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POST-COVID PERSPECTIVES FOR THE AUTOMOTIVE INDUSTRY, OPPORTUNITIES, AND THREATS

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Abstract: The subject of the study is to verify the impact of the SARS-COV2 virus pandemic on the functioning of the automotive industry in the context of the global economy. The conducted research is important due to the enormous change in the functioning of the automotive industry due to the covid pandemic as well as megatrends affecting the industry. The paper aims to verify the determinants influencing the functioning of the automotive industry. The conclusions resulting from the study will be used to better understand the current situation and to prepare the market's strategy for the coming years. The selected research method includes literature and industry research and the Exact Systems company case study. The case study relates to a survey of car and car parts manufacturers in 12 European countries. The author's contribution is an indication of many factors influencing the potential future of the automotive industry available in the literature. Then the author compares these data with the expectations and predictions of the car manufacturers' market participants to draw consistent conclusions.
Keywords: Automotive, Covid, Predictions, Trends, E-mobility

1. INTRODUCTION

The impact of COVID in the automotive branch is hard to define one-dimensional. According to which moment of the pandemic we would like to investigate situation have been extremally fluent. First reactions were quite similar like in every branch excluding deliveries and e-commerce. Panic was present everywhere. But decisions undertaken in each branch of industries caused long-term effects.

The result of the first phase of the pandemic brings a decrease in orders from the market. In some cases, it was reduced on the previously unknown scale.

To better picture the scale of the phenomenon its worth seeing the FADA (FADA - Federation of Automobile Dealers Association) India President - Ashish Harsharaj statement about April 2020:

*This is the first time in automobile history that there have been **no sales/zero sales**, it is a difficult moment for all of us in the automobile community. We look forward to opening of the lockdown and resuming the business again at the earliest, without*

compromising citizen safety. (FADA 2020) For many years supply chain in automotive enterprises was following just-in-time solutions whose main goals are reduction of storaging material to avoid unnecessary wastes called from the Japanese word *Muda* meaning wastefulness. This kind of solution allows reducing additional operations such as additional handling or transporting. The conception is very interesting but when it is required to face with lack of material, transportation problems and general chaos, that type of delivery can cause supply chains breakdowns. To resist of current disruption automotive branch was forced to act. Following the problem-solving methods (VDA, 2018) which are an automotive standard for problem-solving car producers started to undertake actions. Their long-term effects caused by mentioned actions give different types of problems.

2. RESOURCE AVAILABILITY

Pandemic situation and accompanying panic caused a decrease of orders for new cars, hence producers were forced to limit the level of orders to theirs. Temporary moods indicated a lower purchase interest trend for the next months, maybe years. Those decisions were very painful for suppliers. There were mainly 2 groups of suppliers. First with no materials or capacity to fulfill customer orders. Second with material and capacity but with limited by customers level of orders caused by lack of demand or supplies from different suppliers. So, occurred a situation of complicated codependences. Created with any corresponding action with COVID pandemic supply chain complexity triangle becomes up-to-date like never before.

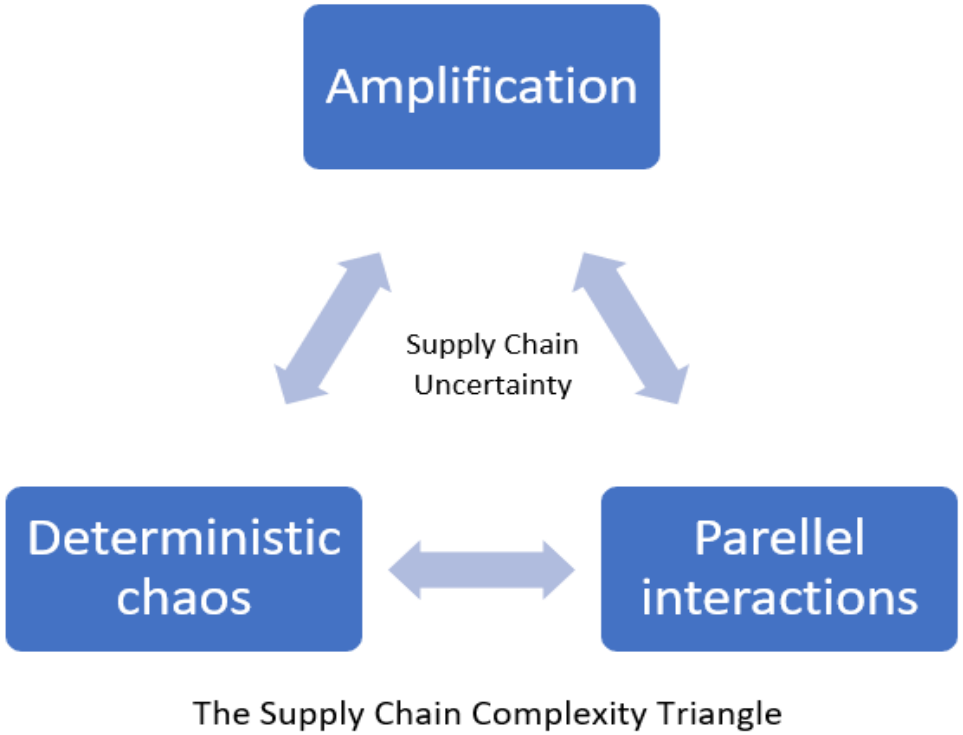

Fig. 1. The supply chain complexity triangle: Uncertainty generation in the supply chain. International journal of physical distribution and logistics management (Wilding, R. 1998)

From the beginning of global supply chains occurrence, automotive has been a very strong and influential branch. The market power of producers with a total yearly spend of over 80 million cars in 2019 (IEA, 2020) It's necessary to consider that every car consists of thousands of parts and the final producer OEM assembly them into the final product which is a vehicle. It gives many activities to do and of course also therefore workplaces.

According to the negative prognosis and due to the potential collapse of demand automotive producers decide to reduce forecasted materials, among other components for electronic inside the vehicle. Most of the semiconductors were ordered from Taiwan's supplier Taiwan Semiconductor Manufacturing Company (TSMC) (Nature). Facing the potential demand crisis the negotiation has started. Worth noting is the fact that in the average car we can find hundreds of electronic components consisting of semiconductors.

In meantime, the electronic market has been booming. Due to the COVID pandemic enclosed in their houses, people become more and more interested in computers, consoles, TVs, and smartphones. Semiconductor producers at the beginning of the pandemic were forced by the automotive industry to reduce levels of deliveries. Struggling with lower orders level caused a successful review into growing branches. Different branches have been developed.

Also, it is important to consider that even if the current chip crisis will be solved some new branches that required semiconductors such as autonomous vehicles, 5G communications or artificial intelligence will be growing. (Chips in a crisis).

As a result, the market got limited volumes of components for automotive and therefore lack of semiconductors for the new cars. The lack of components makes it impossible to sell the cars what causes also fluctuations in ordering different components.

3. TRENDS IN THE AUTOMOTIVE BRANCH

From the beginning of car production, the general model of car use has been stayed unchanged. The owner (even though we consider leasing or rent) was responsible for taking care of maintenance, and assurance of necessary pieces of equipment like fossil fuels, fluids, and more. Also, the owner indicated to him persons were authorized to use the vehicle. Hence, the driver has been responsible for mentioned issues and ensuring the safety of the road users. The rules were not changed a lot within more the one hundred years. The production side of the automotive industry in meantime taken care to optimize its processes. From the very beginning and preparation, the first production line up to the Just-in-sequence deliveries becoming more popular recently. Evolution of each included inside systems was unbroken, tires, steering systems, equipment, and the general whole car components have been developed and changed constantly. For sure more and more electronics were introduced but the general shape and rules remain the same. Still constantly the undisputed king of powertrains systems was internal combustion engines. The situation began to change and nowadays battery electric vehicles (BEV) and hybrids seem to be the future of automotive.

The 21st century has been brought also some new ideas. The important factor for all people and companies worldwide become the electronic market and Internet

development. More of the part of society nowadays have smartphones with connection to the internet. It made space for a rapidly growing sector of carsharing and modern kinds of taxis ordered by apps. The combination of electronics and IT development gives us the possibility to work on big data to make cars autonomous. Time will show which direction it will go but for sure it is worth presenting potential 3 trends briefly below.

3.1. Shared mobility

How innovative it would seem the idea of shared mobility is not a new one. The idea of offering transportation is common from the century as carriages or later on taxis. As the years go by it changes and becomes more and more matching for reality. First mentions about the idea of carsharing are connected with some Swiss cooperative from Zurich managed car share arrangement in 1948 (Shaheen et al., 2021). Next 50 years this idea was being present in societies but with no significant footprint. Shared transport allows to reduce traffics, the number of needed parking spaces, and the number of cars on the road. Also, it can generate a reduction in total transportation costs (Guyader et al., 2021).

The gamechanger was the development of society connection possibilities. The main point was to allow people to contact in real-time. Last years and the constant growth of people with smartphones make the carsharing idea fall on fertile ground.

Nowadays we can understand shared mobility as a set of connected services from the scope of carsharing, bike-sharing, carpooling, scooters pooling, taxi and on-demand services, shuttle services private transit services, and of course public transit services (Guyader et al., 2021). Currently service providers in mentioned mobility feature taking care of the optimization of performance efficiency.

The very important issue is to model demand forecasts. There are many potential models which are implemented in the systems such as:

- *A comprehensive approach to the vehicle imbalance problem* – treating the whole system of carsharing as a whole and by treating internal loop to ensure transportation possibilities in each station;
- *The performance of one-way systems* – a method which estimates demand at the very beginning stage to spread out effectively cars and calculate future charges, not including relocation;
- *Solving the vehicle imbalance through relocation operations* – use of internal staff to relocate vehicles for all stations based on a prediction of demand*;*
- *Full control over where and how to supply vehicles* – it will give the operator possibility to allow only trips which are helping to balance the car fleet and are profitable;
- *Using the users for system balancing* – by using various motivation systems encourage users to support relocation cars between stations/places of demands (Jorge and Correia, 2013).

Previously in the 10s' of the 21st century, the model included usually as necessary sharing stations. By using customized procedures and trend managing enterprises were taken into consideration such factors as station characteristics, relocation costs, staff costs, low service level penalties, customer usage patterns, and maintenance schedules (Kek et al., 2007). The current situation allows using dedicated methods to

predict carsharing service demand like Prophet, Long Short-Term Memory (LSTM), XGBoost, Catboost, lightGBM based on algorithms and access to data in real-time (Alencar et al., 2021).

In 2013 D. J. Fagnant, K. M. Kockelman wrote down an article about the potential implications of using a shared autonomous vehicle (SAV). After using cars will be automatically relocated based on vehicle relocation strategy. The main preliminary finding was a potential limitation of necessary cars in the fleet 11 times, however, the total distance driven will be higher 10%. It is necessary to consider the impact of having a much bigger fleet with more distance traveled. (Fagnant and Kockelman, 2013)

In 2015 T. Donna Chen, Kara M. Kockelman, and Josiah P. Hanna 2015 considered the option of using shared autonomous electric vehicles (SAEV). They are indicated natural synergy by all of these solutions. The findings show the possibility of replacing 5-9 privately owned vehicles. However, it will generate 7-14% more distance driven in total. It is necessary to notice additional factors connected to electric cars such as vehicle range, time of charging. and required infrastructure (Chen et al., 2015).

3.2. Autonomous cars

The last decades caused the occurrence of new opportunities by the development of engineering and especially digitalization. One of those is replacing the driver with a computer. During last year's we were witnesses introducing new options in vehicles like adaptive cruise control, park assistant, lane-keeping assist, or lane departure warning system. So mentioned systems are not the latest one step in the way of autonomous cars. From at least 2008 when the "Boss" won DARPA Urban Challenge we have in our roads, not independent cars. DARPA UC – the contest organized by the Defence Advanced Research Projects Agency as the first competition including testing of autonomous cars in an urban environment. The challenge count 89 teams in the very beginning and included a paper background as a necessary condition. The winner of those competitions Chevrolet Tahoe had an onboard behavioral system has consisted of three subcomponents: *lane driving*, *intersection handling*, and *goal selection*. Worth note is the fact that from 11 vehicles finally qualified in Urban Challenge Final 3 cars completed road without human intervention and an additional 3 with minor ones. "Boss" was created by Tartan Racing Team consisted students, staff, and researchers from a few entities which included Carnegie Mellon University, General Motors, Caterpillar, Continental, and Intel(Urmson et al., 2008). Surely there are many advantages those type of cars as optimization of usage, possible using by people with no driving license, persons older and ill, limitation of emission. Also, it will be easier to manage the fleet of the carsharing fleet. Very useful can became using a car for the demand. As a society, we have to face up such issues as liability, legal agreements, licensing, security, or insurance regulations. Those are complex issues and it seems to be complicated to set up all requirements in different countries or maybe even states in one country at the same level. It can cause a situation that customization of models will be very necessary for every single area (Fagnant and Kockelman, 2015).

Since 2014 SAE International (formerly Society of Automotive Engineers) has been prepared 4 versions of the handbook for autonomous vehicles in a cycle of surface

vehicle recommended practices. The latest revision of SAEJ3016 published in 2021 has been written with close cooperation between SAE On-Road Automated Driving (ORAD) with ISO TC/WG14 since 2018. The main results of the papers are supported below issues:

1. Driver engagement during using a driving automation system
2. Find answers for questions connected with laws, policies, regulations, and standards
3. Preparation framework for driving automation specifications and technical requirements
4. To provide clear and stable communication in the automatic driving topic, also useful handbook allows to saves time and effort

The document has no normative character and the main purpose is to ensure definitions, show branch practice, update current technical standards, and clear general terms of issue (SAE International, 2018). One of the key tasks – definition of automation levels is met in Fig. 2.

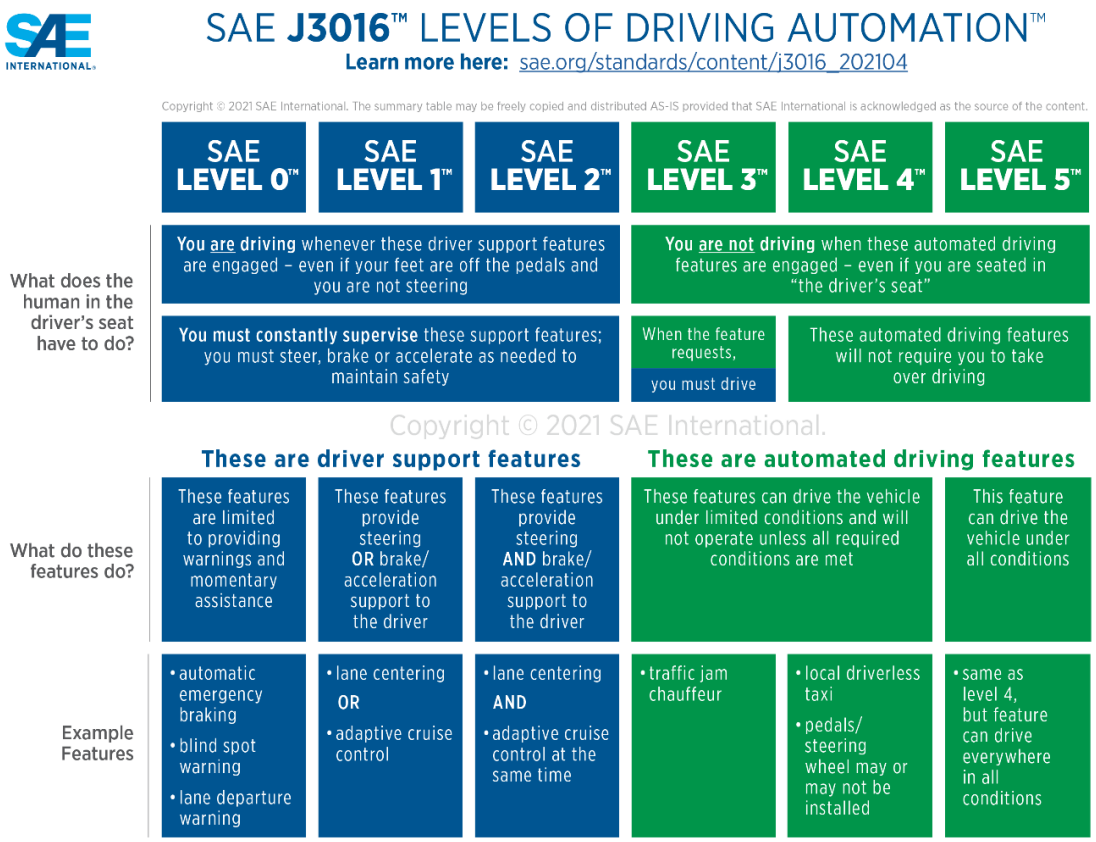

Fig. 2. Levels of driving automation (https://www.sae.org/blog/sae-j3016-update)

Parallelly to engineering development, different researchers are more focused on the economic and social possibilities of autonomous vehicles face with modelling future possibilities of AV. In the literature, many authors are struggling with the potential usage of the AV in the urban logistic. During the years 2015-2020 at least 80 papers are focused on the potential implementation models for AV in society. The authors used an Agent-Based Model forecasting future scenarios and potential benefits for

environmental, urban networks, and finally users. The models developed currently mainly focused on the managing of the fleet of AV cars (Li et al., 2021).

3.3. Electric Cars

Mobility drives into electric cars due to many reasons. For sure it can be indicated such factors as the potential lack of fossil fuels, the impact of traditional cars on the environment caused by emissions as well as potential cost reduction during the useful cycle. A very important issue in the development of E-mobility can be government support (Andwari et al., 2017). In UE countries are forced to reduce emissions during next year, and the aim for the automotive industry is one of the affected branches. It causes as well prizing for users and producers of electric cars as penalties for those producers and users who will not follow the current trend in the industry. The aim is to reduce at least 55% of emissions of greenhouse gas by 2030 (Fit for 55, 2021).
The beginning of the 10s' of the 21st century brings new opportunities in the context of mobility. First commercial passenger cars started to be electric. Change of users mindset as well as turnover into ecology cause rapid growth of the electric cars market.

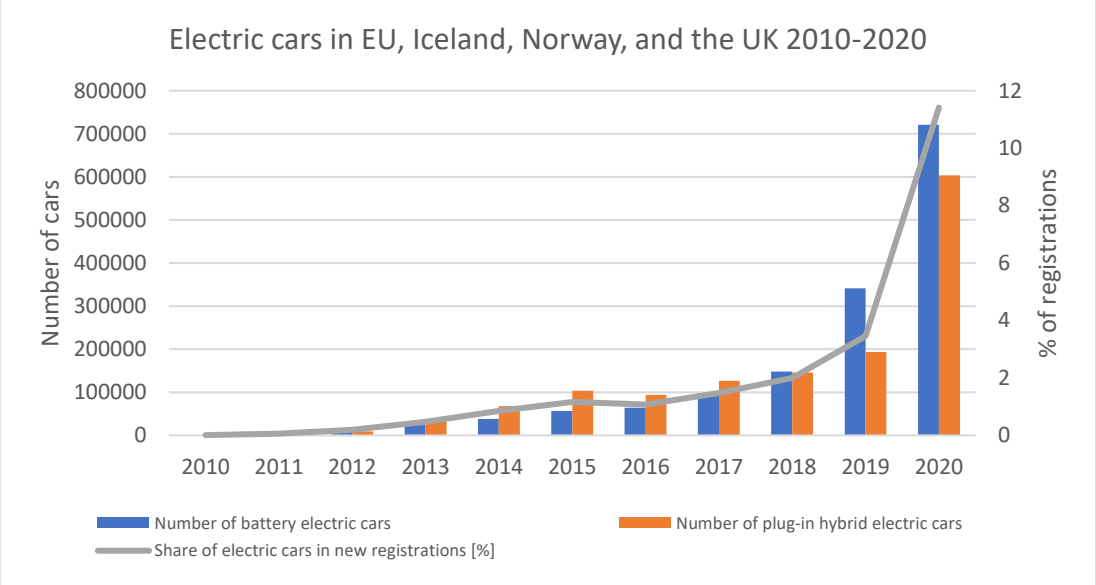

Fig. 3. Electric cars in EU, Iceland, Norway, and the UK 2010-2020 (European Environment Agency 2021)

However, studies made 21st century indicate E-mobility as a more sufficient option in comparison with traditional combustion systems. The very important factor of course is the source of energy. By simulation of using coal energy and hydropower energy, we can be on two different sides of comparison with traditional internal combustion electric vehicles(Notter et al., 2010).
One of the important points that allow battery electric vehicles (BEVs) to replace traditional internal combustion engine vehicles (ICEVs) is the density of power. Power density is the amount of power per unit volume (Jelley, 1946). Only achieving a sufficient value gives the possibility to replace traditional engines, however, it can increase the weight of the vehicle.

It cannot be considered as an option using the batteries in the vehicles with matching somehow price of this solution. Between 2010 and 2020 price of producing Li-Ion batteries decrease 5 times, the forecasts for the next years are not so optimistic however bring additional costs decreases.

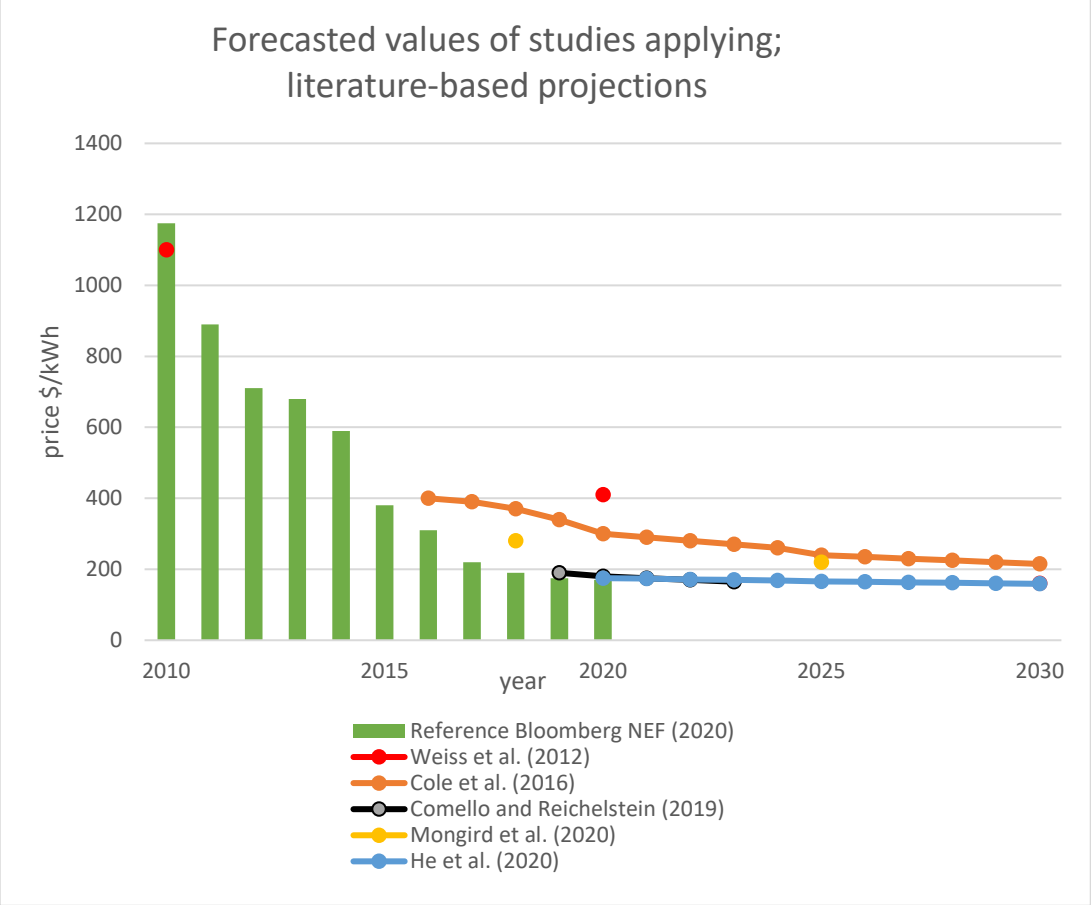

Fig. 4. Forecasted values of studies applying literature-based projections (Mauler et al., 2021)

There are a few possible materials used in the batteries so far. Known and using technologies are:

- Lead-acid battery It is a well-known technology. Due to the low level of energy density more or less 20-40 Wh/kg (Miller, 2009) and limited possibilities to extend it can be treated as short-distance cars. Also, the lifecycle of these types of batteries is not the best in comparison with different types of batteries. The advantage is low cost in the range of ~100USD/kWh. (Burke et al., 2007)
- Nickel Metal Hydride battery (Ni-MH) - So far used mainly in hybrid cars. The cost was between 700 and 800 USD/kWh (Burke et al., 2007) which was less than Li-Ion. Currently, this technology is considered mature with limited options for development. The energy density is in the range of 60-80 Wh/kg which seems to be too less for BEV (Miller et al., 2009)
- Lithium-ion batteries (Li-Ion) – the most popular and considered as the most promising technology so far. Due to the high electromechanical potential of

lithium and relatively low density, it is a very efficient material in range (Scrosati and Garche, 2010) The energy density can be between 100 and 300 Wh/kg. Very important Also livecycle is insufficient level. (Schuster et al., 2015)

- Sodium Nickel Chloride (Na/NiCl2, Zebra) battery – Very interesting technology with many advantages and one but an almost disqualifiable defect. This technology is cheaper than Li-Ion, has high energy density, long lifecycle, resistance to total discharging problems, and is safe. The only but very crucial issue is specific power which means that effectively is useless as the only source in BEVs. It can be used with different power sources as supercondansators (Dixon et al., 2006) (Zhan et al., 2021, Andwari et al., 2017)

4. BRANCH MOODS

As well COVID_19 pandemic as mentioned trends influences the automotive industry. But how the branch feels about this situation. Based on the Exact Systems Co. Motobarometer (Exact Systems, 2021) – the annual report of the moods in the automotive industry. The survey addressed automotive specialists and managers in 10 countries of the European Union the UK and Turkey. 802 respondents participated in the study in the 2021 year edition. It was 5 edition of the Motobarometer, developed by an additional section connected with the COVID 19 pandemic. The survey mainly focused on the current situation of automotive producers and forecasted trends in the coming next years.

Data about Covid's influence on the company's functioning is presented in Fig. 5 indicates how bad or even very bad was the consequences caused by the pandemic. Two-thirds of responders assess the effect as bad or very bad. Almost the same percentage of the study participants declare that their country's economy was comparably affected by the situation as others countries from European Union.

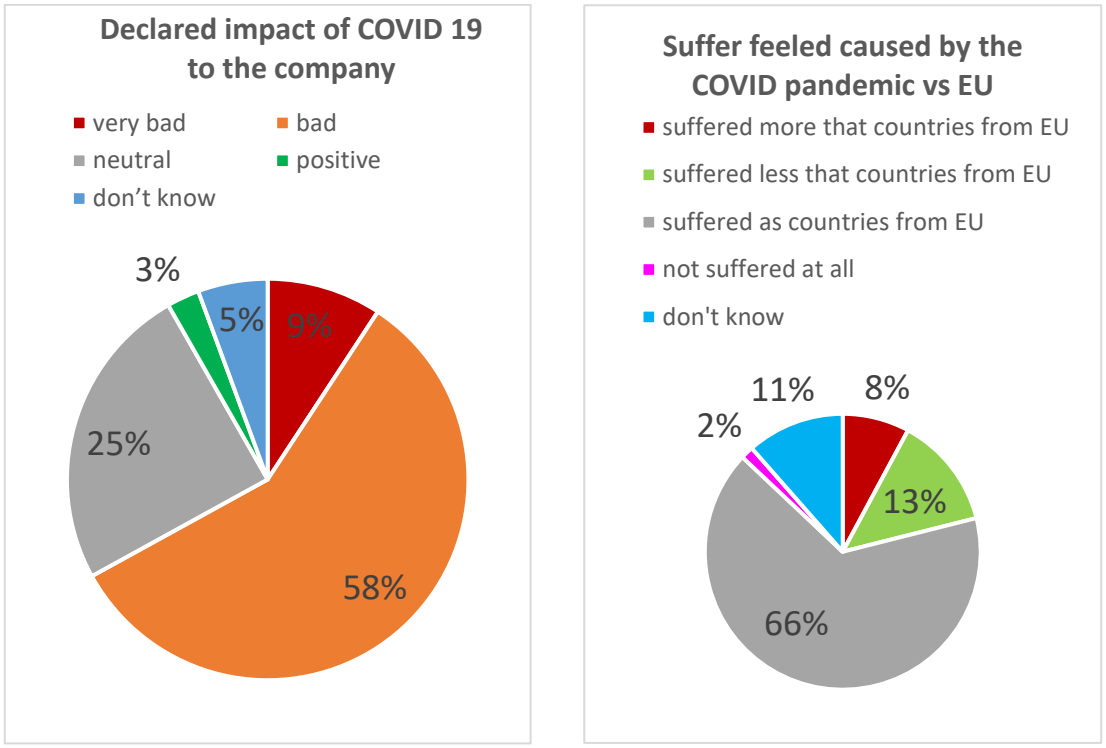

Fig. 5. Motobarometer 2021 www.exactsystems.com (Exact Systems, 2021)

The closest future which means the year 2022 seems to be the easiest to comment on by the automotive experts. In 2022 based on the respondent's predictions it should be visible an increase in the automotive industry. The greatest impact would be expected due to the new orders from abroad (87% of responders), the development of E-mobility (41), and new orders from domestic partners (40%) Fig 6. However, as well as the increase of E-mobility has a positive impact on some enterprises it can be found by different specialized ones as a risk for the businesses. It applies especially to those companies which are part of the internal combustion engines supply chain. Additional risk factors are directly connected with a possible decrease in production thus small orders from partners.

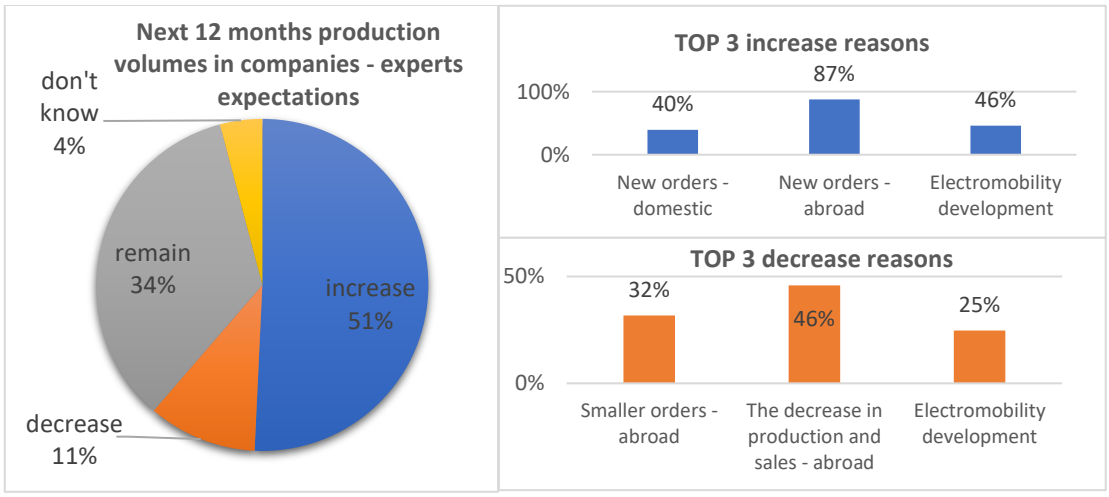

Fig. 6. Motobarometer 2021 www.exactsystems.com (Exact Systems, 2021)

Future could be not so attractive for automotive market participants based on the results in Fig. 7. Increasing prices can purpose treating cars as a luxury good again. Every day we can observe new trends like car-sharing or the development of shared mobility services solutions. The second side of this process can be an increase in the efficiency of vehicle use. Respondents declare based on the current problems with they face up better prepared for future crises as the second most popular answer. But how to predict the nature of future disasters, should be rather mentioned as a wish. Based on the survey, it seems possible that the industry will become more and more consolidated and will produce mainly electric cars. It means that not every current player found their place in the future market. There are so many factors in the future automotive industry context, all of them will be clarifying step by step. It will be a very interesting time for the market.

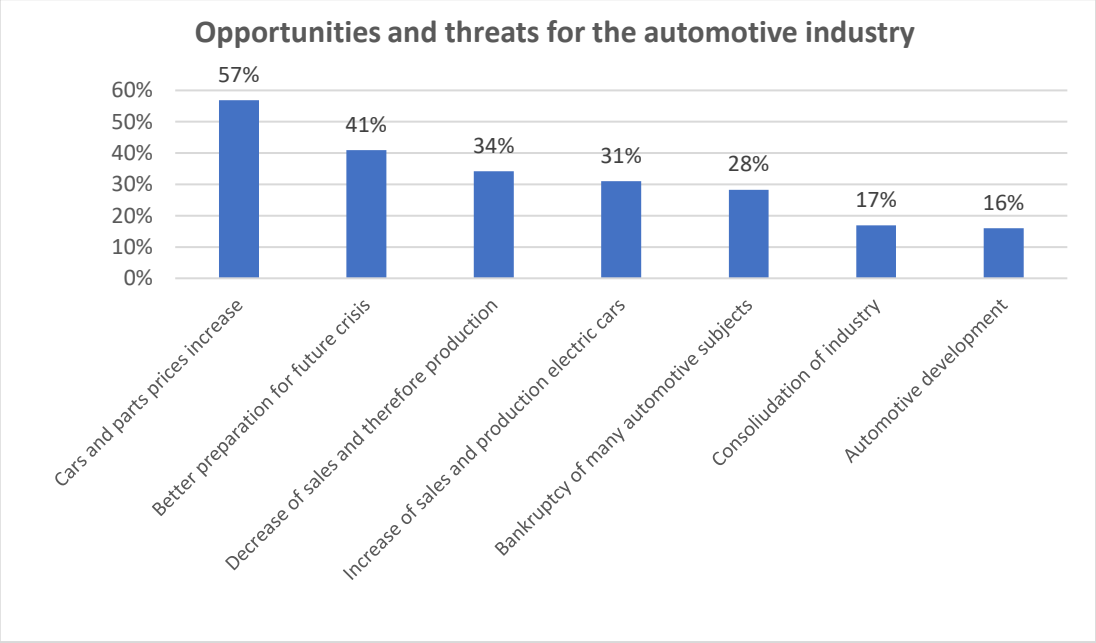

Fig. 7. Motobarometer 2021 www.exactsystems.com (Exact Systems, 2021)

The next results pictured in Fig. 8 show automotive industry experts' answers to questions that most market participants can be interested in. When the level of efficiency will come back to the previous one - achieved before the pandemic. Based on those data opinions are strongly divided. For these questions, opinions are divided between 2022 and 2023-24.

Question about investments in coming 3 years points to the coming development on companies. It can be understood that with no development will be a limited chance to be part of the market in the future hence it is necessary to follow upcoming trends.

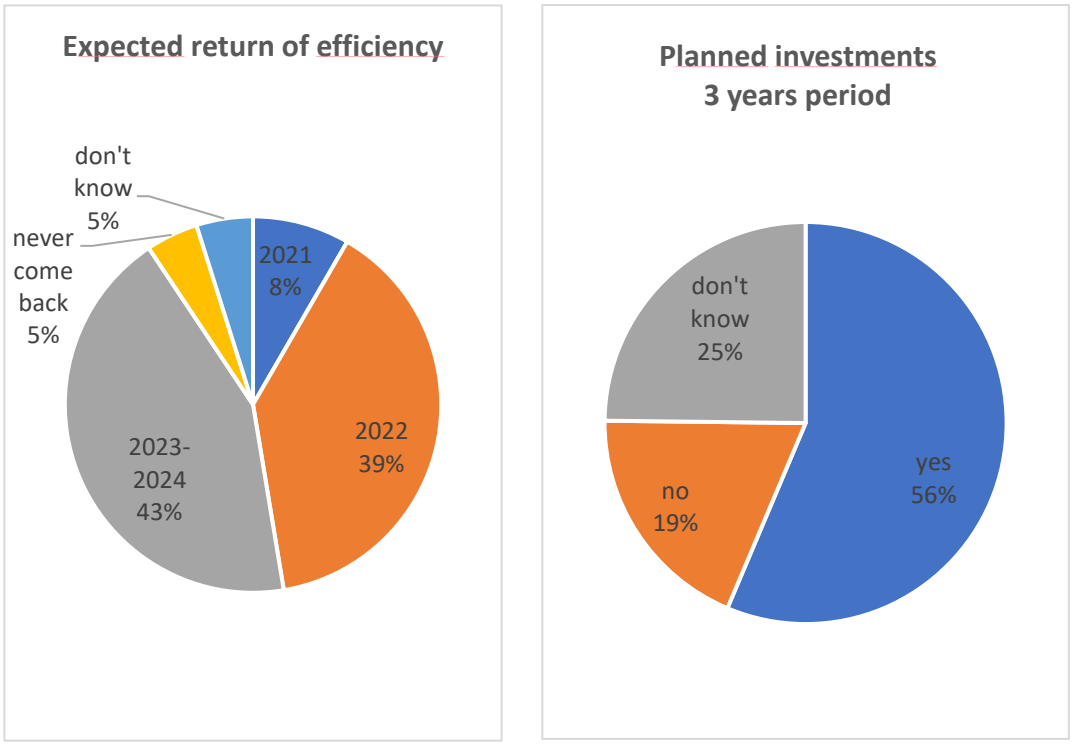

Fig. 8. Motobarometer 2021 www.exactsystems.com (Exact Systems, 2021)

5. CONCLUSIONS

From the beginning of serial production, we had so far trended to make supply chains just in time. Also, production had a very predictable schedule which gives the automotive branch gave manufacturers a sense of calm. Nowadays we were witnesses of the huge turnover into the availability of supplies, therefore, mentality become changing. Current times make the automotive market facing a new type of danger. Broken supply chains, higher prices do not allow easy follow the known path. All necessary actions undertaken to cover problems with supply chains as well as expenses for development will finally found reflected in the car price.

Hence we should consider an increase in cost connected with mobility in the future. The second point of view can be connected with different stories such as extensions of producers' agility.

The answer for more expensive cars can be the development of shared mobility. This is not a new concept. Currently, due to a fact that communication technologies are continuously developed there are many advantages for this solution. Many researchers and papers are focused on the optimization of functioning carsharing networks. Additional value for this issue can be the development of electric cars as well as autonomous vehicles. Using an electric car reduces to 0 exhaust emissions in place of driving. It is desirable especially in city centre's but also out of them. However electric cars create additional challenges. They required a well-developed net of chargers. Charging is requiring time so it can be an additional factor necessary to consider during urban mobility planning. Autonomous cars can also support shared mobility, but before we as a society need to face up with the law, ethical and regulation challenges connected with replacing humans with computers.

European automotive industry participants asked about close future are not aligned. Almost equally but with a small advantage of 2023/2024 than 2022 indicated possible efficiency come back after the coronavirus pandemic. Parallelly some companies will be growing due to the development of electric cars. But for those who are part of internal combustion engines vehicle supply chain members, it can be tough times. Most of the responders are agree that next year will consist of planned investments which means that changing situation in the market is rather common known knowledge. The described forecast fulfillment can be limited by factors not included in the study. The surveys indicate moods only from the European market. The situation on the automotive branch and the influence of mentioned trends are dynamic because all of the factors have to be compared with the geopolitical situation and be dependent on governments decisions. Each change in the law can interfere with a branch structure.

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