry. Also, we will examine whether there are significant differences in the percentage changes in the level of production in the years when the crises occurred.

The following figures show the production trends and the absolute values to be used in the analysis.
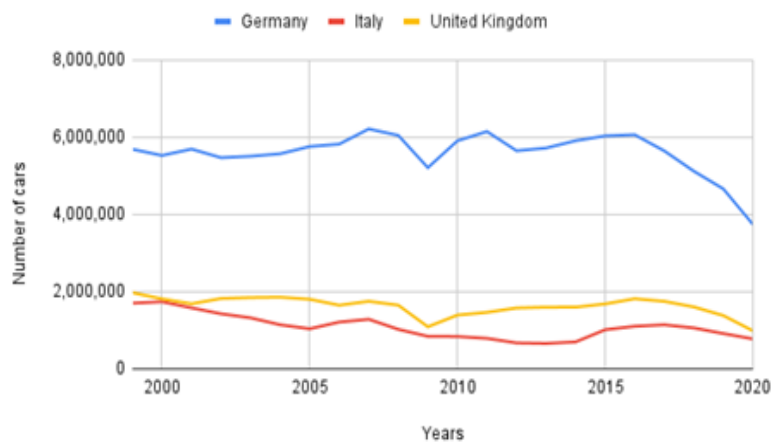
Figure 1. Numbers of cars produced in Europe
Source: Authors according to OICA, https://www.oica.net/production-statistics/,
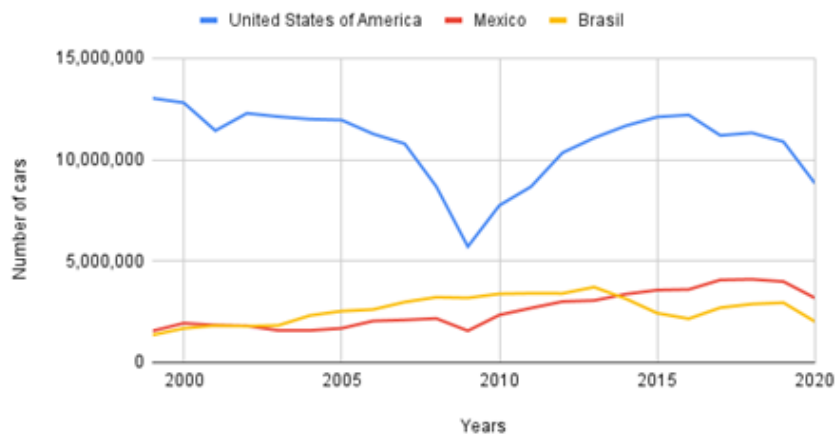Accessed 10th June 2021.

Figure 2. Numbers of cars produced in America
Source: Authors according to OICA, https://www.oica.net/production-statistics/,
Accessed 10th June 2021.
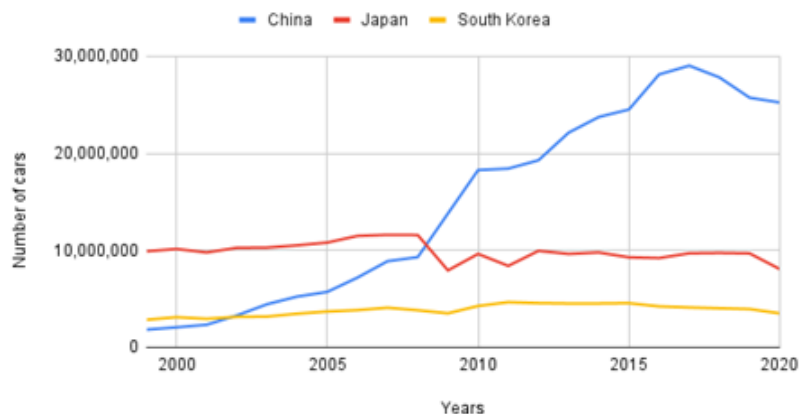
Figure 3. Numbers of cars produced in Asia
Source: Authors according to OICA, https://www.oica.net/production-statistics/
Accessed 10th June 2021.

In order for the analysis to be complete, the mentioned crisis years and production in the automotive industry will be considered from the aspect of the characteristics of the mentioned viruses. Table 1 presents the basic indicators of these viruses, which will be evaluated later in the paper.

Table 1.Characteristics of patients with SARS-CoV-2, SARS-CoV, and MERS-CoV

Virus	Transmission human to human	Incubation period (Days)	Mortality rate	Confirmed cases
SARS-CoV	Transmitted mainly between humans through close contact- YES	2-7	10%	8096
MERS-CoV	Limited transmission between humans through close contact-YES	5-6	34.4%	2519 (From 2012 until January 31, 2020)
SARS-CoV-2	Human-to-human transmission occurs through close contact-YES	7-14	2.03% (28.10.2021.)[1]	246251235 (28.10.2021)

Source: Rabaan et al., 2020

[1]Based on author's calculation according to Worldometers, https://www.worldometers.info/coronavirus/, Accessed 28th October 2021.

In order to conduct the research, the authors used Wilcoxon's and Friedman's tests. Wilcoxon's test works with metric (interval or ratio) data that is not multivariate normal, or with ranked/ordinal data. Generally, it is the non-parametric alternative to the dependent samples t-test. Wilcoxon's sign test tests the null hypothesis that the average signed rank of two dependent samples is zero. Whenever you have data that is composed of definite scores, Wilcoxon's signed rank test is preferred. In the analysis, the authors used Friedman's test. This non-parametric alternative to analysis of variance for repeated measures has been applied because of a small sample and, therefore, non-fulfilment of assumptions for the application of parametric methods. Friedman's test is used to test for differences between groups when the dependent variable being measured is ordinal. It is used to determine whether or not there is a statistically significant difference between the means of three or more groups in which the same subjects show up in each group. It can also be used for continuous data that has violated the assumptions necessary to run the one-way ANOVA with repeated measures.

The Evaluation of Virus Characteristics

The first characteristic of the virus refers to the mode of transmitting the infection and to the subject involved in the transmission. In all three viruses, this segment is identical, since all viruses are transmitted through contact between humans. Another characteristic refers to the incubation period. A longer incubation period makes it difficult to detect the virus. After that, the mortality rate and the total number of cases will be analysed. It is important to note that the data relating to the SARS-CoV-2 virus pandemic used in the analysis was observed in the moment of writing this paper, as the long term effects of the infection are still unknown due to the duration of pandemic.

Virus evaluation is performed on the basis of the fact that the authors assigned coefficients based on a comparative analysis of these characteristics. In the analysis of the sequence, the coefficient values indicate a lower danger, and also a lower degree of virus influence. When it comes to transmission, the coefficient assigned by the authors is 1, since all viruses are transmitted from one human to another through direct contact. When it comes to the incubation period, it is the longest in relation to SARS-CoV-2, and therefore a coefficient of 3 was assigned. The highest mortality rate will correspond to the highest coefficient. This is the case with the MERS-CoV virus, while, according to current data, the lowest mortality rate relates to the current pandemic. When talking about the number of cases, it is by far the largest in relation to the current pandemic, and the smallest in relation to the epidemic of the MERS-CoV virus; accordingly, the coefficient assigned is 1. The values regarding the relativity of these indicators are shown in the table below. According to the

characteristics of the virus, the current pandemic has the greatest impact on the automotive industry, which is going to be tested.

Table 2. Evaluation of viruses

Virus	Transmission human to human	Incubation period (Days)	Mortality rate	Confirmed cases	SUM
SARS-CoV	1	1	2	2	6
MERS CoV	1	2	3	1	7
SARS-CoV-2	1	3	1	3	8

Source: Authors according toRabaan et al., 2020 and Worldometers, https://www.worldometers.info/coronavirus/, Accessed 28th October 2021.

The Impact of the Virus on the Automotive Industry

By evaluating these virus characteristics, we can assume that the current pandemic has the greatest impact on the automotive industry. If we look at the charts and individual trends in production in a specific country, the following can be pointed out.

According to the data related to production in Germany, it can be said that, in 2003, there was no negative impact on production because Germany achieved a growth of 0.7% compared to the previous year. During 2012, a decline of 8.1% was observed compared to the previous year, with a tendency to stabilise. In 2020, the decline was the most drastic and it amounted to 24% compared to the previous year. For the German market, it can be said that the smallest impact was exerted by the SARS–CoV epidemic, while the largest negative impact is present in the current pandemic, according to the movement of production.

When it comes to Italy, the relative negative values of production are recorded in all three years subject to this analysis. In 2003, there was a decrease in the decline compared to the previous one, while a drastic increase followed in 2012. Since this is a country which suffered huge consequences in the health sector during the current pandemic, that impact was transferred to the economy and the year 2020 recorded double digit negative values. It can be said that the SARS-CoV epidemic had the least impact, while it is impossible to precisely gauge the impact of the other two, because the relative values of the decline are almost identical.

In 2003 and 2012, the UK market achieved an insignificant growth in production compared to previous years, and it can be said that the crisis in that period did not have a significant impact. During 2020, significant consequences for car production were noticed, and the decline in production was 29%. For the UK market, it can be concluded that the biggest impact is exerted by the current pandemic, while the impact is relatively identical in the first two cases.

Speaking of the US market, it can be said that there was a decline in production amounting to1.3% in 2003, which continues in the current pandemic, noting that the decline in 2020 reached as much as 19%. During 2012, growth tendencies were recorded, so it can be said that the smallest impact was achieved in that year. Current data indicates that the current pandemic has the greatest impact.

When it comes to Mexico, there was a decline in 2003, and there was an increase in production activities in 2012. Data for 2020 indicates a large drop in production amounting to21%. It can certainly be said that the biggest consequences are the ones from the current pandemic.

In the case of Brazil, 2003 does not show any significant effect on production, while a smaller decline can be observed in 2012. Certainly, the worst impact is expected in the current pandemic, because a drastic drop in production of 32% was recorded in 2020.

Talking about China, growth was achieved in 2003 compared to the previous year. In 2012, a growth of 4.6% was recorded. The biggest consequences are recorded in the current pandemic, wherein negative values exhibit a tendency to increase. Relevant experts point to the fact that the Chinese car market is shrinking, since the initial focus of the current pandemic was the Chinese province of Hubei. According to industry consultant LMC Automotive, China's auto market will shrink between 3% and 5% in 2020 if the corona virus outbreak continues into the second quarter (Ayittey et al., 2020, p.474).

The situation is similar when it comes to Japan, which records the most significant losses in the current pandemic. Data indicating the severity of the consequences can be seen through the losses that occur in both the internal and the external environment of the chains themselves. The results indicate that when Tokyo is locked down for only one day, the production loss outside Tokyo, albeit these areas are not locked down, is already 252 billion yen, or 82% of the production loss in Tokyo (Inoue & Todo, 2020).

South Korea recorded a slight increase in 2003, and a slight decline in 2012. The situation is similar to other analysed countries when it comes to the current pandemic, because South Korea records a drop in production amounting to11%.

Based on the above data, it is possible to assume that the greatest negative impact is exerted by the current pandemic, and the authors test that hypothesis in the continuation of the paper. Additionally, the authors test the statistical significance of the change in production in the specific years when the viruses appeared.

RESEARCH RESULTS AND DISCUSSION

In order to test the stated hypotheses, the authors examined the significance of the change in the level of production in the years when the viruses appeared, and in the year before their appearances using Wilcoxon's test. The following table shows the values of production in the specific years used in the analysis.

Table 3. Number of produced cars in the years when the epidemics and pandemics occurred

Country	P2002	P2003	P2011	P2012	P2019	P2020
Germany	5469309	5506629	6146948	5649260	4661328	3742454
Italy	1427081	1321631	790348	671768	915305	777165
United Kingdom	1823018	1846429	1463999	1576945	1381405	987044
United States of America	12279582	12114971	8661535	10335765	10880019	8822399
Mexico	1804670	1575447	2681050	3001814	3986794	3176600
Brazil	1791530	1827791	3407861	3402508	2944988	2014055
China	3286804	4443686	18418876	19271808	25720665	25225242
Japan	10257315	10286218	8398630	9943077	9684298	8067557
South Korea	3147584	3177870	4657094	4561766	3950617	3506774

Source: OICA, https://www.oica.net/production-statistics/, Accessed 10th June 2021.

Based on Wilcoxon's test, the authors obtained the results shown in the following table.

Table 4. Statistic significance of changes in car production in the consecutive years

Years	Test statistics	p value (Significance)
P2003 - P2002	Z=-0.178	0.859
P2012 - P2011	Z=-1.125	0.260
P2020 - P2019	Z=-2.666	0.008

Source: Authors calculations

According to the realised level of significance (p-value), the authors concluded that there wasn't statistically significant decline in production in automotive industry during the crisis caused by the SARS-CoV and MERS-CoV viruses, while that was different in relation to the SARS-CoV-2 pandemic. In the first two cases, those values are higher than the reference values (0.05), while the value is lower and amounts to 0.008in the case of the current pandemic. Testing results showed that only the SARS-CoV-2 virus caused significant changes in production in the automotive industry. Based on the virus characteristics, it has been proven that the greatest negative impact on production in automotive supply

chains is exerted by the current pandemic. Further in the analysis, the authors tested the statistical significance of the differences in production levels between the three specific years in which the health crises occurred. In order to define these differences, relative changes in production in years when the crises appeared and one year preceding each of the crises was used. The relative changes are shown in the following table.

Table 5. Relative changes in production in the consecutive years

Country	P2003-P2002	P2012-P2011	P2020-P2019
Germany	0.0068	-0.081	-0.1971
Italy	-0.0739	-0.15	-0.1509
UK	0.0128	0.0771	-0.2855
USA	-0.0134	0.1933	-0.1891
Mexico	-0.127	0.1196	-0.2032
Brazil	0.0202	-0.0016	-0.3161
China	0.352	0.0463	-0.0193
Japan	0.0028	0.1839	-0.1669
S. Korea	0.0096	-0.0205	-0.1123

Source: Authors calculations

In order to examine whether there is a significant difference in the average relative changes in the level of production in the years when the crises began, the authors used Friedman's test. Based on the values of x^2 (Chi-square) and the significance level (Asymp. Sig), it can be concluded that there is a significant difference in the percentage changes in production levels between the years in which the viruses occurred. This analysis showed the different impact of health crises on the automotive industry. More precisely, it showed a significant difference in the impact between specific viruses that acted on production in the automotive industry.

This test showed a positive correlation with Wilcoxon's test. The authors confirmed the hypothesis regarding significant differences in the percentage changes in the level of production in the years when the crises began, and also showed the coincidences occurring in the ongoing pandemic via the results of Wilcoxon's test. Testing further revealed significant differences between the percentage changes in the years when the viruses appeared, which showed that each virus had different levels of impact.

During further analysis, the authors examined the specific years in which the viruses appeared, to determine which of those showed a statistically significant difference in the effects of the crises on the automotive industry. Based on Wilcoxon's test, the authors found that a statistically significant difference in effects in the automotive industry exists when we compare the years 2012 and 2020. There is also a significant difference when comparing 2003 and 2020, while there is no significant difference between 2003 and 2012.

CONCLUSIONS

Pandemics of emerging infectious diseases can have very negative consequence. Due to the great impact that health crises can have on the automotive industry, numerous studies examining these impacts are being done. The catastrophic impact of the spread of the SARS-Cov-2 virus has influenced the emergence of a serious number of articles, studies and researches. However, there is still a lack of systematisation of the results obtained by researchers and scientists in the previous period regarding the impact of the spread of this disease on the supply chain. But all researchers agree on one theme – that the emergence of this virus has shown that supply chains continuously find ways to increase their resilience and sustainability (Moosavi, Fathollahi-Fard & Dulebenets, 2022).

The emergence of the pandemic and the effects of its spread through supply chains have shown the low level of resilience of global supply chains and the need to work on defining measures to increase their resilience in health crisis conditions in the future. However, due to their global character, pandemics like this will require global cooperation and the harmonisation of measures to increase resilience not only between companies in the supply chain but also between countries (Golan et al., 2020, p.223). This is the only way to reduce the probability of new pandemics, or to minimise their negative effects if they do occur (Strange, 2020). For these reason, models that simulate the spread of viruses have been created, aimed at reducing the rate of transmission. Disease spread models have been developed to predict the spread patterns and the effect of intervention strategies on populations with complex social and spatial structures (Ekici et al., 2014, p.12). The models were created so that even in conditions of upcoming epidemics and pandemics, business could be conducted with the reduction of harmful effects.

In the literature that examines the domain of the impact of epidemics and pandemics on supply chains in the automotive industry, the current pandemic occupies a dominant place, because it is assumed that it will have the greatest impact. Such attitudes influenced the authors of this paper, and ultimately shaped the analyses presented. The comparison between the health crises analysed by the authors in this paper aimed to examine the different impacts that similar situations may have on automobile production. Such situations are especially specific because there is a pronounced spill-over effect of negative influences, and for that reason, countries from different continents were included in the paper.

Based on the research, the authors conclude that the greatest impact on the levels of production in the automotive industry was achieved by the current pandemic. In addition, a statistically significant difference was observed in the level of average production in years

marked as the beginning of the epidemics and pandemics. The effect that such disturbances have on the supply chains in the automotive industry is undeniable, as is the fact that the chains must increase their resilience in order to more effectively withstand similar situations in the future.

This article also has a few limitations. The first one may relate to the choice of countries analysed in the paper. The authors have made this choice believing that these countries can be identified as those that significantly participate in the automotive industry worldwide, which is the result of a free assessment. Another limitation of the analysis relates to the fact that the SARS-CoV-2 pandemic is still ongoing. The data used by the authors to calculate indicators may change in the long run due to the uncertainty of the current pandemic.

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ПРОЦЕНА УТИЦАЈА ЕПИДЕМИЈА И ПАНДЕМИЈА НА ЛАНЦЕ СНАБДЕВАЊА У АУТОМОБИЛСКОЈ ИНДУСТРИЈИ

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Резиме

Отпорност ланаца снабдевања може бити угрожена бројним факторима из интерног и екстерног окружења. Степен контролабилности фактора који делују из екстерног окружења је мањи, те дејство поменутих фактора може у значајни-јој мери дестабилисати ланце снабдевања. Епидемије и пандемије, као фактори који свој утицај остварују из екстерног окружења, утичу на ланце снабдевања реметећи процесе и активности у њима. Посматрајући епидемије и пандемије, и поредећи их са бројним ризицима из екстерног окружења, у литератури се наво-де специфичности које појаву здравствених криза сврставају у посебну катего-рију ризика. Тренутна ситуација са пандемијом вируса Sars Cov-2 је актуелизо-вала питање отпорности ланаца. У литаратури се наглашава став о томе да нису ланци снабдевања у свим индустријама подједнако изложени утицају епидемија и пандемија. Ланци снабдевања у аутомобилској индустрији често могу бити из-ложени већем утицају, што се може посебно показати анализама које испитују

утицај текуће пандемије. У циљу испитивања утицаја епидемија и пандемија урађене су бројне анализе које су показале различите ефекте које здравствене кризе остварују на активности и процесе у ланцима снабдевања, на тај начин дестабилишући отпорносту мањој или већој мери. Анализа у овом раду показала је различити утицај који појаве вируса остварују на производне активности у ланцима снабдевања. Показана је статистички значајна разлика у утицајима поменутих вируса. Кроз анализу је указано на значај утицаја здравствених криза на аутомобилску индистрију, са циљем развоја даљих истраживања и испитивања последица, које су због трајања пандемије још увек несагледиве.