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An Empirical Investigation of the Impact of Data-Driven Decision -Making on Supply Chain Resilience in the Automotive Industry

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Abstract- The empirical investigation of supply chain risk management techniques is the aim of this paper. The analysis is predicated on a survey that was undertaken in the German automobile sector involving 67 manufacturing facilities. The study identifies supply chain risks by evaluating their probability of occurrence and possible effects on the supply chain after looking into the susceptibility of supply chains generally and major drivers of supply chain risks. The outcomes are displayed in a probability-impact matrix that differentiates supply chain hazards from external sources. Additionally, tools for managing supply chain risks are looked into. As a result, the effect of performance-enhancing supply chain risk management is evaluated. The plants are categorized using a cluster analysis based on parameters indicating the instruments of supply chain risk management in order to differentiate between businesses with a high degree of implementation and those with none or very limited use.

Keywords— Empirical Investigation, Supply Chain Risk Management Techniques, Resilience in the Automotive Industry, Impact of Data-Driven Decision –Making.

1. Introduction

Manufacturing businesses must successfully manage their supply chains in an environment of high complexity and uncertainty in order to boost productivity and responsiveness. Events like Hurricane Katrina, the tsunami in 2004, and 9/11 have brought this topic to light. However, regular issues like supplier losses or poor quality also highlight the significance of supply chain risk management. It attempts to mitigate specific risks within supply chains and lessens the adverse effects of outside disruptions. The automotive sector in particular is renowned for its efforts to enhance its supply chains in response to the challenging business environment. The goal of supply chain management has been to increase cost-efficiency since the 1990s (Lee, 2004). Additionally, businesses actively employ strategies for streamlining supply chain procedures in an effort to satisfy the demands of the competition (Childerhouse et al., 2003). For instance, this is applied in the automobile sector to establish lean supply chains through commonly used ideas like just-in-time and just-in-sequence (Svensson, 2004; Thun et al., 2007). The movement toward lean supply chains reduces inventories through close coordination with suppliers and customers, but it also increases vulnerability because disruptions in the supply

chain are rarely made up for without safety stockpiles. The tendency toward outsourcing, which increases network complexity and creates new interconnections, is another factor contributing to rising supply chain risks (Jüttner et al., 2003). A network's susceptibility increases with its complexity because there are more interfaces (Peck, 2005). Similar to this, supply chain risks rise as a result of globalization since factors like exchange rate, cultural, and transportation hazards become more significant (Berry, 2004). Many papers (e.g. Chopra and Sodhi, 2004) discuss how external events affect supply chains and the enterprises that are a part of them. Land Rover was only able to prevent the loss of 1500 jobs and a nine-month production disruption by expending a great deal of goodwill. The case of German component supplier Robert Bosch, which began supplying its customers with faulty high-pressure pumps for diesel fuel injection systems in early 2005, is another illustrative example of damage amounting to millions of dollars. However, the entire supply chain was impacted because Bosch's subcontractor was responsible for this error. These illustrations demonstrate how a company's dependence and integration within the supply chain give rise to new risks. However, less dramatic events are not the only things that can disrupt supply chains; everyday issues can also have an impact. Similar disruptions are frequently caused by risks pertaining to suppliers, customers, infrastructure, and networks. A well-known network risk is the Bullwhip-effect, a phenomenon that describes how inventory increases as one moves up the value chain (Lee et al., 1997). Supply chain disruptions can result in monetary losses, a damaged reputation or corporate image, which can eventually lead to a decline in demand as well as security and health risks (Jüttner et al., 2003). It is reasonable to assume that a supply chain's performance will suffer as a result of these risks and the resulting effects they carry. While it is not possible or reasonable to make general statements about the financial losses incurred by affected companies and industries due to supply chain disruptions, there are examples of companies that have estimated their daily losses to be between $50 and $100 million, which clearly illustrates the significance of such negative incidents (Rice and Caniato, 2003). The current developments collectively emphasize how important it is to manage risks within a supply chain. Despite the increased focus on supply chain risk management in academia in recent years (Jüttner, 2005), there is still a dearth of research on this topic. In order to analyze the primary supply chain risks and look into tools for an efficient supply chain risk management, empirical research is needed in the field of supply chain risk management. This paper's primary goal is to examine the current state of supply chain risk management in Germany using data from an automotive industry study. The goal is to specifically look into the significance of various risks in relation to the likelihood that they will materialize and the possible effects they may have on the supply chain.

2. Literature Review

The identification, analysis, and control of risks are the components of risk management as a whole. One of the primary differences between Supply Chain Risk Management (SCRM) and traditional risk management is that SCRM is characterized by a cross-company orientation that focuses on entire supply chains rather than just individual companies in order to identify and reduce risks. However, risk management is still largely viewed as a task that is specific to a company in many industries. But as Juttner (2005, p. 131) ¨ notes, "Companies implement organization specific risk management, but there is little evidence of risk management at the supply chain level," risk management is still largely understood as a company-specific task in many industries. According to Tang (2006), additional research indicates that a small proportion of businesses have adopted sufficient risk management techniques, despite their awareness of the potential ramifications for their supply chain. In order to create safe and resilient supply chains, businesses appear to have a lot of catching up to do when it comes to putting instruments for risk identification, analysis, and control into place. An incident's effect on a supply chain is contingent upon both the specifics of the incident and the supply chain's architecture. The latter speaks about a supply chain's vulnerability. Vulnerability is described as "an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain" by Christopher and Peck (2004, p. 3). Supply chain risk management, defined as "the identification and management of risks for the supply chain, through a coordinated approach among supply chain members, to reduce supply chain vulnerability as a whole," aims to mitigate and control vulnerability (Juttner et al., 2003, p. 201). The many risks present in a supply chain present a unique challenge for supply chain risk management. Determining the significance of a specific risk for a supply chain is a crucial component. Survey research papers address the risk associated with the supply chain. Global sourcing and lean manufacturing are discussed by

Atkinson (2006) in relation to supply chain risk management. According to a purchasing executives' survey, only 50% of participants said they frequently monitor supply chain risks. The study also shows that the only department with a broad perspective to handle risks along the entire supply chain is the risk management department. Blackhurst et al. (2005) carried out an empirical analysis of supply-chain disruptions and global sourcing across a number of industries. Critical issues for resilient supply-chain design and disturbance analysis and mitigation were identified. Based on an empirical study, Craighead et al. (2007) assess various types of supply chain disruptions. In addition to design features, they look into the capabilities of warning and recovery in supply chain risk management. Hendricks and Singhal (2005) examine the impact of supply chain disruptions on stock prices and equity risks using a sample of 827 disruption announcements. They come to the conclusion that businesses take time to recover from the damaging effects of disruptions. According to Juttner ¨(2005), an exploratory quantitative survey and qualitative group discussions with supply chain managers revealed that 44% of the responding companies anticipate an increase in supply chain vulnerability within the ensuing quintal. Despite the fact that the data makes it abundantly evident that supply chains need to address risk issues, some contend that the idea of supply chain risk management is still in its infancy.

An analysis of a data set on accidents in the US chemical industry is conducted by Kleindorfer and Saad (2005). They draw conclusions about the design of supply chain risk management based on empirical findings. This concise review of the literature includes a few articles on supply chain risk management, but it also makes it evident that more academic work needs to be done in the area of survey-based research (Wagner and Bode, 2006 being an exception).

3. Supply Chain Hypotheses

(i) Vulnerability of supply chains- Despite the fact that many businesses are aware of the potential risks to their supply chain, managers frequently neglect to use the right tools for supply chain risk management (Tang, 2006). The fact that some risks are eventually overestimated in terms of their likelihood or supply chain impact could be one explanation for ignoring these tools. Another explanation could be that managers are merely ignorant of the relevant tools and disregard them as a result. Lastly, the application of suitable instruments may be hampered by the challenge of quantifying the advantages of supply chain risk hedging. Frequently, the issue stems from the financial validation of tools used in supply chain risk management to avert disruptions or disturbances (Zsidisin et al., 2000).

(ii) Drivers of supply chain risks- Companies have been compelled by certain developments to alter their business practices in order to preserve the competitiveness of their supply chain. In order to meet customer demand, businesses must, on the one hand, provide a wide variety of products or variants, which increases vulnerability because of increased complexity (Harland et al., 2003). Moreover, businesses can no longer afford to concentrate on regional markets. They are compelled to acknowledge the possibilities of worldwide markets concerning suppliers and consumers, leading to an exceedingly intricate supply chain. Supply chains are now more susceptible to disruptions as a result of the close relationships and high level of interconnectedness among businesses within complex networks (Zsisidin et al., 2005).

(iii) Supply chain risks- The following discusses supply chain vulnerability drivers using a framework developed by Christopher and Peck (2004), who differentiate between supply chain risks that are internal and external. It is possible to distinguish between internal company risks and cross-company-based risks with regard to internal supply chain risks. Internal business risks include interruptions brought on by issues that arise inside the company's organizational boundaries, like IT issues or machine failures. A company may have direct control over these risks (Rice and Caniato, 2003). One can differentiate between purchasing risks and demand risks in the context of cross-company-based supply chain risks.

(iv) Instruments of supply chain risk management- Supply chain risk management tools can be divided into two categories: proactive tools and reactive tools. (Note that although both proactive and reactive instruments are induced ex ante, only proactive instruments demonstrate their impact prior to the occurrence of an incident, whereas reactive instruments can only demonstrate their impact after an incident has already occurred.) Measurements related to causes that aim to reduce the likelihood of risk occurrence are known as preventive instruments. Examples of avoiding risk include concentrating on goods that have steady demand and

few variations or concentrating on safe markets. Furthermore, by placing production facilities in secure areas, one can geographically avoid some risks, such as natural disasters.

4. Design And Analysis Of The Research

(i) Design-It makes sense to focus on a single industry because of the variations that exist among them. In this study, the German automotive industry is our main focus. This industry fits the bill because of its strong emphasis on supply chain complexity and close collaboration. Appendix A displays the structural data of the sample, which indicates that the vast majority of participating companies are first tier suppliers. The analysis's goal is to provide practitioner-level insights into the subject of supply chain risk management through an empirical investigation of the issues that have been discussed. 185 surveys have been distributed, and 204 businesses have been contacted for this study. 67 companies' worth of data are included in the final database. Managers in charge of logistics or supply chain management are selected as possible survey respondents because they are thought to be the most knowledgeable in providing the needed information regarding supply chain risk management. Five-point Likert scales, from "strongly disagree" to "strongly agree," are used to measure the questions used in this analysis (the questions are shown in this). The database includes several items about common supply chain risks, tools, and metrics for the plants' competitive performance. The following describes how the supply chain risk management items are used to create factors that present a statistical construct for the specific subject matter.

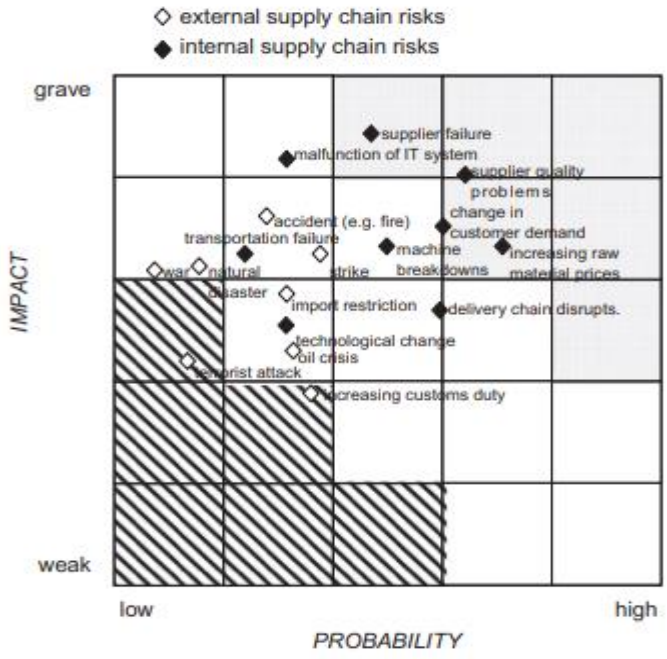

Fig 1: Supply chain risks

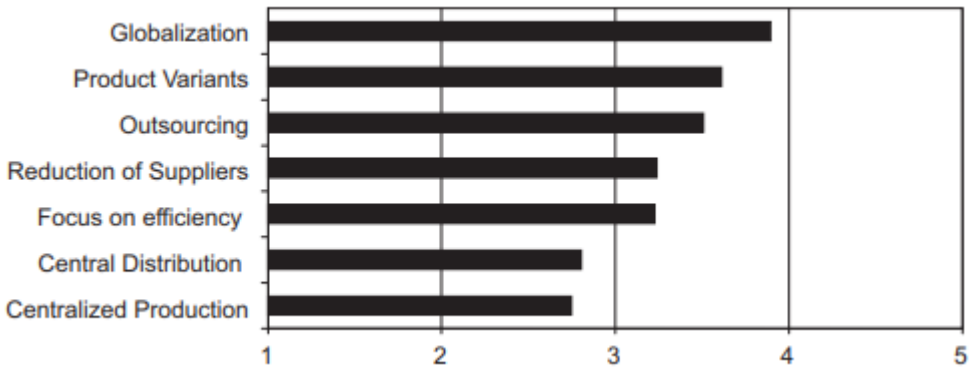

Fig 2: Drivers of supply chain risks

(ii) Analysis-The primary risk factors and supply chain vulnerability estimates will be looked at before standard supply chain risks and the tools of supply chain risk management are analyzed. Regarding the latter, the respondents are questioned about how vulnerable they believe their supply chain to be. On a five-point Likert scale, all respondents' average score is 3.19. Nearly 40% of the businesses believe they are extremely vulnerable (likert scale points 4 or 5). Only one in four managers (points 1 or 2 on the Likert scale) believe that their supply chain is little or no susceptible to disruptions. All things considered, it can be said that the vast majority of managers (nearly 75%) do not believe their supply chain to be highly vulnerable. As a result, hypothesis H11 cannot be disproven. In addition, the managers are asked to estimate the major developments influencing supply chain risks. Figure 2 presents the findings. The need to offer a wide variety of product options and the trend towards globalizing supply chains are the two factors with the highest mean values, as the figure illustrates. Therefore, it is imperative to consider factors that contribute to supply chain complexity as primary causes of supply chain risks. Supply chain drivers include, however, methods for creating a lean supply chain, such as outsourcing, cutting suppliers, or emphasizing efficiency. To provide empirical evidence regarding potential risks that a company may encounter, the different risks are represented using a "probability/impact" matrix. Regarding likelihood of occurrence and effect on the supply chain, the risks can be compared. Moreover, the risks that are most important can be determined. The "probability/impact"-matrix results for both internal and external supply chain risks are displayed in Figure 1 and 2.

$H_1$1. Supply chains are regarded as being susceptible in terms of supply chain risks.

$H_1$2. Complexity and efficiency are key drivers for supply chain risks.

$H_1$3a. Internal supply chain risks have a higher likelihood to occur than external supply chain risks.

$H_1$3b. External supply chain risks have a greater impact on the supply chain than internal supply chain risks.

$H_1$4a. Companies with a high degree of supply chain risk management show a higher performance than companies with a low degree.

$H_1$4b. There is a difference between companies using preventive instruments contrary to those using reactive instruments in terms of performance criteria.

There are clear variations in terms of supply chain risks, as the figure shows. Problems with supplier quality must be considered the most serious risk because they have a high probability and a significant impact. While less common, supplier failure and IT system malfunction are regarded as serious issues.

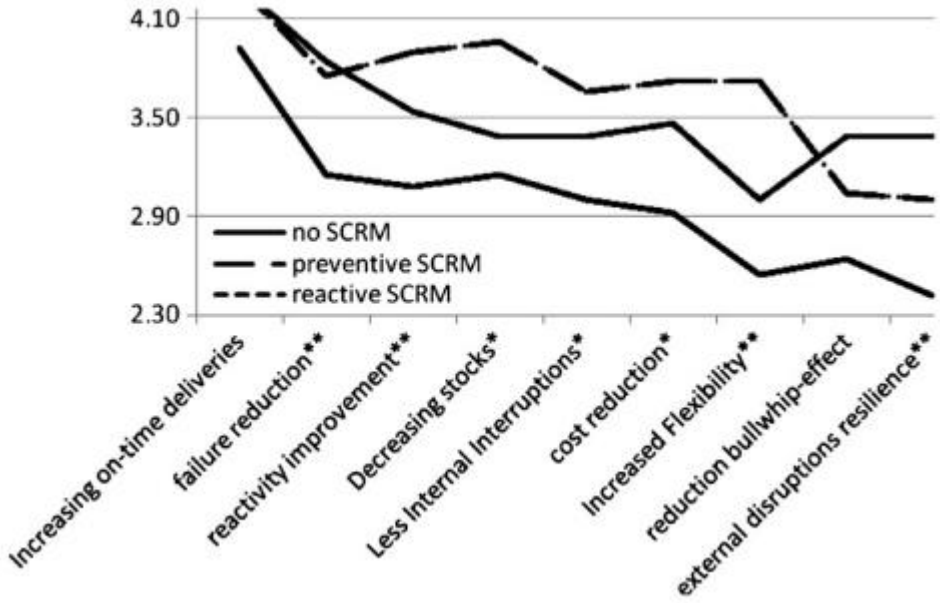

Fig 3: Supply chain performance measures

The highest probability values are noted for rising raw material costs, shifting consumer demand, and disruptions to the delivery chain. The results of a T-test comparing the risks associated with the external and

internal supply chains indicate that, at a high significance level ($p<0.05$), the latter have higher average values for probability. Rejecting hypothesis H13a is not possible. As internal supply chain risks have higher values at a very high significance level ($p<0.05$), the opposite is actually true. Thus, the hypothesis H13b is not accepted. The tools for supply chain risk management will be examined in the sections that follow. Factor analysis and cluster analysis are the tools used for this. First, a factor analysis is used to compile the items related to the supply chain risk management tools. The factors' explained variance and eigen values are examined for validity. Every factor has an Eigen value that is higher than the cutoff of 1.0, and 450% of the variance in the factors can be explained. Furthermore, each factor loading is >0.4.

5. Conclusion

According to the empirical analysis, supply chains are typically thought of as being vulnerable. According to the literature, one possible explanation could be the relatively low degree of implementation of supply chain risk management instruments (Juttner, 2005; Tang, 2006). Moreover, the main developments driving supply chain risks and, consequently, raising supply chain vulnerability are factors increasing complexity, such as globalization and product variants, and factors increasing efficiency, such as outsourcing or supplier reduction. Because of the potential for resulting dependencies to create risks on both the supply and demand sides, globalization increases the risk associated with the supply chain. Furthermore, because they raise supply chain uncertainty, a lot of product variants increase supply chain risks. Outsourcing increases the number of interfaces and dependencies between businesses, which increases the supply network's vulnerability in terms of efficiency. One way to improve supplier relationships is by reducing the amount of suppliers further; however, this can also result in dependency. In addition, as a result of cross-border linkages, the ongoing trend towards off shoring will make supply relationships more intricate and prone to errors, making supply chains more vulnerable. Apart from the previously mentioned drivers, an examination is conducted into the associated supply chain risks. According to the analysis, various risks that could endanger supply chains are rated according to how they would affect the chain and how likely it is that they will occur. The findings show that risks associated with the internal supply chain are thought to be more likely to arise and to have a bigger effect on the chain. The fact that managers implicitly reevaluate the impact based on its expectation value may have an impact on the latter result since they tend to estimate the impact of incidents with a higher likelihood stronger. Nonetheless, the findings suggest that the majority of the risks that supply chains face originate from within the chain.

References

[1]. F.R.P.d. Lima, A.L. Da Silva, M. Godinho Filho, E.M. Dias, Systematic review: Resilience enablers to combat counterfeit medicines, Supply Chain Management: An International Journal (2018).

[2]. D.-W. Kwak, Y.-J. Seo, R. Mason, Investigating the relationship between supply chain innovation, risk management capabilities and competitive advantage in global supply chains, International Journal of Operations & Production Management, 38 (1) (2018), pp. 2-21.

[3]. Pfahl L, Moxham C. Achieving sustained competitive advantage by integrating ecr, rfid and visibility in retail supply chains: a conceptual framework. Prod Plan Control. 2014; 25(7):548–571.

[4]. Tajima M. Strategic value of rfid in supply chain management. J Purch Supply Manag. 2007; 13(4):261–273.

[5]. Hellinger A, Seeger H. Cyber-physical systems. driving force for innovation in mobility, health, energy and production. Berlin: Springer-Verlag Berlin Heidelberg; 2011.

[6]. Rawat DB, Doku R, Garuba M. Cybersecurity in big data era: From securing big data to data-driven security. IEEE Trans Serv Comput. 2019.

[7]. Rozenfeld H, Fernando A, Amaral DC, Toledo JC, da Silva SL, Alliprandini DH, Scalice RK. Gestão de projetos em desenvolvimento de produtos. Uma referência para a melhoria do processo. São Paulo: Saraiva; 2006.

[8]. Stamatis DH. Advanced product quality planning: the road to success. Florida: CRC Press; 2018.

[9]. Thisse L. Advanced quality planning: A guide for any organization. Qual Prog. 1998; 31(2):73–77.

[10]. Teresko J. The new race. Ind Week/IW. 1998; 247(18):40–44.

[11]. Burns K, Marx T. Crisis management planning among tier 2 automobile suppliers: Why suppliers fail to plan. J Conting Crisis Manag. 2014; 22(2):108–112.
[12]. Narayanamurthy G, Tortorella G. Impact of covid-19 outbreak on employee performance–moderating role of industry 4.0 base technologies. Int J Prod Econ. 2021; 234:108075.
[13]. Belhadi A, Kamble S, Jabbour C, Gunasekaran A, Ndubisi N, Venkatesh M. Manufacturing and service supply chain resilience to the covid-19 outbreak: Lessons learned from the automobile and airline industries. Technol Forecast Soc Chang. 2021; 163:120447.
[14]. Ivanov D, Dolgui A. A digital supply chain twin for managing the disruption risks and resilience in the era of industry 4.0. Prod Plan Control. 2021; 32(9):775–778.
[15]. Choi T, Rogers D, Vakil B. Coronavirus is a wake-up call for supply chain management. Harv Bus Rev. 2020; 27:364–398.
[16]. Brettel M, Friederichsen N, Keller M, Rosenberg M. How virtualization, decentralization and network building change the manufacturing landscape: an industry 4.0 perspective. Intl J Inform Commun Eng. 2014; 8(1):37–44.
[17]. Kagermann H, Helbig J, Hellinger A, Wahlster W. Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0: Securing the Future of German Manufacturing Industry; Final Report of the Industrie 4.0 Working Group. German: Forschungsunion; 2013.
[18]. Wang L, Törngren M, Onori M. Current status and advancement of cyber-physical systems in manufacturing. J Manuf Syst. 2015; 37:517–527.
[19]. Wang L, Wang G. Big data in cyber-physical systems, digital manufacturing and industry 4.0. Int J Eng Manuf (IJEM). 2016; 6(4):1–8.
[20]. Salkin C, Oner M, Ustundag A, Cevikcan E. A conceptual framework for industry 4.0. In: Industry 4.0: Managing the Digital Transformation. Cham, Switzerland: Springer: 2018. p. 3–23.
[21]. Rajput S, Singh S. Industry 4.0- challenges to implement circular economy. Benchmark An Int J. 2019; 28(5):1717–1739.
[22]. Mubarik M, Naghavi N, Mubarik M, Kusi-Sarpong S, Khan S, Zaman I, Kazmi S. Resilience and cleaner production in industry 4.0: Role of supply chain mapping and visibility. J Clean Prod. 2021; 292:126058.
[23]. Ivanov D, Dolgui A, Sokolov B, Ivanova M. Literature review on disruption recovery in the supply chain. Int J Prod Res. 2017; 55(20):6158–6174.
[24]. Hendry L, Stevenson M, MacBryde J, Ball P, Sayed M, Liu L. Local food supply chain resilience to constitutional change: the brexit effect. Int J Oper Prod Manag. 2019; 39(3):429–453.
[25]. Puga FP, Castro LBd. Visão 2035: Brasil, país desenvolvido: agendas setoriais para alcance da meta. Rio de Janeiro: Banco Nacional de Desenvolvimento Econômico e Social; 2018.
[26]. Gopal P, Thakkar J. Sustainable supply chain practices: an empirical investigation on indian automobile industry. Prod Plan Control. 2016; 27(1):49–64.
[27]. Philip SV. U.K. Car Industry Joins European Jobs Wipeout to Battle Slump. 2020.
[28]. Cao X. Covid-19: immunopathology and its implications for therapy. Nat Rev Immunol. 2020; 20(5):269–270.