Navigating the Covid-19 Pandemic: a case study of challenges and opportunities for the automotive industry

Navegando na Pandemia da Covid-19: um estudo de caso de desafios e oportunidades para a indústria automotiva

Navegando la pandemia de Covid-19: un estudio de caso de desafíos y oportunidades para la industria automotriz

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Abstract
Without a doubt the Covid-19 pandemic has affected all industries, leaving people without jobs, production lines halted, loss of life and demand for vital goods and services not being met on time. Navigating through the problems that Covid-19 has caused, we will easily notice that one of the most affected industries was the car manufacturing industry. This paper will begin by presenting the overall impact that the Covid-19 pandemic has had on the global economy and will then focus on the case study exploring both the obstacles faced by the automotive sector and the potential benefits post-Covid-19. Specific challenges faced by the automotive industry were, production shutdowns caused by government measures, supply chain disruptions. We will explore how the automotive industry is overcoming these obstacles and can capitalize on new demands and trends to build a more resilient future. Examining the strategies companies have adopted during the Covid-19 era, the case study provides valuable insights for automakers looking to not only weather the storm, but also become stronger and more adaptable in the turbulent waters of the global economy.The end of the paper criticizes some measures that governments have taken to minimize the impact of the pandemic, demonstrating that locking people in their homes has caused far greater social, economic and resilience crises than it should have solved.

Keywords: Covid-19, Automotive Industry, Supply Chain Networks, Production Workforce, Consumer Behavior

Resumo
Sem dúvida, a pandemia da Covid-19 afetou todas as indústrias, deixando pessoas sem emprego, linhas de produção paralisadas, perda de vidas e demanda por bens e serviços vitais não sendo atendidas a tempo. Navegando pelos problemas que a Covid-19 causou, facilmente notaremos que uma das indústrias mais afetadas foi a indústria de fabricação de automóveis. Este artigo começará apresentando o impacto geral que a pandemia da Covid-19 teve na economia global e, em seguida, se concentrará no estudo de caso explorando os obstáculos enfrentados pelo setor automotivo e os benefícios potenciais pós-Covid-19. Os desafios específicos enfrentados pela indústria automotiva foram paralisações de produção causadas por medidas governamentais e interrupções na cadeia de suprimentos. Exploraremos como a indústria automotiva está superando esses obstáculos e pode capitalizar novas demandas e tendências para construir um futuro mais resiliente. Ao analisar as estratégias adotadas pelas empresas durante a era da Covid-19, o estudo de caso fornece insights valiosos para as montadoras que buscam não apenas resistir à tempestade, mas também se tornar mais fortes e adaptáveis nas águas turbulentas da economia global. O final do artigo critica algumas medidas que os governos tomaram para minimizar o impacto da pandemia, demonstrando que trancar as pessoas em suas casas causou crises sociais, econômicas e de resiliência muito maiores do que deveria ter resolvido.

Palavras-chave: Covid-19, Indústria Automotiva, Redes de Cadeia de Suprimentos, Força de Trabalho de Produção, Comportamento do Consumidor

Resumen
Sin duda, la pandemia de Covid-19 ha afectado a todas las industrias, dejando a personas sin empleo, líneas de producción paralizadas, pérdida de vidas y demanda de bienes y servicios vitales que no se satisfacen a tiempo. Navegando por los problemas que ha causado el Covid-19, fácilmente notaremos que una de las industrias más afectadas fue la de fabricación de automóviles. Este artículo comenzará presentando el impacto general que la pandemia de Covid-19 ha tenido en la economía global y luego se centrará en el estudio de caso que explora los obstáculos que enfrenta el sector automotriz y los beneficios potenciales post-Covid-19. Los desafíos específicos que enfrentó la industria automotriz fueron los cierres de producción causados por medidas gubernamentales y las interrupciones de la cadena de suministro. Exploraremos cómo la industria automotriz está superando estos obstáculos y puede capitalizar nuevas demandas y tendencias para construir un futuro más resiliente. Al analizar las estrategias adoptadas por las empresas durante la era Covid-19, el estudio de caso proporciona información valiosa para los fabricantes de automóviles que buscan no sólo capear la tormenta sino también volverse más fuertes y más adaptables en las turbulentas aguas de la economía global. El final del artículo critica algunas medidas que tomaron los gobiernos para minimizar el impacto de la pandemia, demostrando que encerrar a las personas en sus hogares provocó crisis sociales, económicas y de resiliencia mucho mayores de las que debería haber resuelto.

Palabras clave: Covid-19, industria automotriz, redes de cadena de suministro, fuerza laboral de producción, comportamiento del consumidor.

1. INTRODUCTION

The COVID-19 pandemic has left an indelible mark on global industries, reshaping economies, disrupting workforces, and halting production lines. Among the most profoundly impacted sectors is the automotive industry, which experienced significant operational and financial setbacks. First section of the paper delves into the myriad ways in which the pandemic has influenced the global economy, with a particular focus on the automotive sector. We begin by outlining the general effects of the pandemic, highlighting the extensive job losses, production disruptions, and the cascading challenges in meeting the demand for essential goods and services.

The automotive industry, characterized by its complex and interdependent supply chains, faced unique challenges including production halts enforced by governmental lockdowns and widespread supply chain disruptions. These obstacles not only stalled manufacturing but also exposed vulnerabilities within the sector's global operations framework.

In this context, our case study explores how automotive companies have navigated these turbulent times. We will examine the strategies that have allowed them to address immediate challenges and position themselves advantageously for a post-pandemic world, potentially benefiting from new demands and emerging market trends.

1.1. Overview of the automotive industry pre-COVID-19

Before the COVID-19 pandemic struck, the automotive industry was navigating through a phase of significant transformation and growth, influenced by evolving technologies, changing consumer preferences, and stringent environmental regulations (Kaitwade, 2021).

The automotive industry was one of the largest and most important economic sectors worldwide, generating billions in revenue and employing millions globally. Major markets like the United States, China, Germany, and Japan were at the forefront, not only in terms of production but also in technological advancements and market sales. The industry was highly cyclical, with sales and production closely tied to global economic conditions.

There was a significant push towards innovation, particularly in the areas of electric vehicles (EVs), autonomous driving technology, and connected car solutions. Companies were investing heavily in research and development (R&D) to pioneer technologies that could provide them with a competitive edge. The rise of EVs was spurred by environmental concerns and the tightening of emissions regulations across the globe, pushing automakers to reconsider their fuel-dependent portfolios (Krzywdzinski, 2020). Before pandemic, the automotive sector was characterized by a complex, interlinked global supply chain. Manufacturers sourced parts from multiple suppliers across different countries, optimizing costs and production efficiency. This globalization of the supply chain, while beneficial in terms of cost and efficiency, also made the industry vulnerable to disruptions in any part of the world (Mchopa, 2021).

In terms of envirnoment, regulatory pressures were increasing, with governments around the world imposing stricter emissions standards and safety regulations. This regulatory landscape forced automakers to innovate cleaner, safer vehicles and often resulted in increased production costs. (Talanquer, 2020).

In addition, consumer preferences were evolving, with an increasing demand for

technologically advanced, fuel-efficient, and environmentally friendly vehicles. The market saw a growing interest in SUVs and crossovers, at the expense of traditional sedans. Digital sales channels and personalized customer experiences were also becoming more important, reshaping how cars were sold (Hill, 2020).

Despite its strengths, the industry faced several challenges including overcapacity, high operational costs, and intense competition both from established players and new entrants like Tesla. The shifting geopolitical landscape, trade tensions (especially between the U.S. and China), and Brexit also posed significant risks to the stability and efficiency of the automotive supply chain (Barbieri, 2024).

In summary, the pre-pandemic automotive industry was marked by a delicate balance of robust growth prospects tempered by significant operational challenges and a rapidly changing technological landscape. This context set the stage for the industry's response to the unprecedented disruptions caused by the COVID-19 pandemic.

1.2. Initial impact of the pandemic on global industries

The initial impact of the COVID-19 pandemic on global industries was both immediate and severe, affecting nearly every sector across the world. The disruption was characterized by a sudden halt in operations, a collapse in consumer demand, and a profound shift in how businesses operated (Szczygielski, 2022).

The retail sector, particularly brick-and-mortar stores, was hit hard as non-essential businesses were forced to close temporarily. This led to a dramatic shift towards online shopping, which saw a surge in demand that many online platforms struggled initially to manage due to logistics and supply chain issues (Arain, 2021). Also travel restrictions, border closures, and the fear of spreading the virus led to an unprecedented collapse in the travel and tourism industry. Airlines, hotels, and travel-related services saw revenues plummet as cancellations soared and future bookings dried up (Škare, 2021).

While many sectors struggled, the technology industry experienced a dual impact. On one side, companies related to digital communications, remote work technologies, and e-commerce solutions saw increased demand. On the other side, companies reliant on hardware

production faced challenges similar to the manufacturing sector with disrupted supply chains and production delays (Scarlat, 2022).

The automotive industry saw immediate impacts from factory shutdowns, disruptions to parts supplies, and a sharp drop in consumer demand. Car dealerships closed, and vehicle sales fell drastically as economic uncertainty made consumers hesitant to make large purchases (Pató, 2020). All these challenges affected the financial sector that faced challenges with market volatility, increased demand for digital services, and the need to provision for bad loans due to the economic downturn. Central banks around the world took unprecedented steps to stabilize markets and support their economies (Al-Khawaja, 2023).

In terms of healthcare, all medical systems was overwhelmed with the immediate need to treat COVID-19 patients while also facing shortages of personal protective equipment (PPE), ventilators, and other critical supplies. Non-emergency procedures were postponed, and many health services were strained to their limits (Huang, 2024). Thus, the initial impact of the COVID-19 pandemic was a profound test of resilience across all industries. Businesses had to adapt quickly to unprecedented conditions, balancing immediate health concerns with economic survival. This period highlighted the importance of agility, digital readiness, and the ability to pivot operations in response to global crises.

The remainder of the paper critically assesses the broader governmental responses to the pandemic. It argues that some measures, particularly the extensive lockdowns, may have precipitated deeper social, economic, and structural crises than those they sought to mitigate. By analyzing these dynamics, the study aims to offer valuable insights for automakers striving not only to survive but to thrive in the uncertain waters of the global economic landscape post-COVID-19.

2. CHALLENGES FACED BY THE AUTOMOTIVE INDUSTRY DURING COVID-19

The entire automotive industry was hit hard by the COVID-19 pandemic, facing a multitude of challenges that disrupted its operations, supply chains, and market dynamics. Therefore, the initial impact of the COVID-19 pandemic was a profound test of resilience.

Businesses in this sector had to adapt quickly to unprecedented conditions, balancing immediate health concerns with economic survival (Mohammed, 2023).

2.1. Supply chain disruptions: Global dependencies

The automotive industry, well before the COVID-19 pandemic, had intricately woven a global network of supply chains that optimized costs and maximized production efficiency. However, this global dependency became a significant vulnerability when the pandemic struck, leading to widespread disruptions (Kaitwade, 2021).

The automotive supply chain is highly globalized, with car manufacturers sourcing parts from numerous suppliers located in different countries. For instance, a single car can contain parts sourced from multiple continents. This setup, while cost-effective under normal circumstances, is susceptible to disruptions from any single point within the network. When the pandemic led to lockdowns in major manufacturing hubs like China, South Korea, and later Europe and the Americas, the ripple effects were immediate and severe.

In this context, the vulnerabilities exposed by the pandemic have prompted many companies within the automotive industry to reassess and restructure their supply chain strategies. This includes diversifying supply sources, increasing inventory levels of critical components, and developing more flexible and resilient supply networks that can better withstand global disruptions (Mchopa, 2021).

As shown in this section, the COVID-19 pandemic highlighted the risks of global dependencies in the automotive industry's supply chain. The lessons learned from these disruptions are likely to drive significant changes in supply chain management practices, with an increased focus on resilience and risk mitigation. Automakers and suppliers are now more than ever aware of the need to balance cost efficiency with the security and flexibility of their supply networks (Rokicki, 2023).

2.2. Decrease in consumer demand and economic downturn

The COVID-19 pandemic precipitated a significant economic downturn, impacting consumer confidence and spending across many sectors, including the automotive industry.

This decline in consumer demand was influenced by multiple factors, each compounding the challenges faced by automakers during this period (Klein, 2021).

The sudden onset of the pandemic led to widespread economic instability. Governments around the world implemented lockdown measures to control the virus's spread, significantly impacting businesses and leading to job losses and reduced income for millions of consumers. The uncertainty about the future, coupled with reduced disposable income, made consumers hesitant to make significant financial commitments like purchasing new vehicles (Škare, 2021).

With the shift towards remote work and the reduction in social and commuting activities, the immediate need for new vehicles diminished. Consumers reprioritized their spending, focusing more on essentials and less on big-ticket items like cars. The fear of economic instability made long-term financial planning more cautious, directly affecting discretionary spending (Kähkönen, 2023).

Despite the decline in consumer demand was not uniform across all regions, it reflected the varying impacts of the pandemic and the strength of economic recovery efforts by different governments. Markets in Asia, for example, saw a quicker recovery in automotive sales compared to Western Europe and the United States, where recovery has been more protracted. But the pandemic has long-lasting effects on consumer behavior, leading to sustained changes in how and why people choose to purchase vehicles. Automakers needed to adapt to these changing dynamics, focusing more on flexibility, digital sales platforms, and the growing interest in environmentally friendly vehicles as consumer awareness of sustainability issues grows (Chervenkova, 2023).

2.3. Challenges in manufacturing and assembly operations

The COVID-19 pandemic brought unprecedented challenges to manufacturing and assembly operations in the automotive industry. These challenges not only disrupted the immediate production capabilities but also exposed the need for significant strategic adjustments in how automotive manufacturers operate (Chervenkova, 2023).

The main challenges in manufacturing was a result of restrictions. Since many manufacturing plants around the world were forced to shut down temporarily or operate at

reduced capacity to comply with governmental lockdown measures or due to outbreaks among workers. These shutdowns and delays had a ripple effect, causing significant backlogs, increased costs, and logistical complications in resuming full operations once restrictions were eased (Abbasi, 2023).

All these challenges collectively tested the resilience and adaptability of the automotive manufacturing and assembly operations, highlighting areas for future improvement and investment.

2.4. Regulatory and safety concerns during the pandemic

During the COVID-19 pandemic, the automotive industry faced a complex array of regulatory and safety concerns that affected both operations and compliance. These concerns impacted how companies managed their workforce, production processes, and overall business practices (Kapoor, 2024).

Automotive manufacturers had to quickly adapt to new health and safety regulations designed to prevent the spread of COVID-19 within their facilities.

This included:

- Implementing social distancing measures on production floors and in common areas;
- Requiring the use of personal protective equipment (PPE) such as masks and gloves;
- Increasing sanitation protocols, including the frequent cleaning of shared surfaces and the use of sanitizing stations;
- Conducting health screenings for employees at facility entry points, including temperature checks and health questionnaires (Abatan, 2024).

In addition to safety measures, there were regulatory changes related to the manufacturing processes. For example, companies had to consider modifications in their production practices to accommodate the new health guidelines without compromising the quality and safety of the vehicles produced. The pandemic also forced automotive companies to ensure that their suppliers adhered to similar health and safety standards. Ensuring compliance across the supply chain added another layer of complexity and required robust supply chain management systems.

The regulatory and safety concerns during the COVID-19 pandemic required automotive manufacturers to navigate a rapidly changing environment filled with new challenges. Addressing these concerns was critical not only to ensure compliance but also to protect employees, maintain production integrity, and manage legal and financial risks effectively (Abatan, 2024).

3. TECHNOLOGICAL ADAPTATIONS AND INNOVATIONS

3.1. Shift towards digital platforms for sales and customer engagement

During the COVID-19 pandemic, the automotive industry had to rapidly adapt to the changing landscape by embracing digital platforms for sales and customer engagement. This shift was driven by necessity as traditional sales methods became untenable due to lockdowns and social distancing measures (Hu, 2023).

Automakers and dealerships swiftly moved to online sales platforms to facilitate vehicle purchases. These platforms allowed customers to browse models, configure features, and even complete purchase transactions from the safety of their homes. Virtual showrooms and detailed online galleries enabled a near-physical shopping experience, catering to the needs of consumers who were unable to visit dealerships (Hu, 2023)

To simulate the in-person buying experience, automotive companies developed virtual showrooms. These digital environments used high-resolution images, videos, and interactive elements to give potential buyers a detailed view of vehicles. Some brands also offered virtual reality (VR) experiences, allowing customers to 'sit' in a car and explore its features in a virtual space (Bhatia, 2024). Additionally, augmented reality (AR) apps were developed to project virtual models of cars into real-world environments through customers' smartphones or tablets (Tantawi, 2023).

Customer service operations also shifted online, with automakers enhancing their chat services, video consultations, and online support options. AI-powered chatbots were integrated into websites and social media platforms to provide instant responses to customer inquiries, schedule service appointments, and even discuss financing options (Hu, 2023).

The sale of spare parts and accessories also moved online, with e-commerce platforms being either integrated into existing websites or developed as standalone offerings. This allowed customers to purchase parts directly from manufacturers or authorized dealers, ensuring quality and compatibility while also providing a convenient service option (Vazquez Hernandez, 2024).

Finally, the delivery and initial servicing of vehicles adapted to meet new health guidelines. Dealerships offered remote delivery services where new vehicles were delivered directly to customers' homes. Contactless pickup and drop-off services for maintenance and repairs became commonplace, ensuring that customer interaction remained minimal (Chervenkova, 2023).

Thus, the shift towards digital platforms for sales and customer engagement has not only helped the automotive industry navigate through the pandemic but has also set the stage for future developments. These innovations have improved the efficiency of the sales process, enhanced customer experience, and the potential for further digital integration in sales and services.

3.2. Acceleration of automation and robotics in manufacturing

The COVID-19 pandemic acted as a catalyst for accelerating the adoption of automation and robotics in the automotive manufacturing sector. As manufacturers faced the twin challenges of maintaining production amidst social distancing requirements and mitigating the risks of future disruptions, many turned to automation and robotics (Arain, 2021).

Although the initial investment in robotics and automation technology can be significant, these systems offer long-term savings by reducing labor costs, minimizing waste, and optimizing resource use. Over time, the return on investment from improved efficiency and higher product throughput can be substantial. The acceleration of automation and robotics in automotive manufacturing, spurred by the COVID-19 pandemic, is likely to continue as the benefits of these technologies become more evident. This trend not only supports immediate needs related to health and safety but also aligns with broader industry goals of enhancing efficiency, quality, and flexibility in the face of future challenges (Arman, 2024).

3.3. Implementation of AI and IoT for better supply chain management

As a result of pandemic, automation technologies were increasingly integrated with IoT (Internet of Things) devices and AI (Artificial Intelligence) to create smarter manufacturing environments (Mathew, 2023).

The implementation of Artificial Intelligence (AI) and the Internet of Things (IoT) in automotive supply chain management has been a significant trend, accelerated by the challenges presented by the COVID-19 pandemic. These technologies are transforming how automotive companies monitor, manage, and optimize their supply chains, providing critical advantages in a complex and fluctuating market environment (Mathew, 2023).

IoT devices enable real-time tracking of materials and components across the supply chain. Sensors and RFID tags are used to monitor the location and condition of goods as they move from suppliers to manufacturing plants and onto distribution centers. This real-time data helps companies manage inventory more effectively, reduce the risk of stockouts or overstock situations, and respond more swiftly to disruptions (Ali, 2023).

The implementation of AI and IoT in the automotive industry's supply chain management not only addresses the challenges brought about by the COVID-19 pandemic but also sets a foundation for more resilient, efficient, and responsive operations in the future. These technologies enable automakers to adapt more quickly to market changes and consumer demands, ensuring a competitive edge in a rapidly evolving industry (Jankovic-Zugic, 2023).

4. CASE STUDY ON CHALLENGES AND OPPORTUNITIES FOR THE AUTOMOTIVE INDUSTRY

A case study methodology was utilized to examine the effects of COVID-19 on the operational processes within the automotive industry and to assess the performance of companies during this time. In this context, an automotive company was carefully selected to ensure the collection of valid and reliable data.

The research began by formulating research questions and initial hypotheses derived from literature reviews that discussed the disruptions caused by the COVID-19 pandemic on manufacturing firms. Additionally, the study employed a case study research method.

Consequently, a leading global automobile manufacturer (Ford Motor Company) with

local production facilities in Romania was chosen for analysis as a case study. Access to involve the company's employees and managers in the research presented a key challenge. Furthermore, the research aimed to debate the broader impacts of the pandemic across various functions of the supply chain operations.

In line with previous studies, the following research hypothesis is developed:

RH1: The company's production and supply operations faced multiple disruptions including shortages of raw materials and spare parts, limited transportation, fluctuating labor availability, demand variability, and new health and safety mandates (Arain, 2021).

Shortage of raw materials and spare parts: Particularly noted was a shortage of semiconductors. Despite these challenges, the company managed to sustain its production standards due to its dominant market position (Vazquez Hernandez, 2024). Availability of transportation: The pandemic led to border closures significantly impacting logistics and transportation. This situation forced a shift from traditional logistics models to more flexible alternatives, leading to increased lead times for the company due to factors like border closures and a shortage of truck drivers.

Availability of labor: Health and safety measures, including social distancing, were implemented, affecting labor availability especially on the manufacturing floor where proximity among workers is common, contrasting with more isolated conditions for managerial staff.

Demand fluctuations: A significant increase in demand variability was reported by 84.48% of employees. Lockdowns led to reduced demand across various sectors including tourism and automotive, driven by raw material delays and governmental restrictions.

RH2: Safety protocols were not adequately maintained, particularly in manufacturing and logistics areas (Talanquer, 2020).

Safety concerns: About 70.27% of manufacturing and 73.80% of logistics staff reported difficulties in adhering to social distancing due to operational necessities, raising concerns over COVID-19 risks and impacting employee mental health. In contrast, managerial staff felt safer, benefiting from remote working conditions and reduced workplace density.

RH3: Challenges associated with remote working negatively correlated with the reliability and performance of operations (Kähkönen, 2023).

Remote work difficulties: Despite the adoption of remote working by higher-level staff, operational activities still heavily depended on physical labor. Around 77.08% of manufacturing floor employees faced challenges working from home, affected by partial remote working conditions and disruptions in work schedules, which hindered their ability to work effectively.

RH4: There is a positive relationship between operational readiness and the adoption of new technologies or solutions (Alzubi, 2023).

Technology implementation: The introduction of automated technologies helped mitigate productivity losses during the crisis, supporting the company's operational continuity. These findings illustrate how the company navigated complex challenges during the pandemic, identifying both strengths and areas needing improvement in its crisis response strategy.

5. METHODOLOGY

5.1 This research study was conducted across four distinct phases:

Phase 1: For this study a quantitative method represented by a questionnaire was utilized. In general terms, questionnaires offers the advantage of garnering detailed, free-flowing responses focused around a central objective. However, analyzing these responses can be complex, as linking them to specific research questions, hypotheses, or literature can be

challenging. Consequently, this format was deemed less suitable for this study.

The questions were generally open-ended, aligning with the study's objectives and research questions. Respondents were chosen based on their roles within the organization, such as production managers, supply chain managers, and directors, and their experience, specifically those with at least five years in their roles and who had managed operations during the COVID-19 pandemic.

This selection was intended to gather rich insights into the company's strategic risk mitigation measures in operations and organization. Ultimately, questionnaires were applied with the help of four managers, whose suitability was verified before applying the questionnaire, in order to ensure appropriateness for the study.

Phase 2: This phase involved the development of hypotesis and potential hypotheses related to the company's operations during the pandemic. The questionnaire was specifically designed for both employees and managers, considering the impacts of COVID-19 on operational activities. The selection of participants was based on standardized nonprobability sampling, aligning with the structured framework of the study. Purposeful sampling was initially used during data collection, targeting employees working in the case study companies who could provide firsthand insights into operational initiatives during the pandemic.

Phase 3: The exploration of descriptive analysis methods focused on comparing the measures the selected company had implemented to maintain operations during the pandemic, thus contributing new perspectives to existing theories.

Phase 4: This final phase analyzed and discussed the results, providing the case study with a conceptual framework and recommendations to enhance operational efficiency and strategies to mitigate future disruption risks.

6. STUDY RESULTS

The research study presented findings from a questionnaire conducted to evaluate hypotheses concerning disruptions in supply chain, logistics, and production systems during the COVID-19 pandemic. A key result confirmed how the examined company's supply chain and

production systems coped throughout the pandemic. This led to a focus on the company's vulnerabilities during COVID-19.

The principal findings from the hypothesis testing include:

Table 1
Hypothesis and results

Employee Training and Awareness:	About 85.06% of employees received training or briefings on COVID-19 precautions, while 14.94% were not informed. Managerial staff were generally more aware of these briefings than other employees.
Response to COVID-19	Approximately 81.03% of employees believed that the company responded swiftly to the pandemic, whereas 18.96% disagreed.
Impact on Working Hours	Changes in working hours were reported by employees, with 50.57% experiencing reductions, 19.54% seeing no significant change, and 29.89% noting increased hours.
Change in Job Responsibilities	Most employees (68.97%) saw no significant change in their job scope, 26.44% reported an increase in their tasks, and 4.60% experienced a reduction.
Implementation of New Technologies	The majority of employees acknowledged that the company introduced new technologies and solutions during the pandemic.
Sick Leave Rates	41.38% of employees took sick leave, with over half of the manufacturing floor staff affirming this.
Job Security Concerns	Significant concerns about job security were more prevalent among shop floor and warehouse staff, with 88.28% and 85.71%, respectively, expressing worries about losing their jobs.
Safety Concerns in Production Areas	A high percentage of shop floor (81.08%) and warehouse employees (78.57%) felt unsafe working in production areas, compared to 14.29% of managerial staff.
Social Distancing Challenges	Due to the nature of their work, 70.27% of shop floor and 73.80% of warehouse staff reported difficulties in maintaining social distancing.
Production Performance	There was a decrease in production performance, with 77.65% of employees noting a slight decrease and 20.7% observing a significant drop.
Stock Levels	During the pandemic, 66.28% of employees noted a slight increase in stock levels, while 22.09% reported no change.
Demand Fluctuations	Demand variability increased, with 84.48% of employees reporting an increase and 10.34% stating it remained stable.
Material Shortages	Raw material and spare part shortages were major disruptors, with 90.80% of employees acknowledging a decline in operational performance due to these shortages.

Transportation Restrictions	A significant 92.53% of employees reported that operations were impacted by transportation restrictions.
Labor Availability	Due to safety reasons such as sick leave, 92.53% of employees reported reduced labor availability.
Remote Work Adaptation	While a work-from-home policy was implemented, 45.40% of employees, mainly from manufacturing and logistics, did not work from home.
Remote Work Concerns	Among managerial employees, the primary concerns were the mental health of employees (36.73%) and lack of team communication (26.53%).
Cybersecurity Training	All managerial employees confirmed the implementation of new cybersecurity training modules to adapt to remote working conditions.
Hiring Freezes	A significant portion of managerial staff (90.48%) acknowledged a pause in hiring during the pandemic.
Preparedness	Only 61.90% of managers felt that the company was adequately prepared with risk management strategies before the pandemic.

The results from the questionnaire (Annex 1) shed light on the principal issues impacting the company's supply chain operations throughout the pandemic. The company faced substantial challenges from mid-March 2020 to late April 2021 due to the unforeseen scale and impact of the COVID-19 pandemic. Initially, both the industry and the company underestimated the virus, perceiving it as a localized issue that would primarily affect the Asian region. However, the spread of the virus escalated dramatically, affecting global operations. The empirical data reveals that the company had been engaged in both proactive and reactive risk management strategies in its supply and manufacturing operations. It is critical for the company to accurately detect and assess risks to avert future disruptions.

Yet, the company's just-in-time (JIT) operational model, characterized by minimal inventories and shortened lead times, poses challenges in proactive risk identification due to the inherently reactive nature of the industry. Consequently, identifying potential risks before they manifest is particularly challenging.

The various types of risks and disruptions experienced by the organization are categorized into several groups. These identified risk groups and their priorities are detailed in

Table 2. This categorization is essential for understanding how the company can better prepare and respond to similar challenges in the future.

Table 2
Risk groups and their priorities

Risk Priority	Risk Identification Group
High	Supply risk Demand risk Manufacturing risk Information risk
Medium	Transportation risk
Low	Financial risk

The classifications of risk previously identified are explained as follows:

Supply Risk: During the COVID-19 pandemic, shortages of raw materials and spare parts significantly disrupted production supply chains. Specific materials like steel, certain plastics, and semiconductors were in short supply, extending lead times and impacting manufacturing at the company's facilities. The company first noticed a semiconductor shortage in December 2020, realizing by early 2021 that this would affect operations for at least the next year. Despite these challenges, the company managed to mitigate most disruptions through meticulous management to maintain operational continuity.

Demand Risk: The company witnessed significant fluctuations in demand throughout the pandemic, creating planning challenges. Initially, there was a sharp decline in demand leading to temporary production halts. However, by May, demand began to recover, allowing operations to resume more quickly than anticipated.

Manufacturing Risk: The early stages of the pandemic saw high risks due to the potential for coronavirus transmission among employees, prompting production stops, especially among Chinese and other Asian suppliers. This disruption affected the availability of essential components for car manufacturing. The combined impact of reduced supply and demand led to decreased production volumes and elevated labor costs, despite reduced

resource utilization. The company prioritized maintaining a safe production environment in compliance with government and local health guidelines to minimize the risk of virus spread and ensure employee safety.

Data and Information Risk: Accurate information flow is critical, yet during the pandemic, disruptions were frequent, particularly in communication with tier 1 and tier 2 suppliers. This resulted in delays and occasional loss of information, posing risks to operations. Greater transparency and the adoption of Industry 4.8 technologies are seen as crucial for future risk mitigation and ensuring smoother operational flows.

Transportation Risk: The pandemic profoundly affected transportation, with government restrictions leading to closed borders and reduced shipping capacities. These challenges were exacerbated for industries reliant on just-in-time (JIT) delivery methods, where timing and accuracy are crucial. Transportation issues led to increased costs and required more stringent management of cross-border activities.

Financial Risk: Financially, the company faced risks from decreased sales and the wider impacts of supply and demand disruptions that began in early 2020 when COVID-19 became a global issue. Compounded by the semiconductor shortage, these challenges created production bottlenecks, limiting the company's production capacity and sales potential.

Table 3 details the prioritization of these risks along with recommended actions for improvement based on the identified issues.

Table 3
Prioritization of risks along with recommended actions

Identified Problems at the Organization during the COVID-19 Pandemic	Improvement Actions										
	Re-Design Supply Chain	Industry 4.0	Heathy and Safety	Risk Management	Automated Production	Forecasting and Monitoring	Employee's Well-Being	Sustainable Production	Trainings and Skills	Engagement	Communication
Concern of health and safety of employees	x	x	x	x	x		x		x	x	x
New COVID-19 regulations	x		x	x		x	x				x
Shortage of raw materials and spare parts	x			x		x					x
Unavailability of transportation	x			x		x					x
Unavailability of workforce	x	x		x	x	x		x	x		x
Halted production	x	x		x	x	x		x	x		x
Semi-automated production	x	x		x	x	x		x	x		x
Demand fluctuations	x			x		x					x
Limitation of remote work		x	x	x			x		x	x	x
Well-being of employees			x				x		x	x	x
Lack of risk management policy				x		x					x
Lack of new technology infrastructure	x	x		x	x	x		x	x		x

The mitigation of these risks varied based on their assessment and the specific impacts on the company. Addressing these challenges requires ongoing improvement and strategic planning to prevent future disruptions.

7. CONCLUSIONS

The COVID-19 pandemic has imparted several crucial lessons and strategic insights for the automotive industry, particularly in how companies can enhance resilience and adaptability in the face of significant disruptions.

The pandemic underscored the vulnerability of rigid, just-in-time (JIT) supply chains. The automotive industry learned the importance of having flexible, adaptable supply chain strategies that can adjust to unexpected disruptions like raw material shortages or transportation delays. Strategies such as diversifying supply sources, increasing stock of critical components, and developing relationships with multiple suppliers in different regions can mitigate the risks associated with over-reliance on single-source suppliers.

Demand fluctuations during the pandemic highlighted the need for better forecasting and demand management tools. Automotive companies must invest in advanced analytics and market research to better predict customer behavior and adjust production accordingly. This not

only prevents overproduction and resource wastage but also ensures that companies can swiftly respond to changes in consumer demand.

The transition to remote work during the pandemic was challenging, especially for an industry that relies heavily on physical operations. The experience has shown the need for better technological infrastructure to support remote work, including cybersecurity measures and digital communication tools that facilitate collaboration and maintain operational continuity. Furthermore, digitalization of processes, from design and testing to sales and customer service, can create more resilient business models.

The lessons learned from navigating the challenges of the COVID-19 pandemic provide strategic insights that can guide the automotive industry in strengthening its resilience against future disruptions. Embracing flexibility, enhancing digital capabilities, prioritizing health and safety, and investing in sustainable practices are just a few strategic moves that can help automotive companies thrive in an increasingly uncertain global landscape.

The impact of the virus on the industry has underscored the critical need for new digital business models and transformation strategies that should be implemented across all levels of management and staff post-COVID.

On another note, the research identifies new challenges that necessitate a redesign of existing automotive supply chains to enhance sustainability in business operations. These insights are crucial for planning future operational adaptations in response to manufacturing companies' supply chain operations. Automakers and suppliers are urged to reconsider their supply chain risk models, from the procurement of raw materials to the production of final products, to safeguard their market positions, manage supply chain disruptions, and protect their workforce.

The limits of the research consist in the fact that the questionnaire was conducted only on the employees of a single company (Ford Otosan Craiova). Future research will focus on getting more data from different companies, from different continents in order to obtain a macro-level overview of the impact of Covid-19.

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