"Which supply chain adaptations in the manufacturing industry are required moving forward in the face of uncertain market conditions?"

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Abstract

In this research, the transformation and adaptability of supply chains within the manufacturing sector amidst volatile market conditions are meticulously examined. Utilizing an exploratory methodology, secondary data sources facilitated a qualitative appraisal of the supply chain management of three automotive entities, contextualized against the backdrop of the unprecedented disruption from the Covid-19 pandemic. Drawing upon the Resource-Based View and Transaction Cost Theory, the supply chain management practices of these automotive enterprises were scrutinized. The findings underscore that, given the escalating unpredictability of the global landscape, there's a pronounced propensity for companies to gravitate towards greater internalization in production and exerting dominance over pivotal supply chain segments, such as battery cell production. Vertical integration emerges as a strategic alternative against potential upheavals, bestowing upon manufacturers a modicum of steadiness in an otherwise capricious environment. The trajectory towards heightened vertical integration is anticipated to not only persist but intensify in the ensuing era. This research proffers invaluable perspectives for supply chain management within the manufacturing realm, aiming to adeptly steer and adapt to the evolving contours of the sector.

Title: *"Which supply chain adaptations in the manufacturing industry are required moving forward in the face of uncertain market conditions?"*

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Key words: *supply chain management, RBV, TCT, vertical integration, automotive*

Resumo

Nesta pesquisa, a transformação e a adaptabilidade das cadeias de suprimentos no setor de manufatura em meio a condições de mercado voláteis são examinadas meticulosamente. Utilizando uma metodologia exploratória, fontes de dados secundários facilitaram uma avaliação qualitativa da gestão da cadeia de abastecimento de três entidades do sector automóvel, contextualizada no contexto da perturbação sem precedentes da pandemia de Covid-19. Com base na visão baseada nos recursos e na teoria dos custos de transação, foram analisadas as práticas de gestão da cadeia de abastecimento destas empresas do sector automóvel. As conclusões sublinham que, dada a crescente imprevisibilidade do panorama global, existe uma propensão acentuada para as empresas gravitarem em direção a uma maior internalização da produção e exercerem domínio sobre segmentos fundamentais da cadeia de abastecimento, como a produção de células de bateria. A integração vertical surge como uma alternativa estratégica contra potenciais convulsões, conferindo aos fabricantes um mínimo de

estabilidade num ambiente caprichoso. Prevê-se que a trajetória em direção a uma maior integração vertical não só persista como se intensifique na era que se segue. Esta investigação oferece perspectivas valiosas para a gestão da cadeia de abastecimento no domínio da indústria transformadora, com o objetivo de orientar e adaptar-se habilmente aos contornos em evolução do sector.

Título: "Que adaptações da cadeia de abastecimento na indústria transformadora são necessárias para avançar face a condições de mercado incertas?"

Autor: Paul Hauschild

Palavras-chave: gestão da cadeia de abastecimento, RBV, TCT, integração vertical, sector automóvel

Content

List of Figures

Abbreviations

CEO	Chief executive Officer
EVs	Electric Vehicles
GVCs	Global Value Chains
IOT	Internet of Things
M.Sc.	Master of Science
MNCs	Multinational corporation
MOU	Memorandum of understanding
OEM	Original Equipment Manufacturer
R&D	Research and Development
RBV	Resource-Bases View
SC	Supply chain
SCM	Supply chain management
SCN	Supply chain network
SMEs	Small and medium-sized enterprise
TCE	Transaction Cost Economics
TCT	Transaction Cost Theory
US	United States
VRIN	Valuable, rare, inimitable, non-substitutable
VW	Volkswagen

1. Introduction

The impact of uncertain market conditions on supply chains (SCs) in the manufacturing industry has been well documented in the literature (Ivanov & Dolgui, 2020). Disruptions to SCs can result in significant financial losses, missed production targets, and damage to a firm's reputation (Carter & Rogers, 2008). However, the recent Covid-19 pandemic has brought unprecedented uncertainty to the manufacturing industry, with far-reaching effects on global supply chains. The pandemic has highlighted the need for firms to be agile and adaptable to effectively navigate and respond to changing market conditions (Wellener et al., 2022).

This study aims to provide an in-depth analysis of the strategic change in SCs in the manufacturing industry derived from the example of the automotive industry. As one of the most critical sectors of the manufacturing industry, with a complex supply chain network (SCN) that spans multiple countries and continents (Gereffi et al., 2005), the automotive industry has been heavily impacted by the Covid-19 pandemic, with many firms facing significant supply chain disruptions (Alicke et al., 2022). Therefore, this study focuses on the SCs of three automotive companies to analyze the strategic change and adaptation that occurred in uncertain market conditions triggered by the Covid-19 pandemic.

The reader can expect an analysis comparing the strategic change of SCs before the pandemic with the strategic changes made in response to the pandemic. The automotive industry is selected for this study due to its complex SCN and the significant impact of the pandemic on this industry.

The goals of this study are threefold:

1. It aims to analyze the strategic change and adaptation of supply chains in the automotive industry in uncertain market conditions.
2. It aims to provide insights into supply chain management that will help to effectively navigate and respond to changing market conditions.
3. It aims to provide a basis for future research on the strategic orientation of supply chains in the manufacturing industry, with implications for other industries.

1.1 Research topic

This exploration intends to juxtapose the supply chain tactics employed by three automotive manufacturers - Tesla, Volkswagen, and Ford – pre- and post Covid-19. Presented in a case study format, the analysis focusses on discerning alterations in their strategic maneuvers in the wake of the pandemic to accommodate the newly uncertain market conditions. To fully comprehend the impact of Covid-19 on the strategies of automobile manufacturer´s SCs, a few terminologies warrant elucidation. The term "strategy" in this context denotes the blueprint or approach an entity embraces to accomplish its objectives (Johnson et al., 2009). An "automobile manufacturer" embodies a corporation that ideates, fabricates, and commercializes automobiles (Law Insider, 2023). The term Covid-19 pandemic signifies the global health catastrophe incited by the SARS-CoV-2 virus, which surfaced towards the end of 2019 and has had far-reaching economic and societal repercussions (World Health Organization, 2023).

The vast reverberations of the pandemic across global supply chains have incited a rich vein of scholarly discourse, with a particular focus on the automotive industry's resilience under this unprecedented disruption. Ivanov & Dolgui (2020) have pioneered exploring the resilience of supply chain structures under pandemically-induced contingencies, unearthing potential pathways towards redundancy, increased visibility, and enhanced agility. Their groundbreaking computational models underscore the intricacies of this global ripple effect originating from localized disruptions. Concurrently, Queiroz et al. (2020) have delved into empirical analyses, delineating a landscape of operational adaptations, transformations in supplier relationships, and production schedule adjustments in the face of the pandemic. In a solo endeavor, Ivanov (2020) further scrutinized potential mitigation measures, highlighting the merits of supplier diversification, digital transformation, and regionalization or localization of supply chains. Despite these significant strides, an uncharted territory remains in understanding the post-pandemic evolution of SCs within the manufacturing industry. Specifically, the extant literature needs to include more in dissecting the long-term implications of COVID-19 on the structural and strategic reconfigurations of supply chains beyond the immediate crisis response.

To juxtapose the strategic maneuvers of these automotive manufacturers before and after the Covid-19 pandemic, this exploration will employ an amalgamation of secondary data sources encompassing scholarly articles, yearly reports, industry reports and news releases. The methodology segment will elaborate on the rationale behind selecting these three manufacturers. The findings of this investigation will appeal to researchers and practitioners in the manufacturing industry and policymakers and stakeholders keen on understanding the repercussions of the Covid-19 pandemic on the strategic maneuvers of manufacturing corporations, particularly those in the automotive sector. Furthermore, this investigation is rooted in the extensive management domain, with an accent on strategic management. By juxtaposing the strategic orientations and adaptation in the automotive industry, this research aims to yield insights of value to both the academic and the practitioner in the manufacturing sector.

The chosen automotive industry is intricate and dynamic, necessitating effective strategic adaptation for entities operating within it. By comparing the strategic orientations of the SCs of Tesla, Volkswagen, and Ford against fluctuating and uncertain market conditions, this research aims to augment the literature on strategic management in the manufacturing industry, thereby informing strategic decision-making for entities in this sector. Given the contemporary context of the pandemic and its ongoing challenges, this master thesis also endeavors to contribute to the existing literature by analyzing previous studies and applying them to the current Covid-19 context, an area not extensively researched due to its recency. The outcomes of this research also hold implications for entities operating in other industries reliant on efficient supply chains, thereby facing similar challenges.

1.2 Structure of the Master thesis

The following chapter provides a comprehensive literature review, which examines the research conducted on supply chains in the manufacturing industry, management theories related to supply chain management, and it additionally explores the existing literature on strategic adaptation during uncertain times in the industry.

In the subsequent chapter, the methodology employed in this research will be presented, including the selection criteria for car manufacturers and the data sources chosen for analysis. The data is presented and analyzed in the results part, followed by a discussion on the findings, implications for strategy-making and future research in the field. Lastly, this thesis will highlight the study's limitations and provide concluding remarks summarizing the essential findings and recommendations for future research.

2. Literature review

The supply chain management (SCM) domain is crucial to the smooth operation of organizations in the manufacturing industry, encapsulating the orchestration of activities instrumental to the generation and delivery of products and services to consumers (Christopher, 2016). SCs significantly influence the competitive edge of enterprises in the manufacturing sector, with effective management practices associated with improved profitability, customer satisfaction, and operational efficiency. Thus, understanding the determinants of deploying various SC strategies is paramount for organizations aspiring to retain their agility and competitiveness amidst the continuously evolving global scenario.

Manufacturing firms' present challenges in their SCM involve escalating complexity, surging costs, and the ramifications of unpredictable market conditions (Wellener et al., 2022). The Covid-19 pandemic, as a case in point, has highlighted the significance of resilience and adaptability in supply chains, given its substantial disruption of global supply chains and the manufacturing industry (Sakthivel et al., 2021).

This literature review plunges into the factors affecting the selection and execution of supply chain and value chain strategies within the manufacturing industry, harnessing robust theoretical frameworks such as the Transaction Cost Theory (TCT) and Resource-Based View (RBV). By interrogating these theories in tandem with the broader context that envelops SCs, this review offers an exhaustive understanding of the dynamics molding SCM practices and their subsequent influence on the performance of manufacturing entities.

2.1 Global value chains

Global value chains (GVCs) represent the full range of activities that firms and workers worldwide perform to bring a product from its conception to its production to the customer. This includes all steps from the design, production, marketing, distribution, and support to the final consumer. The activities comprising the whole value chain can be contained within a single firm or be distributed among different firms and within a single geographical location or spread over more expansive areas (Gereffi & Fernandez-Stark, 2018).

In this increasingly globalized world, GVCs have become a prominent framework for understanding the organization of global industries and the distribution of value-adding activities across national borders (Gereffi et al., 2005). Through this lens, one can perceive the interconnectedness of local and global economies and develop strategies to leverage opportunities and mitigate challenges posed by global economic integration.

The introduction of GVCs into economic and business research has brought significant insights by highlighting the complex relationships and dynamics within and between firms operating in multiple locations. This understanding has facilitated studying international trade and economic development, corporate strategies, and labor market outcomes (Kaplinsky & Morris, 2001).

The subsequent compilation outlines various research studies undertaken in the realm of GVCs. Each scholarly contribution enriches the discourse surrounding GVCs, bringing forth diverse viewpoints and discoveries related to various GVC facets. The compilation covers a spectrum of subjects, such as governance within GVCs, economic development implications of GVCs, innovative processes within GVCs, and methods to align GVCs towards fostering development. Eminent and well-cited researchers are the authors of these papers, indicating the significant scholarly attention GVCs have attracted over time.

Every paper in the list provides unique observations and findings, typically context-specific, but collectively, they present an inclusive synopsis of GVCs and their myriad influences and impacts. The reader will notice that exploring GVCs is an intricate and cross-disciplinary task, necessitating insights from various fields like economics, business studies, political economy, and development studies.

While the understanding of GVCs continues to mature, this compilation represents a substantial, yet non-exhaustive, selection of the extant academic work. As the global economy progresses and morphs, our comprehension of GVCs and their role in guiding economic development and business strategy will also continue to evolve.

Topic	Authors	Year	Title	Research Topic	Main Findings
Concept and Evolution of GVCs	Gereffi, G., Humphrey, J., & Sturgeon, T.	2005	"The governance of global value chains"	Analysis of GVC governance types	Defines five types of GVC governance: market, modular, relational, captive, and hierarchy.
	Kaplinsky, R.	2000	"Globalisation and unequalisation: What can be learned from value chain analysis?"	Examining inequality in global value chains	Identifies unequal distribution of gains in GVCs and highlights potential for developing countries to upgrade in GVCs.
	Gibbon, P., Bair, J., & Ponte, S.	2008	"Governing global value chains: An introduction"	Exploring governance in global value chains	Discussion of governance structures, illustrating how GVC governance impacts economic development.

Role of MNCs in GVCs	Coe, N. M., Dicken, P., & Hess, M.	2008	"Global production networks: Realizing the potential"	Role of MNCs in shaping GVCs	Describes the significant influence of MNCs in shaping and controlling GVCs.
	Gereffi, G.	2014	"Global value chains in a post-Washington Consensus world"	Assessing the impact of MNCs in GVCs	Argues that MNCs can both create opportunities and threats in host economies in the GVC context.
	Ponte, S., & Ewert, J.	2009	"Which way is "up" in upgrading? Trajectories of change in the value chain for South African wine"	Upgrading strategies of MNCs	Discusses the various upgrading strategies used by MNCs, such as process, product, functional, and chain upgrading.
Role of SMEs in GVCs	Humphrey, J., & Schmitz, H.	2002	"How does insertion in global value chains affect upgrading in industrial clusters?"	SMEs participation in GVCs	Highlights the challenges and opportunities for SMEs in joining and moving up in GVCs.
	Bair, J., & Gereffi, G.	2001	"Local clusters in global chains: The causes and consequences of export dynamism in Torreon's blue jeans industry"	Impact of GVCs on local SMEs	Examines how local firms integrate into GVCs and the impact on their development.
Technology and GVCs	Ernst, D., & Kim, L.	2002	"Global production networks, knowledge diffusion, and local capability formation"	The role of technology in GVCs	Illustrates how technology plays a vital role in shaping GVCs and fostering local capability formation.
	Lee, J. R., Gereffi, G., & Beauvais, J.	2012	"Global value chains and agrifood standards: Challenges and possibilities for smallholders in developing countries"	Technology and standards in agrifood GVCs	Details how technology and standards shape the agrifood GVCs, affecting smallholders in developing countries.
	Sturgeon, T.	2002	"Modular production networks: A	Modular production networks in	Examines how modular production

			new American model of industrial organization"	technology GVCs	networks influence the organization and dynamics of technology GVCs.
Power and Politics in GVCs	Neilson, J., Pritchard, B., & Yeung, H. W. C.	2014	"Global value chains and global production networks in the changing international political economy: An introduction"	Influence of power and politics on GVCs	Explores the critical roles of power and politics in shaping the dynamics and outcomes of GVCs.
	Davis, D., Kaplinsky, R.,Morris, M.	2018	Rents, Power and Governance in Global Value Chains	Governance of GVCs	Addresses the generation of rents and the distribution of gains in the global operations of governed Global Value Chains (GVCs) and seeks to provide an architecture for analyzing the governance of GVCs.
Standards and Governance in GVCs	Nadvi, K.	2008	"Global standards, global governance and the organization of global value chains"	Impact of standards on GVC governance	Illustrates how standards shape GVC governance and affect the participation of firms.
	Lee, J., Gereffi, G., & Beauvais, J.	2012	"Global value chains and agrifood standards: Challenges and possibilities for smallholders in developing countries"	Role of standards in agrifood GVCs	Explores how standards in the agrifood GVC pose challenges and opportunities for smallholders in developing countries.
	Ponte, S., & Gibbon, P.	2005	"Quality standards, conventions and the governance of global value chains"	Role of quality standards in GVC governance	Investigates how quality standards affect the governance of GVCs, focusing on the coffee industry.

Upgrade and Innovation in GVCs	Humphrey, J., & Schmitz, H.	2002	"Developing country firms in the world economy: Governance and upgrading in global value chains"	Upgrade strategies in GVCs	Analyzes the strategies and challenges of upgrading for firms in developing countries within GVCs.
	Ponte, S., & Ewert, J.	2009	"Which way is "up" in upgrading? Trajectories of change in the value chain for South African wine"	Upgrade trajectories in wine GVC	Traces the upgrade trajectories within the South African wine GVC.
	Morrison, A., Pietrobelli, C., & Rabellotti, R.	2008	"Global value chains and technological capabilities: A framework to study learning and innovation in developing countries"	Role of GVCs in fostering learning and innovation	Argues that participation in GVCs can spur learning and innovation in developing countries.
GVCs and International Trade Policy	Baldwin, R., & Lopez-Gonzalez, J.	2015	"Supply-chain trade: A portrait of global patterns and several testable hypotheses"	GVCs and international trade	Describes the significant role of GVCs in shaping global trade patterns and offers testable hypotheses.
	Sturgeon, T., Van Biesebroeck, J., & Gereffi, G.	2008	"Value chains, networks and clusters: reframing the global automotive industry"	Role of GVCs in the automotive industry	Analyzes how GVCs are reshaping the global automotive industry and its implications for trade policy.
	Kowalski, P., Lopez Gonzalez, J., Ragoussis, A., & Ugarte, C.	2015	"Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-Related Policies"	GVC participation and trade policy implications for developing countries	Examines the implications of GVC participation for trade and trade-related policies in developing countries.

GVCs and Economic Development	Rodrik, D.	2018	"New technologies, global value chains, and developing economies"	Impact of GVCs and technology on developing economies	Discusses how new technologies and GVCs impact economic development in developing countries.
	Kaplinsky, R.	2000	"Globalisation and unequalisation: What can be learned from value chain analysis?"	Inequality and GVCs	Highlights how GVCs can exacerbate income inequality and outlines potential strategies for equitable development.
	Taglioni, D., & Winkler, D.	2016	"Making Global Value Chains Work for Development"	Strategies to leverage GVCs for development	Presents strategies for developing countries to leverage GVCs for economic development.
Environmental Sustainability and GVCs	De Marchi, V., Di Maria, E., & Ponte, S.	2013	"The greening of global value chains: Insights from the furniture industry"	Environmental sustainability in GVCs	Investigates how GVCs can be leveraged for environmental sustainability, using the furniture industry as a case study.
	Levy, D. L.	2008	"Political contestation in global production networks"	Environmental politics in GVCs	Explores the role of politics in shaping the environmental outcomes of GVCs.
	Sturgeon, T., & Kawakami, M.	2011	"Global value chains in the electronics industry: Characteristics, crisis, and upgrading opportunities for firms from developing countries"	Environmental implications of electronics GVCs	Discusses the environmental implications of the electronics GVCs and upgrading opportunities for developing countries.

As a conclusion of this extensive examination of the literature surrounding GVCs, it's unmistakable that the wealth of research available paints a complex and multilayered picture. From foundational theoretical perspectives to explorations into their organic evolution and contemplations on their intricate governance and structure GVCs are highly covered in the literature and show many facets. Yet, even within this abundance of knowledge, gaps can be found that future research can fruitfully address. A conspicuous lacuna is an exploration of how emergent technologies, such as artificial intelligence (AI) and blockchain, could sway the dynamics of GVCs, a topic merely skimmed by Baldwin (2016) and Kano et al. (2020). Similarly, the intertwining of GVCs and sustainability, encompassing environmental impacts and the sway of green policies, remains a largely untapped well of inquiry, despite its growing pertinence in our current era. Additionally, honing in on the resilience of GVCs, particularly in the wake of global upheavals such as pandemics or geopolitical shifts, could offer profound insights into the robustness of these intricate networks.

As this shifting landscape of the global economy is navigated, it becomes increasingly imperative that fresh perspectives on these and other emerging aspects are uncovered to better comprehend and adeptly manage the complex machinery of GVCs.

2.2 Supply chains

SCs are of pivotal significance in manufacturing, serving as the lifeline facilitating the prompt and proficient delivery of goods and services to consumers (Christopher, 2016). As a result, SCM emerges as a cardinal element, harmonizing all requisite activities for creating and disseminating products and services (Christopher, 2016). The competence of SCM can materially sway a corporation's competitive standing within the manufacturing industry (Akkermans et al., 1999).

A scholarly exploration by Sodhi & Tang (2012) accentuates the prominence of SCM in manufacturing, disclosing that corporations employing effective supply chain practices, such as risk management, financial hedging and partnerships, tend to relish enhanced profitability, heightened consumer satisfaction, and superior operational performance. Furthermore, SCM can act as a competitive advantage, enabling organizations to pare down costs, boost quality, and escalate customer satisfaction (Mentzer, 2004).

Nevertheless, the manufacturing sphere grapples with many challenges in managing their SCs, such as spiraling costs, mounting complexity, and the aftermath of unpredictable market conditions (Wellener et al., 2022).

The recent surge of the Covid-19 pandemic has shed a harsh light on the precarity of global supply chains, throwing manufacturing sector dynamics into disarray and leaving deep imprints of disruption (Sakthivel et al., 2021).

Literary landscapes teem with studies that reinforce resilience in SC paradigms within the manufacturing industry. Such resilience has the potential to serve as a buffer during erratic market episodes and catalyze effective adjustment strategies during these periods of market volatility (Christopher & Peck, 2004; Gereffi et al., 2005; Scholten et al., 2014). Multiple vectors have been identified as contributors to supply chain resilience, including, but not limited to, the widespread adoption of emerging digital technologies, the implementation of comprehensive risk management blueprints, and fostering of robust and reliable supplier relationships (Ponomarov & Holcomb, 2009).

Moreover, external facets such as regulatory frameworks instituted by governments, the constant shift in environmental regulations, and the simmering geopolitical tensions have been investigated for their reverberating effects on SCM within the manufacturing sector (Govindan et al., 2015; Sarkis et al., 2011; Wang & Zhang, 2022). The landscape of uncertainty is multifaceted, featuring elements like economic flux, rapid technological advancements, and an ever-evolving consumer preference matrix. Events of unpredictability, such as the Covid-19 pandemic, underscore the tangible influence these external variables exert on SCs.

Economic indicators, such as fluctuating exchange rates, inflationary trends, or shifts in interest rates, tend to reshape a firm's supply chain operations significantly. This is achieved by realigning cost structures and inducing ripples in the industry's competitive dynamics (Christopher, 2016). Technological revolutions introduce an additional degree of uncertainty, with the potential to upend traditional business models and redraw the contours of industry landscapes (Bughin & Hazan, 2017). Firms must demonstrate agility, readiness to embrace technological breakthroughs, and adaptability to stay ahead of the curve amidst such shifts. The fluidity of consumer preferences adds another layer of complexity, urging companies to maintain an adaptive stance toward their SC strategies to cater to these evolving demands (Christopher, 2016).

The Covid-19 pandemic has profoundly impacted the manufacturing industry, disrupting global SCs and triggering unprecedented uncertainty in market dynamics (Sakthivel et al., 2021). Firms have grappled with many challenges, such as labor shortages, logistic disruptions, and oscillating demand patterns, leading to a cascade of operational hurdles, including delays, ballooning costs, and weakened operational efficiency (Ivanov, 2020). Industry reports from thought leaders, such as those disseminated by McKinsey, underscore organizations' urgency to prioritize SC resilience and display nimbleness in the face of such disruptive events (Alicke et al., 2022). This could entail a shift towards diversifying supplier bases, bolstering inventory reserves, or harnessing the power of digital technologies to augment SC visibility and control (Alicke et al., 2022).

In summary, to navigate this web of challenges effectively, firms must cultivate a granular understanding of the market they operated in, surveil trends continuously and reassess SCs. This will enable them to stay in the driver's seat, steering their supply chain strategies with agility and foresight. Investigations of SCs in the manufacturing sector underscore the crucial role of effective SCM practices in assuring the competitiveness and robustness of corporations within this industry. The Covid-19 pandemic has further underscored the need for organizations to adapt to evolving market conditions and strengthen their SCs to tackle future disruptions.

2.2.1 Supply chain strategy analysis frameworks

The Transaction Cost Theory (TCT) and Resource-Based View (RBV) are integral theoretical frameworks for assessing SC strategies within the manufacturing industry. TCT, as explained by Williamson (1981), underscores the need to pare down transaction costs when orchestrating SC activities, with corporations choosing either in-house production or outsourcing based on cost considerations. Conversely, RBV, as Barney (1991) posited, accentuates the significance of exploiting a corporation's unique resources and capabilities to achieve a sustainable competitive edge in SCM. By melding these two frameworks, scholars can understand the factors that sway the adoption and efficacy of various supply chain strategies in the manufacturing sector.

2.2.1.1 Transaction cost theory

TCT introduced by Williamson (1981), presents a critical lens for scrutinizing SCM within the manufacturing industry. TCT proposes that corporations structure their operations, including SC activities, to pare down transaction costs tied to market exchanges. An essential facet of TCT is the role of governance structures in influencing SC decisions and curtailing transaction costs. Within the purview of TCT, governance structures denote the apparatus through which organizations orchestrate and govern their SC activities, including contractual arrangements and decision-making processes (Rindfleisch & Heide, 1997). Corporations might adopt varied governance structures, from market-based mechanisms, such as spot contracts, to hierarchical structures, akin to vertical integration, depending on the transaction costs of each choice (Williamson, 1981).
For example, uncertainty and asset specificity represent two essential factors influencing transaction costs in SCM, and they substantially impact the selection of governance structures

(Williamson, 1981). Heightened uncertainty from factors like oscillating demand or technological transitions can inflate transaction costs and spur corporations to adopt hierarchical governance structures, such as vertical integration, to mitigate risks (Malhotra et al., 2005). Likewise, asset specificity, signifying the extent to which investments dedicated to a specific transaction hold limited value outside that transaction, can impact a company's choice of governance structure (Williamson, 1981). When asset specificity is heightened, firms might favor hierarchical governance structures to shield their investments and pare down the risk of opportunistic conduct by external suppliers (Walker & Weber, 1984).

By examining the interplay between transaction costs and governance structures, TCT affords a robust framework for comprehending the strategic choices made by corporations in organizing their supply chains to optimize efficiency and curtail transaction costs. This viewpoint enables researchers and practitioners to glean valuable insights into the factors propelling supply chain decisions and the role of governance mechanisms in shaping SCM practices.

2.2.1.2 Resource-based theory

RBV another compelling theoretical framework for assessing SC strategies in the manufacturing industry, was fashioned by the intellectual efforts of Barney (1991) and Wernerfelt (1984). In this viewpoint, a firm's unique resources and capabilities are deemed crucial in molding its SC strategies, contributing significantly to its competitive landscape. The central thesis of RBV emphasizes the importance of deploying a firm's valuable, rare, inimitable, and non-substitutable (VRIN) resources to secure a sustainable competitive advantage within the bustling marketplace Barney (1991).

The applicability of RBV to SCM is high, as it casts a spotlight on the strategic significance of optimally harnessing an organization's resources and capabilities in the context of its SC processes. Here, SCM transforms into a strategic asset that equips firms to maximize their inherent strengths to carve out and uphold a competitive advantage within the market sphere (Collis & Montgomery, 1995).

Applying RBV to analyze a company's SC necessitates exploring how it leverages its unique resources and capabilities to yield customer value and establish a competitive foothold. For example, firms with a robust logistics backbone can engineer efficient distribution networks, ensuring punctual product and service delivery. This, in turn, boosts customer satisfaction and confers a competitive edge (Christopher, 2016). Similarly, companies cultivating strong supplier relationships can secure preferential access to scarce inputs or negotiate favorable terms, thus triggering cost savings and quality enhancements (Dyer & Singh, 1998).

Beyond this, RBV can guide the identification of areas where a firm's resources and capabilities might be underexploited or underdeveloped, uncovering opportunities for refinement in SCM. For instance, a company boasting advanced technological prowess may benefit significantly from incorporating digital solutions, such as AI or data analytics, to streamline its SC operations and improve efficiency (Gunasekaran et al., 2017). RBV provides a valuable scaffold for understanding and dissecting a company's SC strategy in the context of its resource and capability. RBV paints a comprehensive picture to achieve a competitive advantage. By focusing on the strategic gravity of SCM and the role of internal strengths, RBV affords an extensive perspective that complements the TCT in scrutinizing SC strategies within the manufacturing industry.

2.2.1.3 Analyzing supply chains with these theories

In the academic sphere, TCT and RBV were looked at alone, while only later research argues that both theories can be complementary. Both perspectives are required to analyze and understand collaboration (Combs & Ketchen, 1999). While TCT is more concerned about governance, RBV focuses on competitive advantage by analyzing the firm's resources. Both theories are critical concepts in the research of SCs. Recent research has also found that both theories can act as complementary tools (Kim, 2017).

Nevertheless, it needs to be considered that some practitioners state that both theories are not enough to analyze and decide when to outsource or not (McIvor, 2009).

2.2.2 Adaptability and responsiveness

The significance of SC adaptability and responsiveness has been extensively discussed in the academic literature, especially regarding their role in addressing market uncertainties. Scholars recognize these two dimensions as essential attributes for successful SCM, influencing firms' competitive advantage and overall performance (Gligor & Holcomb, 2012; Ivanov, 2020).

SC adaptability refers to the capacity of a SC to modify its operations in response to external disruptions and variations (Ivanov, 2020). A high degree of adaptability allows firms to adjust their SC strategies and configurations swiftly following changes in market conditions (Scholten & Schilder, 2015).

In the manufacturing industry, the concept of SC adaptability is vital. Companies in this sector often face diverse disruptions like demand fluctuations, supplier failures, or external crises like pandemics. Mandal (2012) argues that firms that demonstrate a high SC adaptability can

mitigate the effects of such disruptions, sustain their operations, and achieve better performance.
Supply chain responsiveness, on the other hand, denotes the ability of a SC to respond promptly to changes in customer demand or market requirements (Gligor & Holcomb, 2012). Responsiveness is closely related to agility, emphasizing speed, flexibility, and customer-centricity in SCM (Christopher, 2000; Yusuf et al., 1999).

In the context of the manufacturing industry, SC responsiveness becomes crucial, especially when dealing with volatile and uncertain market conditions (Christopher & Towill, 2001). For instance, Yusuf et al. (1999) suggested that manufacturing firms with responsive SC can meet varied and changing customer requirements, contributing to improved customer satisfaction and business performance. The adaptability and responsiveness of SC can be improved through various strategic initiatives. Implementing digital technologies such as advanced analytics, artificial intelligence, and Internet of Things (IoT) can increase SC visibility, enabling faster decision-making (Queiroz et al., 2020). With access to real-time data, companies can further gain insights into fluctuations in demand, allowing them to adjust their operations accordingly to respond more quickly to market changes. Diversifying sources of supply also increases adaptability and improves it by reducing the dependence on a single supplier, thereby lowering the risk of supply disruptions. Building solid relationships with multiple suppliers expands the ability to switch to other suppliers in the event of unforeseen events (Choi & Linton, 2011). In addition, purchasing and implementing flexible manufacturing systems can significantly increase responsiveness. Such systems offer the possibility of rapidly adapting production lines to a product demand or specification change. This allows better response to sudden disruptions in the SC, reducing downtime and maintaining business continuity (Sethi & Sethi, 1990).
Influential for adaptability is also the promotion of a culture that implements agility within the organization. This is essential to improve adaptability and responsiveness. Part of this fosters an organizational mindset that values rapid decision-making, continuous learning, and adapting quickly to changing circumstances (Sharifi & Zhang, 1999).

Adaptability and responsiveness become even more pertinent in uncertain market conditions. Ivanov (2020) noted that uncertain environments could cause severe disruptions in SC, requiring them to be adaptable and responsive to mitigate risks and ensure business continuity. In the manufacturing sector, firms that effectively manage their SC´s adaptability and responsiveness are better equipped to handle market uncertainties (Christopher & Towill, 2001; Ivanov, 2020). This evidence emphasizes the need for manufacturers to enhance these supply chain attributes, especially in light of increased global uncertainties, such as those triggered by the COVID-19 pandemic.

3. Research methodology

This research aims to undertake a case study analysis, examining and investigating the SC adoption implemented by three prominent automotive manufacturers — Tesla, Volkswagen, and Ford — within the context of uncertain market conditions, such as the pandemic. The automotive industry has been selected as the sample for this study, as it is one of the largest and most significant sectors in the manufacturing industry (OICA, 2021). By garnering insights from this comparative analysis, the study provides valuable guidance for other manufacturing firms on effectively navigating and responding to market uncertainties, ultimately facilitating the achievement of competitive advantage in SCs. The findings of this research will contribute to the broader scholarly understanding of SCM strategies in the manufacturing industry under volatile market conditions. Scholars have argued that insights from one industry can be transferred to other industries, provided that the industries share similar characteristics and challenges (Porter, 1985). Therefore, the insights gained from the automotive sector can offer crucial lessons for companies across the manufacturing industry aiming to enhance their adaptability and responsiveness in the face of market uncertainties.

3.1 Research design

This study adopts an experimental research design, utilizing a qualitative approach to examine transformations in the SCM practices from secondary data sources within the automotive industry amid volatile market conditions. The research sample includes three renowned automotive manufacturers: Tesla, Volkswagen, and Ford, each exhibiting unique strategies in SCM. The choice of an experimental research design over a quantitative method stems from the complexity of quantitatively gauging changes in SCM. Moreover, while a qualitative approach with interviews is adept at interpreting complex and context-specific phenomena, it may demand excessive time and resources, which may not be feasible within the scope of a master's thesis (Bryman, 2016).

The secondary data deployed spans two epochs: *"Time 1"* (pre- and during the COVID-19 pandemic) and "*Time 2"* (post-COVID-19, from 2022 onwards). This methodological approach facilitates a thorough analysis of how SCM within the automotive sector evolved over these time frames and gives the ability to compare each firm's SCs at both times while also allowing a comparison between firms.

The secondary data sketches the SCM practices, intended actions, and perceived risks of the selected automotive manufacturers – Tesla, Volkswagen, and Ford. Due to the highly complex SCs, this SC evaluation focuses on electro mobility and, even more specifically, on the SCs for battery production. This is due to the strategic importance of this specific sector in the automotive industry, as it represents the future market and is, therefore, strategically crucial for car manufacturers to prepare themselves well for the future.

These selected firms have adopted a distinct approach to navigate the unpredictable market climate. By juxtaposing and dissecting the SCs of the three firms, the case study intends to illuminate the strategies automotive firms employ to adapt to shifting market conditions and the alterations made in response to disruptions such as the pandemic.

The collected data was systematically dissected using the qualitative research methodology of grounded theory. This allowed to discern the underpinnings, contextual factors, temporal developments, and potential future trends. Grounded theory, in its capacity, facilitated a deep comprehension of the primary drivers embedded within the data, leading to the formulation of a clear theoretical framework. Grounded theory is a preferred methodology for qualitative data analysis and renowned for its inductive orientation and the generation of novel theories borne out of the data itself (Charmaz, 2006; Glaser & Strauss, 2010).

In the first stage, primary data from the three case companies – Tesla, Volkswagen, and Ford - were rigorously scrutinized at the two discrete time points: Time 1 and Time 2. Textual data from varied sources such as annual reports, company news releases, and other pertinent documents were meticulously examined line-by-line to extricate salient points linked to SC strategies. These points were then coded, signaling the onset of the first step: open coding. This involved allocating codes to data segments in alignment with their inherent content and significance, thereby uncovering valuable insights within the datasets (Corbin & Strauss, 2014). The data was first collected and then labeled in the open coding step. The data were sorted according to the company it provided information to and divided into the two previously defined time periods. This stage revealed prominent themes and patterns in the data.

The coded data for each company was further subjected to axial coding to discern relationships between codes and organize them into meaningful clusters (Strauss & Corbin, 1990). This categorization was performed independently for each company during both times, aiding in recognizing unique strategic trends and their progression over time. This approach of axial coding revolved around the automotive manufacturer and the connection of codes around five central topics: "supplier relationship," risk assessment," "vertical integration," "joint ventures," and "other." The category "other" embodies the category in which relevant data was entered that did not fit into one of the other four identified topics but was relevant despite this. This served to abstract more complex concepts and established connections between them. The procedure culminated in structuring the data to facilitate the formulation of a coherent theoretical framework and an improved understanding of the SCM of all three companies (Charmaz, 2006).

The final stage employed selective coding to synthesize the previously identified codes and categories into a select category encapsulating the study's findings in a written format. This step signifies the culmination of the open and axial coding processes and expounds on the study's findings and implications (Glaser & Strauss, 2010). The categories derived from each company were contrasted with detecting overarching themes across all three firms. This procedure facilitated the identification of shared strategic adjustments in their SCM in response to the pandemic, thereby spotlighting industry-wide trends. The iterative cycle of coding and recoding, continual comparison, and theme validation ensured the formulation of a robust thematic framework that precisely encapsulated the strategic shifts in the SCM of the case companies.

By adopting this research design, the study aims to furnish a comprehensive understanding of the shifts in SCM in the automotive industry, thereby offering valuable insights applicable to the broader manufacturing sector. The exploratory approach, coupled with the qualitative evaluation of secondary data sources will enable a detailed and diverse investigation of the research questions within the constraints of a master's thesis.
In the end, this analysis will proffer a comprehensive understanding of the strategic implications of COVID-19 on the SCs of these significant automotive companies, with implications that extend to the manufacturing industry and beyond.

3.2 Data collection

For this study, an array of secondary data was gathered on the SC decisions of Tesla, Volkswagen, and Ford. Besides company-published annual reports and press releases, the data collection process leveraged the Bloomberg Terminal to find published articles about the researched topics. A systematic search for relevant keywords and their combinations was performed, such as "Tesla supply chain," "Volkswagen supply chain," "Ford supply chain," "Tesla vertical integration," “Volkswagen vertical integration,” “Ford vertical integration,” “Tesla supplier,” Volkswagen supplier,” "Ford supplier," “Tesla procurement,” "Volkswagen procurement," “Ford procurement,” “Tesla battery production,” “Volkswagen battery production,” “Ford battery production,” “Tesla lithium supply,” “Volkswagen lithium supply,” “Ford lithium supply,”.

The Bloomberg Terminal, renowned for providing real-time market data, news, and in-depth analysis, is a substantial asset for academic researchers seeking current and comprehensive business strategy data (Bloomberg, 2023a). The reliability of Bloomberg data sources is highly regarded, given their practice of featuring reputable newspapers on their platform. Consequently, the compiled data, although secondary, can be deemed reliable for this research. In addition, the analysis draws upon the most recent four years' annual reports from each of the three automotive manufacturers: Tesla, Volkswagen, and Ford. These documents offer an official and detailed account of the companies' operations, financial performance, and strategic initiatives, thereby serving as an invaluable resource to comprehend the subtle strategic changes in their supply chain management.

The use of secondary data sources is appropriate in this study as it allows for the examination of a large amount of information that has already been collected, saving time and resources. Company reports encompass comprehensive details on a firm's strategies, operations, and performance and are prepared by experts within the organizations. Additionally, employing secondary data from multiple organizations facilitates a more comprehensive perspective, enabling comparisons between different approaches to SCM under uncertain market conditions. Published news publications and business articles from renowned publishing houses further serve as a valuable resource, offering an intimate glimpse into their strategic orientation.

In addition to secondary qualitative data, some quantitative data will be used to compare the financial performance metrics of the car producers. This includes financial metrics, costs, and revenue growth. The use of quantitative data allows for a comparison of the financial performance of car producers, providing a more comprehensive understanding of their strategic decisions and actions and giving insights into whether SC adaptations may have been successful or not.

3.3 Data validity and reliability

Utilizing secondary data, particularly company reports, as this study's primary source of information presents merits and potential limitations regarding data validity and reliability. Company reports are deemed valuable sources of information, as they encompass comprehensive details on a firm's strategies, operations, and performance and are prepared by experts within the organizations (Gibbert & Ruigrok, 2010). Moreover, regulatory oversight and adherence to reporting standards contribute to the credibility of company reports (Denzin & Lincoln, 2011). Additionally, employing secondary data from multiple organizations facilitates a more comprehensive perspective, enabling comparisons between different approaches to supply chain management under uncertain market conditions.

Conversely, several challenges regarding validity and reliability when using secondary data may arise. One such concern is the potential for biased or incomplete information in company reports, which may present a favorable image of the organization (Gibbert & Ruigrok, 2010). This issue can be mitigated by triangulating data with other sources, such as industry reports and academic literature, thereby ensuring the accuracy and comprehensiveness of the information (Denzin & Lincoln, 2011).

Another constraint involves secondary data not always aligning with specific research objectives, potentially resulting in gaps in the analysis (Saunders et al., 2016).

In conclusion, the use of secondary data in this study, primarily derived from company reports, offers valuable insights into the SC strategies of automotive manufacturers under uncertain market conditions. By acknowledging and addressing potential limitations, the validity and reliability of the data can be enhanced, ensuring the credibility of the study's findings.

4. Results

In this part of the work, the collected data and, thus, the data collection results are compiled and presented in written form. A detailed introduction to the topic will be given, and the findings will be presented.

4.1 Cases from the automotive industry

In the following, the three automotive companies, Tesla, Volkswagen, and Ford, will be introduced, and the reader will be given a short overview of the company and their overall strategy. The inclusion of stock charts in this study is an ideal tool, providing a visual representation of each automotive manufacturer's financial performance throughout the COVID-19 pandemic. By highlighting their respective trajectories from the lowest price points ("COVID lows") to their all-time highs, these charts offer a macro-level view of the financial impact the pandemic has had on each company, indirectly reflecting the market's confidence in their strategic adaptability and future outlook (Bodie et al., 2017).

However, as Bodie et al. (2017) cautioned, stock prices are influenced by a multitude of factors beyond the underlying financial health and operational efficiency of the company. This includes investor sentiment, market hype, and forward-looking projections (Trueman et al., 2000). For instance, stock prices can be artificially inflated due to market speculation or investor enthusiasm about prospects, even if a company's current financials or performance metrics do not substantiate this optimism.

This phenomenon is particularly pronounced in technology-driven sectors, such as electric vehicles, where future potential often significantly influences stock valuations (Chen et al., 2001). Therefore, while stock charts provide a valuable dimension for comparative analysis, they should not be interpreted in isolation nor considered the most reliable parameter. More substantive operational and strategic parameters must be evaluated to comprehensively and accurately understand each company's performance during the pandemic.

4.1.1 Tesla

Tesla, Inc. is a multinational American corporation specializing in electric vehicles, energy storage, and solar energy solutions. Founded in 2003 by a group of engineers, with Elon Musk investing in the young firm and becoming CEO later, Tesla's mission is to accelerate the world's transition to sustainable energy (Reed, 2020).The company has experienced rapid growth in the last decade and especially since the pandemic, with its flagship Model S, Model X, Model 3, and Model Y electric vehicles, as well as its innovative energy products such as Powerwall, Powerpack, and Solar Roof (Sparks, 2023). Tesla's market capitalization has surpassed that of many traditional automotive manufacturers, making it one of the most valuable car companies in the world (Mathews, 2021).

One key factor differentiating Tesla from other automobile manufacturers is its vertically integrated supply chain. Unlike traditional automakers, Tesla directly controls many aspects of its supply chain, from battery production and vehicle assembly to sales and service. This unique approach allows Tesla to be more agile and responsive to changes in the market, ensuring better control over product quality, cost, and delivery (Root, 2023).

Tesla's Gigafactories, which are built leveraging vertical integration are a prime example of its strategy. By manufacturing components in-house, Tesla can leverage economies of scale, reduce production costs, and ensure a steady supply of crucial components (Tesla, 2017). Another differentiating factor in Tesla's supply chain is its direct-to-consumer sales model. By bypassing traditional dealership networks and selling vehicles directly through its website and company-owned showrooms, Tesla can maintain better control over pricing, customer experience, and inventory management (Hamilton, 2022). The car manufacturer is intensely data-driven to gather valuable data. At the same time, the Tesla is driven but also on customer preferences and behaviors, which can be used to inform future product development and marketing strategies (Singh, 2021).

Below is the Tesla stock price with a visualization of its performance from the Corona low to old highs and its current performance compared to the Corona low. It can be seen that after the share price collapse resulting from the Covid-19 pandemic, the stock has gained over 1500% percent, which is a fifteen-fold increase. Due to market uncertainties and worse-than-expected performance, the stock has since fallen sharply again. It has yet performed over 900% from the Corona lows, standing at $260 when writing this research.

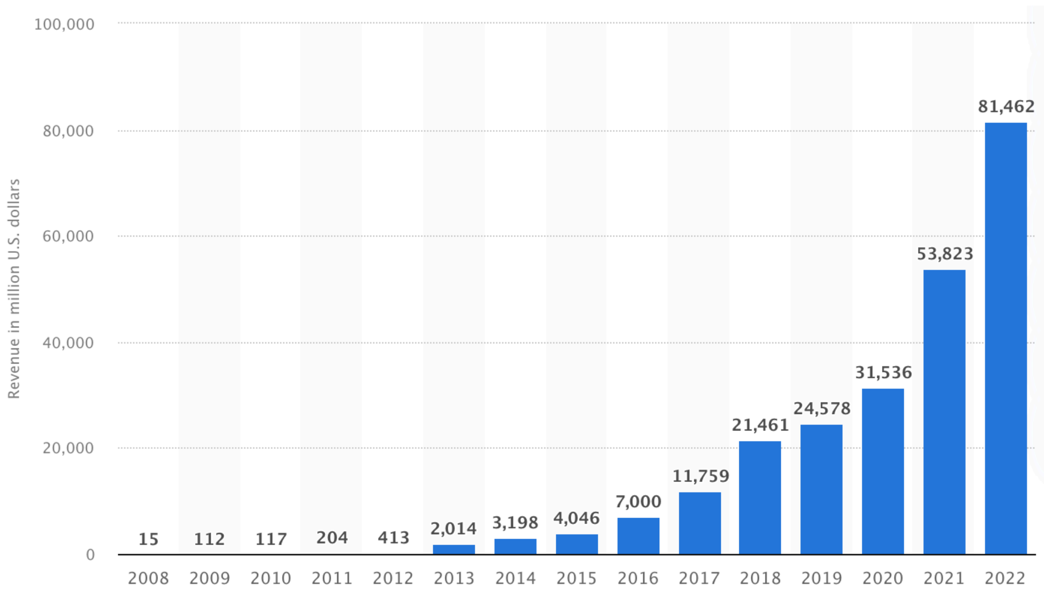
Figure 1: TradingView – Tesla´s stock chart

Source 1: Own construction

In analyzing Tesla's financial performance, a clear trajectory can be observed. In the pre-COVID year of 2019, Tesla demonstrated revenues of $24 billion and almost 370.000 vehicles sold. However, the onset of the pandemic in 2020 had no negative impact, with revenues rising to $31 billion and vehicle sales to almost 500.000 units. Tesla demonstrated even stronger

financials in 2022, post-COVID, as revenues grew to $81 billion and vehicle sales rose to 1,3 million
(Statista, 2023a, 2023b).

Figure 2: Tesla´s yearly revenue



Source 2: (Statista, 2023b)

Tesla's unique supply chain structure and innovative business model make it an ideal case study for examining the impacts of vertical integration, direct-to-consumer sales, and advanced technology adoption on company performance and supply chain resilience.

4.1.2 Volkswagen

Volkswagen AG, founded in 1937, is a German multinational automotive manufacturing company headquartered in Wolfsburg, Germany. As one of the world's largest automakers, Volkswagen Group comprises several well-known brands, including Volkswagen Passenger Cars, Audi, Porsche, Bentley, Bugatti, Lamborghini, Skoda, SEAT, and Volkswagen Commercial Vehicles (Volkswagen Group, 2023b). With a strong focus on innovation and sustainability, the company's mission is to become a global leader in electric mobility, aiming to reduce emissions and ultimately become carbon neutral until 2050 (Volkswagen Group, 2023a).

A key aspect of Volkswagen's supply chain is its globally integrated network of production facilities. The company operates more than 120 manufacturing plants across Europe, Asia, Africa, and the Americas, which allows it to leverage economies of scale and optimize production processes for various markets. Moreover, Volkswagen's supply chain management focuses on close collaboration with suppliers, ensuring a stable supply of components while promoting sustainability, quality, and cost efficiency (Volkswagen, 2022a).

Volkswagen has recently intensified its efforts to transition towards electric mobility, setting it apart from many traditional automakers. The company's "New Auto" strategy outlines ambitious goals for electric vehicle production, including launching over 70 new electric models and a significant investment in electric vehicle research and development. To support this strategic shift, Volkswagen has initiated a series of supply chain transformation projects, such as securing long-term contracts for battery supplies and investing in expanding charging infrastructure (Volkswagen, 2022a).

Another distinguishing factor in Volkswagen's supply chain is its sustainability and responsible sourcing commitment. The company has implemented stringent environmental and social standards for its suppliers. Furthermore, Volkswagen has taken significant steps to enhance transparency and traceability in its supply chain, particularly in sourcing raw materials such as cobalt, essential for electric vehicle battery production (Volkswagen, 2022a).

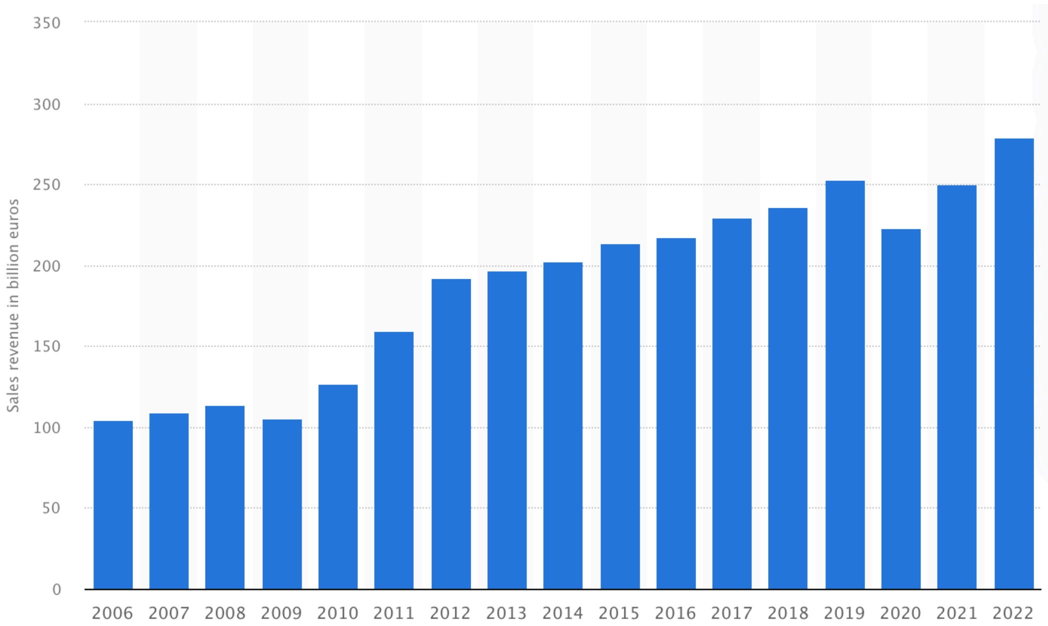
The following chart shows the performance of the Volkswagen share. It can be seen that after the Corona stock market crash, the share gained 160%. After a significant decline in the price, it dates at the time of the master thesis at only about 120 €, thus 30% higher than at the Corona lows.

Figure 3: TradingView – Volkswagen´s stock chart

Source 3: Own construction

In the year before the COVID-19 pandemic, 2019, Volkswagen exhibited stable, increasing financial performance with revenues of $252 billion and total vehicle sales of more than 10 million. However, the tumultuous events of 2020 led to a decline in revenues to $222 billion, and the number of vehicles sold was reduced to 9,3 million units. Nevertheless, in the aftermath of the pandemic in 2022, Volkswagen rebounded, with revenues rising to $279 billion, marking the highest revenue ever recorded. Vehicle sales also surged, below pre-Covid highs with 8,2 million units (F&I Tools, 2022; Statista, 2022).

Figure 4: Volkswagen´s yearly revenue



Source 4: (Statista, 2022a)

Volkswagen's extensive global presence, strategic focus on electric mobility, and commitment to sustainability make it a compelling case for understanding the challenges and opportunities traditional automakers face as they adapt to the rapidly evolving automotive landscape. By examining Volkswagen's supply chain management and future transformation initiatives and innovative strategies, this case study will provide valuable insights into how a leading automotive manufacturer responds to disruption in their supply chain.

4.1.3 Ford

Ford Motor Company, established in 1903 by Henry Ford, is a leading multinational automaker headquartered in Dearborn, Michigan, United States (Ford, 2023b). The company ranks as the fifth-largest global automotive manufacturer by production volume and offers a diverse product portfolio, including passenger cars, trucks, and commercial vehicles under the Ford and Lincoln brands (Ford, 2022a; Johnston, 2023).

Ford's supply chain management has historically been characterized by a complex, globally distributed network of suppliers and outsourced manufacturing. However, recent challenges, including the COVID-19 pandemic and the semiconductor chip crisis, have prompted Ford to reconsider its supply chain strategies (Ford, 2022a). Ford is increasing the firm's focus on electric vehicles (EVs), which has required a reevaluation of its supply chain management and needed components. The company has made significant investments in battery production and charging infrastructure to ensure a stable supply of essential components and support the transition to electric mobility Ford's commitment to EVs also differentiates it from other automakers, as it emphasizes the importance of adapting supply chain strategies to accommodate emerging technologies and market trends (Ford, 2022a).

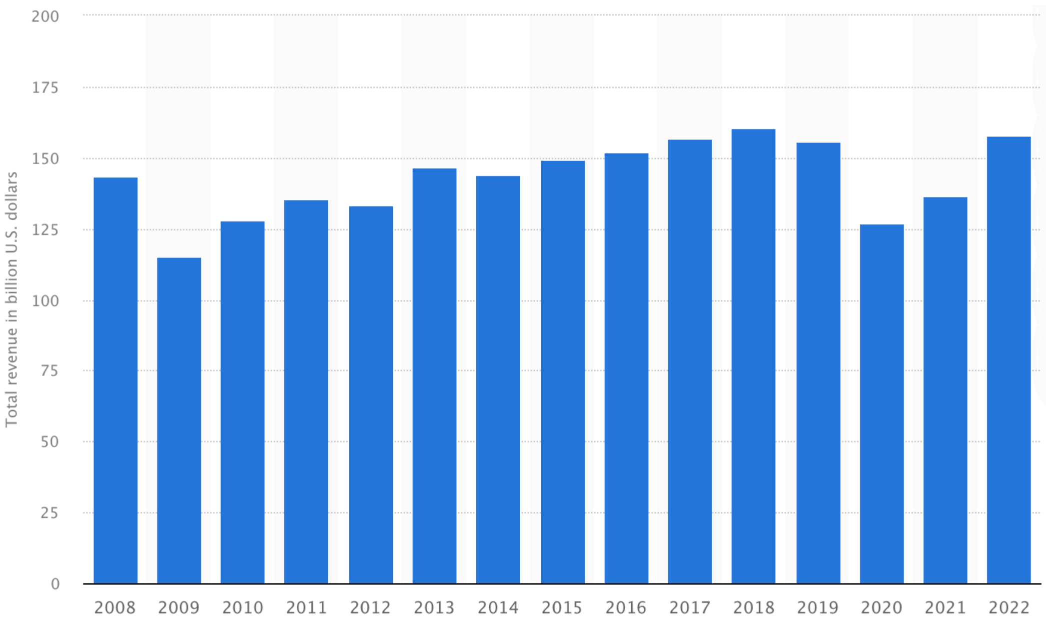
Since the Corona lows, the share of the automobile manufacturer Ford has put in a strong performance and has risen by over 500% at one point. Meanwhile, in July 2023, the stock is standing less high but still shows an increase of over 250%.

Figure 5: TradingView – Ford´s stock chart

Source 5:Own construction

Before the COVID-19 pandemic 2019, Ford reported healthy financial figures with revenues of over $150 billion and 5,3 million vehicles sold. The pandemic year of 2020, however, marked a downturn, with revenues falling to $127 billion and vehicle sales to 4,2 million units. Nevertheless, demonstrating adaptability, Ford, in 2022, reported a resurgence with revenues of $158 billion to pre-Covid highs while vehicle sales remained lower with 4,2 million vehicles sold (F&I Tools, 2022; Statista, 2022b)

Figure 6: Ford´s yearly revenue



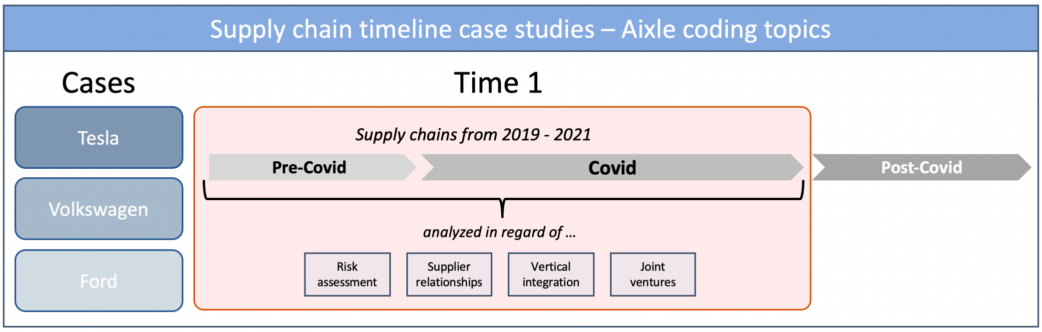
Source 6:(Statista, 2022b)

Ford Motor Company offers a valuable case for analyzing the shift towards deeper integration in the automotive industry in response to the COVID-19 pandemic and other market challenges. A comprehensive comparison of how different companies with distinct supply chain strategies have adapted to rapidly changing market conditions can be drawn by including Ford alongside Tesla and Volkswagen.

4.2 Supply chains pre- and during Covid-19

This section scrutinizes the supply chains of the three automakers at "time 1." The objective is to highlight the automakers' positions in risk assessment, supplier relationships, vertical integration, and joint ventures within their supply chains.

Figure 7: Supply chain timeline "Time1"



Source 7: Own construction

4.2.1 Tesla

In its 2019 annual report, Tesla disclosed that it procures thousands of components from hundreds of suppliers worldwide. The company has fostered close relationships with those supplying or manufacturing critical parts for producing electric vehicles. However, components are typically procured from a single-source supplier (Tesla, 2020a). From a risk standpoint, Tesla acknowledges that this single-source supply chain frequently leaves the company vulnerable to supply shortages. Various factors, including a shifting business environment, natural disasters, and other factors beyond the company's control, can disrupt deliveries. In such a situation, the failure of a single-source supplier of a vital part could lead to disastrous consequences, potentially causing product design changes, production delays, and the shutdown of manufacturing facilities (Tesla, 2020a). For certain essential parts, Tesla strives to diversify suppliers, where feasible, to prevent disruptions in the supply chain. Furthermore, Tesla also indicated in its 2019 annual report that the automaker minimizes risk by maintaining a safe stock of crucial production parts (Tesla, 2020a).

Another risk mitigation strategy involves forming long-term agreements with suppliers, provided it benefits both parties. Tesla aims to negotiate such long-term purchasing agreements at competitive rates, particularly for materials whose prices are governed by supply and demand. Tesla had a supply agreement with Ganfeng Lithium Co., one of the largest lithium suppliers, which provided Tesla with lithium from 2018 to 2020. A subsequent deal has been inked between Tesla and a Ganfeng Lithium subsidiary. This agreement is valid from 2022 for three years. However, it is unclear whether Tesla acquired Lithium from Ganfeng in 2021, as this year is not covered in the initial or the subsequent three-year contract (2018-2020 and 2022-2025) (Werwitzke, 2021). Another lithium supplier is Livent Corp, with whom Tesla is extending the existing supply deal until the end of 2021 (Reuters, 2020b). According to its statements, Tesla considers itself well-positioned in 2019 with adequate access to raw materials from suppliers to meet its needs (Tesla, 2020a).

Tesla, a contemporary company with a strong inclination towards vertical integration, manufactures more hardware and software in-house than its automotive competitors. CEO Elon Musk describes the company as highly vertically integrated. This integration offers the company a competitive edge, allowing it, for instance, to swiftly adapt designs to new requirements or developments, like alternative chips (Jin, 2022a). Tesla manufactures chips, car batteries, and seats. Furthermore, the company employs a direct sales strategy to customers, bypassing intermediaries, and provides car service and charging networks (Jin, 2022a). The company's manufacturing facilities, known as Gigafactories, play a crucial role in Tesla's success. As their name "Giga" suggests, these factories are substantial innovative manufacturing sites. They produce car parts and complete the other steps necessary to manufacture a working car under one roof. This arrangement boosts production capacity, saves costs, and enhances quality (Howland, 2021).

Tesla procures most of its batteries needed for production from suppliers such as Panasonic, CATL, and LG Energy Solutions. For example, since 2013, Tesla has secured battery production through a joint venture with Panasonic to develop a new generation of automotive-grade battery cells collaboratively. This agreement was initially inked in 2011 and extended in 2013. The partnership has already facilitated more than 130 million customer-driven miles (Panasonic Group, 2013). Elon Musk views this partnership as integral to Tesla's success and essential for further boosting production output to meet increased demand. In April 2020, the two companies signed a new three-year plan to manufacture more lithium-ion batteries at Tesla's Gigafactory in Nevada (Reuters, 2020a).

The global semiconductor shortage challenges the manufacturing industry and the American car manufacturer, as articulated in the firm's 2020 annual report. This crucial chip shortage has affected Tesla's supply chain and production. The company has resorted to alternative parts and newly programmed software to mitigate the issues arising from these shortages. However, according to Tesla, whether this strategy will remain viable as production scales to meet projected growth rates is yet to be determined. Due to Tesla's reliance on its suppliers Panasonic and CATL for the cells necessary for car production, the company acknowledges in its 2020 annual report that it has a limited number of suppliers producing battery cells according to Tesla's specifications. This situation creates risks and leaves little room for flexibility.

Consequently, the company is exposed to potential shortages and claims that in the long term, expanding in-house production of such cells is the only way to become more efficient, scalable, and cost-effective compared to the current system (Tesla, 2020b). Elon Musk considers it essential to produce batteries in-house to manufacture cost-effective cars with extended driving times at scale. In late 2020, Musk announced plans to cut costs by half by manufacturing batteries in-house soon. This strategy is crucial because batteries have historically been the most expensive component of electric cars, and reducing costs at this point is the only way to decrease overall car production costs (Jin, 2022b). During its battery day in September 2020, the automaker unveiled its in-house developed 4680 batteries for the first time. These batteries, made from new materials and manufacturing processes, are expected to reduce the cost per kilowatt-hour by up to 56% (Bleakley, 2023). Additionally, these batteries are six times more potent and offer a 16% extended range (Lyons, 2020).

Even though no direct comment was made regarding the carmaker's inclination towards further vertical integration, a 2022 filing for tax breaks in Texas for the potential construction of a lithium refinery suggests otherwise. Industry experts interpret such a move as the only way to meet the set goals and thus increase lithium demand (Dempsey, 2022). During the pandemic and the ensuing parts shortages, particularly the chip shortage, Tesla allowed its customers to accept and purchase vehicles with missing parts. This practice ensured continued sales and prevented manufacturing car inventory accumulation. Tesla even removed some sensors and other car features to facilitate easier production and adapt to the scarcity of certain parts. In the case of missing chips, Tesla managed to rewrite its software to be compatible with available chips. Volkswagen's CEO, Herbert Diess, lauded this as impressive (Jin, 2022a).

4.2.2 Volkswagen

To predict pricing trends, Volkswagen conducts regular analyses of its supply chain and raw material markets. In 2019, the automobile retailer projected that commodity prices would likely surge in the subsequent year and retain high volatility in the ensuing years. Internal preventive measures encompassed establishing long-term, stable supply agreements to avert disruptions in the supply chain. To accomplish this, developments are consistently monitored and meticulously analyzed, and preemptive steps are taken to prevent supply bottlenecks early on (Volkswagen, 2019). Nonetheless, the company identified another risk associated with suppliers - a growing trend of insolvencies in 2019. While many suppliers faced significant financial challenges, government aid stabilized them, averting a wave of insolvencies. According to the company's reports, procurement department experts continuously monitor these developments and initiate necessary countermeasures to prevent supply chain bottlenecks (Volkswagen, 2019). A primary countermeasure the company employs is to diversify its supplier portfolio and encourage local diversification, which minimizes economic and geopolitical risks (Volkswagen, 2019).

Volkswagen has indicated that it is exploring backward integration to mitigate commodity risks arising from recent volatility. The group is forging partnerships and entering into long-term supply agreements, which ensures a steady supply of essential materials and competitive pricing (Volkswagen, 2021a). A case in point is the partnership with Gangfeng in 2019 to secure an adequate supply of Lithium (Shicong, 2019). Lithium producers are strategically vital partners for efficiently meeting raw material demand and planning costs. This partnership stemmed from the Volkswagen e-Raw Material Team's analysis aimed at securing the raw materials necessary for fleet electrification (Volkswagen Group, 2019). In 2019, the car manufacturer plans to introduce over 70 new all-electric vehicles in the coming years, which would substantially boost the demand for construction raw materials, particularly for battery production.

Consequently, securing materials is a critical success factor in this endeavor. The 10-year agreement with Gangfeng alone has allowed Volkswagen to secure nearly all of the required Lithium, the most crucial component for batteries (Volkswagen, 2021b). Due to the growing interest in battery cells, driven by the increasing production of electric vehicles, Volkswagen is fortifying its position by implementing a strategy that includes multiple strategic suppliers for battery supply (Volkswagen, 2021a).

In its 2019 annual report, Volkswagen outlined plans for forging long-term strategic partnerships in China, Europe, and the US to satisfy the high demand for battery cells. A notable instance of such partnerships is with Northvolt AB, a Swedish start-up in which the automaker holds approximately 20% ownership. The start-up is erecting a factory in northern Sweden, which will supply Volkswagen with premium segment battery cells from 2023 onwards (Volkswagen, 2021g). Volkswagen had also planned to co-operate a battery cell factory in Salzgitter with the Swedish company to augment its abilities using the battery specialists' knowledge (Volkswagen, 2019). However, this venture fell through due to the ambitious pace of Volkswagen's plans. Northvolt was replaced as a partner in the Salzgitter project by the Chinese battery cell company Gotion High Tech, in which Volkswagen is the majority stakeholder (Volkswagen, 2021d). Volkswagen considers such partnerships critical for its success in the electric vehicle sector and to propel technological transformation. The company is conscious of potential risk factors, such as delays and disagreements with partners, and strives to mitigate these through close collaboration and communication (Volkswagen, 2019).

For this reason, Volkswagen has initiated three additional strategic partnerships in the battery domain to solidify its position. These partnerships, with Umicore (a leading materials technology group), 24M (a battery specialist), and Vulcan Energy Resources (a cleantech company), are independent of one another. However, they collectively contribute to developing a battery value chain (Volkswagen, 2021f). The joint venture with Umicore aims to supply the group with cathode materials and integrate the procurement of materials for battery production into the value chain (Volkswagen, 2021f). Simultaneously, the group is expanding its internal production capacities (Volkswagen, 2021a). The increasing demand for battery cells and the consequential dependence on their suppliers represent a growing risk. Thus, Volkswagen manages several crucial suppliers while concurrently devising plans for its battery production. In doing so, the group intends to delve deeper into its value chain to produce the cells and extract the raw materials themselves (Volkswagen, 2021a).

Volkswagen's partnership engagement in its supply chain allows the group to influence prices and capacities to optimize the company's benefits (Volkswagen, 2021a). Particularly for the planned transition towards electronic cars, the company views vertical integration as a crucial driver for success. As part of the NEW AUTO strategy launched in 2021, the car manufacturer aims to control all stages of its battery activities' value chain if deemed critical for success (Volkswagen, 2021a). The NEW AUTO strategy envisions Volkswagen building a regulated battery supply chain through partnerships and its efforts, creating a closed loop in the value chain for more cost-effective and sustainable batteries (Volkswagen, 2021e). An insider indicated that a company-controlled supply chain enables the company to control the largest cost pool, which is vital for its success (Volkswagen, 2021e). Another project by Volkswagen to minimize supply chain shortages involves integrating the entire supply chain into a cloud-based open platform. The objective is to unite all companies in the entire value chain on a single platform, creating a global ecosystem with continuous information exchange (Volkswagen, 2019). Volkswagen is a founding member of the Catena-X automotive network, an alliance of 25 partners to date, aiming to establish uniform data and information flow standards in the automotive value chain. This digital network for manufacturers, suppliers, and sellers could save costs for all parties involved (Volkswagen, 2021c). As the Covid-19 pandemic hit, Volkswagen implemented safe working conditions, preserved supply chains, and maintained liquidity through 100 measures designed to mitigate risks at the organization, termed the 100-point plan. The group showed resilience in such a severe crisis, with only a 15% reduction in deliveries by the end of the fiscal year 2020 (Volkswagen, 2019).

Volkswagen is channeling its efforts into exploring new business areas. The company anticipates a shift in sales and profit sources. While the core revenue currently comes from selling combustion engines, it is expected to transition towards battery-powered electric vehicles, and eventually, it will lean further towards software and services (Volkswagen, 2021e).

4.2.3 Ford

Ford procures an array of raw materials from various suppliers located globally. These resources encompass metals, precious metals, energy, and plastics. Many components incorporated in Ford vehicles are solely accessible via individual suppliers. This signifies that in the event of shortages, there is limited capacity for expedited production or transitioning to a different supplier (Ford, 2019). Single-source suppliers persistently pose a risk to the supply chain due to a scarcity of alternative options in the event of disruptions.

Furthermore, these suppliers can leverage their unique position in bargaining, potentially threatening production stoppages to negotiate more favorable prices (Ford, 2019). Hence, Ford's dependency on its suppliers for material provision is substantial. A dearth of certain parts, such as semiconductors, could disrupt automobile production. Nonetheless, Ford perceives its current resources as adequate for meeting existing demands. However, unpredictable risks associated with raw material procurement persist. The 2020 semiconductor crisis exemplifies this predominantly. Since numerous components are globally sourced from suppliers, who have their suppliers, an acute component scarcity can bring the entire production process to a standstill (Ford, 2020). Such a scarcity was observable in the case of semiconductors, with as many as 50 modules installed in a single vehicle.

Ford's CEO, Jim Farley, posited that the company needed to deliberate on the extent of vertical integration it desired. Until the pandemic, the firm predominantly procured commodities such as batteries from the market. The disruptions witnessed during the pandemic, however, revealed the vulnerabilities of this system. Consequently, Ford resolved to integrate electric motors and inverters vertically into its supply chain, a strategy expected to facilitate the transition from combustion engines to electric vehicles and secure a foothold in the burgeoning market (Weber, 2020).

During the second-quarter call, CEO Farley announced that significant alterations had been made to the supply chain, including modifying existing procurement structures (Donati, 2021). This endeavor aims to enhance transparency and bolster communication with semiconductor manufacturers and other critical component providers. Amidst the semiconductor shortage, the auto OEM engaged in close correspondence with suppliers, learning, as Farley articulated, that the supply chain for vital electronic parts necessitated a different construction. Considering the high cost of these critical parts, constituting approximately 50-60% of the material components installed, the objective is to mitigate this cost factor through vertical integration (Leonard, 2021).

The widespread shortage of chips compelled automobile manufacturers to curtail their production, often prioritizing the most profitable vehicles for available chips. This scarcity incited manufacturers to explore innovative methods to secure better chip access (Nellis & Klayman, 2021). Ford achieved this through collaboration with Global Foundries, a pioneering entity in the semiconductor manufacturing industry. The non-binding agreement between them aimed to augment chip production capacity for Ford and jointly spearhead research and development in the chip domain (Atiyeh, 2021). The joint venture intended to promote semiconductor production and innovation in the US, supply chips to Ford, and simultaneously cater to the American market (Ford, 2021). Ford's CEO stressed the need to devise novel collaboration methods with suppliers to diminish dependence on suppliers for both Ford and the US (Whalen & Gregg, 2021).

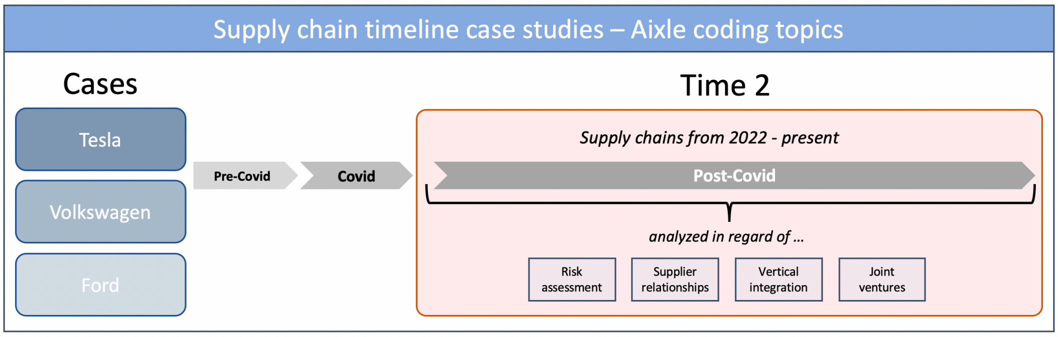
Furthermore, in April 2021, Ford announced the establishment of the Ford Ion Park Center of Excellence for global batteries, a research and development facility in Michigan. This marks a shift in Ford's approach, as a company that previously saw no advantage in vertical integration now aims to manufacture its batteries (Halvorson, 2021). Ford revealed its BlueOval City project for battery production in September 2021, sited in Tennessee. This vertically integrated ecosystem is slated to house a manufacturing plant for vehicles and batteries (Ford, 2023a). The in-house battery production is slated to collaborate with South Korean battery manufacturer SK Innovation under the BlueOval SK joint venture. This partnership is expected to operate battery plants starting in 2025 (Handelsblatt, 2021). This planned factory with SK Innovation marks the inception of a new strategy toward more robust vertical integration. The collaboration is projected to generate 60 gigawatts of batteries annually for the automobile manufacturer (Atiyeh, 2021). Although Ford previously lacked R&D in chip development, the company aims to cultivate this expertise in the future, as stated by spokeswoman Jennifer Flake (Whalen & Gregg, 2021).

Following the onset of the Covid pandemic, Ford has succeeded in resuming production. However, the company continues to grapple with higher rates of employee absenteeism and disruptions to the supply chain associated with Covid. At this stage, the future impacts of restrictions on production, supply chains, and vehicle sales remain uncertain.

4.3 Supply chains post-Covid-19

This segment scrutinizes the trajectories of three automobile manufacturers and their supply chains in the time succeeding the Covid-19 pandemic. The goal is to delineate how these automotive manufacturers have strategized their stances in risk assessment, supplier relationships, vertical integration, and collaborative ventures within their supply chain following the hardships incited by the pandemic.

Figure 8: Supply chain timeline "Time 2"



Source 8: Own construction

4.3.1 Tesla

During a recent earnings discourse, Elon Musk articulated that the COVID-19 pandemic had manifested some of the most complex supply chain dilemmas Tesla has ever encountered (Kay, 2021). This global health crisis has exposed Tesla to a multitude of disruptions. Tesla's operations were disrupted by shutdowns following health stipulations, rampant inflation, and augmented transportation and commodity costs (Tesla, 2022b). These conditions project potential hazards to Tesla's production, thus risking the automaker's revenue. Lithium, a cardinal raw material for Tesla and the manufacturing of electric vehicles, holds strategic importance. Securing this element is imperative to ensure the stability of production.

In light of this, Tesla has nurtured numerous affiliations with diverse lithium suppliers. Since 2018, Tesla has had supply contracts with Ganfeng Lithium Co., and they have further extended this long-term agreement for an additional three years, providing the automaker with an uninterrupted supply of lithium from 2022 until 2025 (Werwitzke, 2021). Tesla has comparable accords with other lithium and cobalt suppliers, the latter being utilized in batteries produced by its collaborator, Panasonic (Barrera, 2023). Remarkably, in the wake of the pandemic, Tesla has transitioned from relying solely on established, large mining conglomerates to initiating off-take agreements with emergent junior mining enterprises. These nascent companies, still in the developmental phase and not currently producing lithium, provide Tesla with a secured future supply while they gain liquidity for their mine's further development. The Tesla off-take agreement with Piedmont Lithium is a paradigm of such an enterprise. This junior mining firm is slated to supply Tesla with the requisite raw material in the latter half of 2023 (Barrera, 2023). The entities have consented to a binding 3-year contract, with the option to prolong the contract for another three years. Tesla is set to procure approximately 125,000 metric tons of lithium from the mining company from 2023 to 2025 (Lambert, 2023). Apart from lithium, Nickel emerges as another important raw material for Tesla. The company sealed its inaugural deal in January 2022 with Talon Metals to purchase Nickel concentrate over the subsequent six years. This deal marks the first agreement with a nickel supply originating from the US. Talon Metals operates its mine in Minnesota, adhering to stringent environmental standards (Schneyder, 2022). Moreover, the Brazilian miner Vale SA entered into a second extended agreement in May 2022 to supply the electric vehicle manufacturer with additional Nickel (Araujo, 2022).

Tesla is inclined to deconstruct its vertical integration to the degree of direct raw material extraction. This intent is demonstrated by the automaker's strategy to procure a stake in the Swiss raw materials conglomerate Glencore in 2022. The firms discussed Tesla's potential acquisition of 10-20% of the group to ensure a secure supply of raw materials. The transaction, however, did not materialize due to Glencore's coal mining ventures, which contravene Tesla's sustainability objectives. Despite this, it does signify Tesla's readiness to immerse itself in the raw materials sector, potentially establishing its presence to secure its requirements irrespective of cost, to avoid any risk of shortage (Hook & Dempsey, 2022). Echoing these sentiments, Tesla's CEO Elon Musk, during a Financial Times interview in May 2022, revealed that the possibility of acquiring and operating a mine, in addition to striking deals in the mining sector, was not out of the question. Musk stated that he is committed to ensuring the transition to more sustainable energy sources, even if that necessitates establishing a foothold in the mining industry (Campbell & Musk, 2022).

Amid these uncertainties and the resulting implications on its business model, Tesla's next production growth phase revolves around its factories. The construction of Gigafactory Berlin-Brandenburg, planned since 2019, took longer than anticipated but was operational by March 2022 (Shead, 2022). The development of Gigafactory Texas and the expansion of Gigafactory Shanghai are set to elevate the company's automobile manufacturing capacity (Tesla, 2022b). Moreover, Tesla's Megapack battery factories, geared towards producing high-output battery cells at lower costs, are another essential part of Tesla's production enhancement strategy. The inaugural Megapack battery factory in California began operations in 2022. Another proposed plant in Shanghai is projected to commence battery production in 2024 (Weaver, 2023). In-house battery production is critical for bolstering Tesla's production resilience, enabling the company to control this previously critical supply chain component and swiftly implement upgrades (Yoon, 2023b). Evidence of this strategy's execution is visible in Tesla's current material shipment arrangement with South Korea's L&F in 2023, which involves a $2.9 billion consignment for battery materials, as opposed to fully assembled batteries, demonstrating Tesla's commitment to the vertical integration of the battery supply chain (Yoon, 2023b).

In response to the broader semiconductor crisis, Tesla has leveraged and installed alternative parts and reprogrammed software to mitigate these issues in 2022 (Tesla, 2022b). Tesla remains hopeful of locating viable substitutes for absent components or conceiving its replacements over a particular duration. However, questions persist regarding this approach's speed, longevity, and feasibility, especially given the escalating demand for automobiles. Negotiating cost reductions with suppliers in the current market landscape is also formidable due to their superior negotiating position (Tesla, 2022b).

Elon Musk, Tesla's CEO, conveyed his appreciation via Twitter for the commendable efforts of Tesla's employees and key suppliers, attributing the company's successful navigation through the crisis to their contributions (Phillips, 2022). Demonstrating resilience, Tesla registered an 87% surge in completed car deliveries in 2021, achieving a record during the pandemic. This impressive performance is also attributable to Tesla's ability to manufacture parts in-house, rewrite software, and manage parts shortages more effectively than other automotive retailers (Jin, 2022a).

4.3.2 Volkswagen

The tumultuous supply chain scenario, particularly concerning the semiconductor industry and the Russia-Ukraine conflict, has significantly impacted the automotive retailer. After experiencing a revival in sales in 2022 following the Covid-induced downturn, the organization has been grappling with production limitations brought about by material shortages due to the abovementioned crises (Volkswagen, 2022a). Volkswagen's procurement and supply chain operations are strategically aimed at ensuring resource availability and preempting and addressing potential deficits. Supplier audits are routinely conducted to validate their capacity to fulfill delivery obligations. The Russia-Ukraine conflict serves as a case in point for the efficacy of Volkswagen's system. Through the firm's crisis management apparatus and a worldwide supplier network, Volkswagen navigated the supply chain disruptions induced by the geopolitical unrest. As a result, alternative sites for supply deliveries were established and activated, mitigating immediate losses (Volkswagen, 2022a).

Nonetheless, the semiconductor crisis led to diminished car production due to a shortage of materials. China's dominant role in semiconductor production and strict lockdown measures significantly contributed to these bottlenecks. Furthermore, geopolitical tensions are prompting Western firms to relocate their markets from China and diversify their supply chains. Volkswagen, which derives about half of its sales from China, intends to consolidate rather than dilute its position in this important market. The company's decision is bolstered by internal assessments that estimate a low likelihood of a Chinese invasion of Taiwan. CEO Oliver Blume has indicated that Volkswagen would be attuned to the needs of its Chinese clientele (Nilsson, 2023b). He also underscored in an earnings call that supply chain hurdles are increasingly becoming a standard business condition instead of an anomaly (Nilsson, 2022).

Throughout the Corona pandemic, Volkswagen adopted a strategy of maintaining enduring supply contracts with its suppliers to mitigate these challenges. The German car manufacturer ensured a supply of carbon-neutral lithium through multiple long-term agreements, one of which was signed with Vulcan Energy Resources in 2021. Furthermore, Volkswagen entered into a memorandum of understanding (MOU) with the Canadian government to expedite the development of a regional, sustainable supply chain for raw materials within Canada. These actions exemplify Volkswagen's strategic commitment to procuring the requisite materials for battery production and its readiness to embark on novel pathways (Volkswagen, 2022a).

Herbert Diess articulated in 2023 his company's ambition to gain complete control over the entire cycle, from acquiring raw materials to recycling used batteries. While the desire of automotive manufacturers to secure a more significant stake in the electric vehicle value chain is not unprecedented, Volkswagen's approach has stirred anxiety among suppliers concerned about potential business losses (Hollinger, 2022). In a strategic move, Volkswagen initiated its dedicated battery company, PowerCo, in July 2022, with the mandate to oversee all battery-related aspects for the car retailer. These responsibilities encompass the research and development of batteries, procurement of raw materials, and recycling at the end of the product's life cycle. With its inaugural battery hub scheduled in Salzgitter, Volkswagen aims to steer its operations internationally and foster consistent advancement in cell technology. The Salzgitter factory, slated to commence its battery production for Volkswagen in 2025, underscores this aim (Günnel, 2022). By 2030, PowerCo anticipates operating six battery manufacturing facilities dispersed across Europe and North America. The internally produced battery cells are projected to maximize synergies, mitigate supply chain risks, and yield up to 50% manufacturing cost savings for the car firm (Volkswagen, 2022b).

In a collaborative effort, Volkswagen's PowerCo and the Belgian materials technology company Umicore established a joint venture in 2022. The venture's primary role is to equip the European cell factories with cathodes and other essential materials, with operations expected to commence in 2025. The venture aims to incorporate materials supporting a cell capacity of 160 GWh annually (Volkswagen, 2022a). Moreover, Volkswagen entered into additional joint ventures 2022, notably with Huayou Cobalt and Tsingshan Group, to ensure a steady supply of nickel and cobalt for the Chinese market. These strategic alliances complement Volkswagen's objective to establish a global network of battery cell factories and secure essential raw materials through regional partnerships (Goh et al., 2022). The Volkswagen China Group revealed that these partnerships are intended to substantially lower battery production costs, aiming to achieve a 30-50% cost reduction per battery.

The Covid pandemic, geopolitical unrest, and the Russian-Ukrainian war have led to critical shortages in raw materials, causing nickel prices to surge by nearly 400%. To counterbalance such market volatility, Volkswagen plans to use joint ventures to ensure an adequate supply of raw materials for electric batteries with a capacity of 160 GWh (Goh et al., 2022). In a departure from past practice, a Volkswagen procurement executive indicated at a 2022 automotive convention that Volkswagen is now familiar with the operations of mining companies, suggesting a potential shift towards direct raw material extraction. In response to what has been termed the worst supply chain disruption ever witnessed, Volkswagen has entered into a direct procurement agreement to combat resource shortages, as disclosed by Chief Purchasing Officer Murat Aksel (Reuters, 2022b).

The crux of Volkswagen's strategy to ensure adequate battery supplies lies in vertical integration. By fostering cell production via PowerCo, Volkswagen can exercise greater control over costs while influencing the availability and sustainability of utilized materials (Volkswagen, 2022a). In 2023, Volkswagen announced plans to erect its first North American battery manufacturing facility. This Canadian site is set to deliver batteries to Volkswagen's vehicle plant in North Carolina, with the decision to choose Canada also influenced by the green incentives offered by the US government. Under Volkswagen's 10-point plan, developing production facilities in North America is prioritized to secure raw materials and fully manufacture rather than merely assemble batteries (Nilsson, 2023a). The vision for a North American fabric has always been part of Volkswagen's strategy, including additional Gigafactories to exert greater control over the value chain. Government incentives have expedited this process, which includes an investment plan of 180 billion to expand in the world's largest markets, America and China (Nilsson, 2023b).

4.3.3 Ford

In a press release dating September 2022, Ford publicized its intention to revamp and restructure its international supply chain. This declaration followed the company's acknowledgment of over a billion dollars in ancillary supplier costs in Q3 2022 due to supply chain predicaments. The strategic objectives encompass ensuring consistent sourcing, in-house development of crucial technologies and competencies, cost-cutting, and quality control (Wayland, 2022). Ford's production process heavily relies on its suppliers for the timely delivery of critical components. Any deficit or bottleneck in the supply of critical parts such as semiconductors and vital raw materials like Lithium, Cobalt, and Nickel could disrupt the car manufacturing process (Ford, 2022a).Another potential risk is suppliers' failure to fulfill their contractual obligations due to factors like below-expected miner output or quality issues, thereby significantly affecting production (Ford, 2022a).To counter raw material and part shortages, Ford, in its 2022 annual report, divulged its strategy to potentially stockpile certain materials and maintain higher-than-usual inventories (Ford, 2022a).

Ford, in its 2022 annual report, disclosed that it opts for multi-year sourcing contracts due to the capricious raw materials market, resulting in high prices and planning difficulties. Higher prices, which inflate material costs for both the carmaker and its suppliers, can be mitigated by long-term agreements (Ford, 2022a). Furthermore, Ford also signs off-take agreements with raw material suppliers to secure the required quantities. These agreements compel the car manufacturer to purchase a stipulated quantity of raw materials from the supplier annually over an agreed period (Ford, 2022a). Access to the requisite raw materials is vital to sustain electric car production. Plans involve multi-year commitments with raw material suppliers, despite the risk of a future demand slump that could leave Ford with excess raw materials (Ford, 2022a).

Ford signed a supply agreement in June 2022 with Liontown Resources, an Australian mining firm, in its quest for lithium, an essential raw material for battery production. According to this agreement, the car manufacturer will purchase 150,000 dry metric tons of lithium concentrate annually for five years. This concentrate is a crucial source of lithium required for electric vehicle production (Reuters, 2022a). Another lithium supplier, SQM, entered into a long-term strategic agreement with Ford in 2022 to secure this indispensable raw material (Bloomberg, 2023b). Similarly, securing Nickel, another important raw material, for Ford's production process led to a non-binding MOU with BHP, an Australian firm, for a multi-year contract. This agreement allows BHP to supply Ford with the essential raw material for battery production as early as 2025, potentially extending to other raw materials mined by BHP (Irwin-Hunt, 2022). The car manufacturer has multiple partnerships with mining companies to directly source the extracted raw materials, which is crucial to implement the company's electrification plans and tackling industry-wide supply chain shortages (Irwin-Hunt, 2022).

In March 2023, Jim Farley stated that the company would increasingly opt for sourcing in rather than out, with the battery supply chain falling under the company's purview, including raw material extraction (Yoon, 2023b). Ford is moving significantly towards vertical integration with the construction of its new manufacturing facility, BlueOval City in Tennessee, and the BlueOval SK battery park. BlueOval City announced in 2021 and slated for completion by 2025, is on track and will serve as Ford's most advanced manufacturing complex and a blueprint for its electric future (Lehbrink, 2022)The BlueOval SK battery park, in partnership with SK Innovation in Kentucky, is also set to be operational by 2025. Ford aims to produce its batteries through this factory, further integrating the value chain of electric vehicles (Lehbrink, 2022).

At the onset of 2023, Ford announced its partnership with Chinese battery manufacturer Contemporary Amperex Technology Corp. (CATL) on a $3.5 billion battery factory. While Ford wholly owns the battery fabric, it licenses the Chinese partner's battery technology. The joint operation of the Michigan-based plant is expected to commence in 2026, with the collaboration set to bolster Ford's expertise and capabilities in battery production, laying the groundwork for Ford's future independent battery production endeavors (Wayland, 2023)Moreover, Ford is eligible for subsidies under the Inflation Reduction Act, which rewards domestic production of batteries and chips by American automakers (Huang, 2023). The primary challenge in both cases—autonomous production or joint ventures—is securing essential raw materials like Nickel and lithium. Ford CEO Jim Farley declared that the organization strives to achieve planned vehicle numbers in the coming years. A pivotal strategic move for Ford's competitiveness is establishing a raw materials ecosystem in North America, with sourcing ideally occurring near the final production sites of cars and batteries (Foote, 2022).

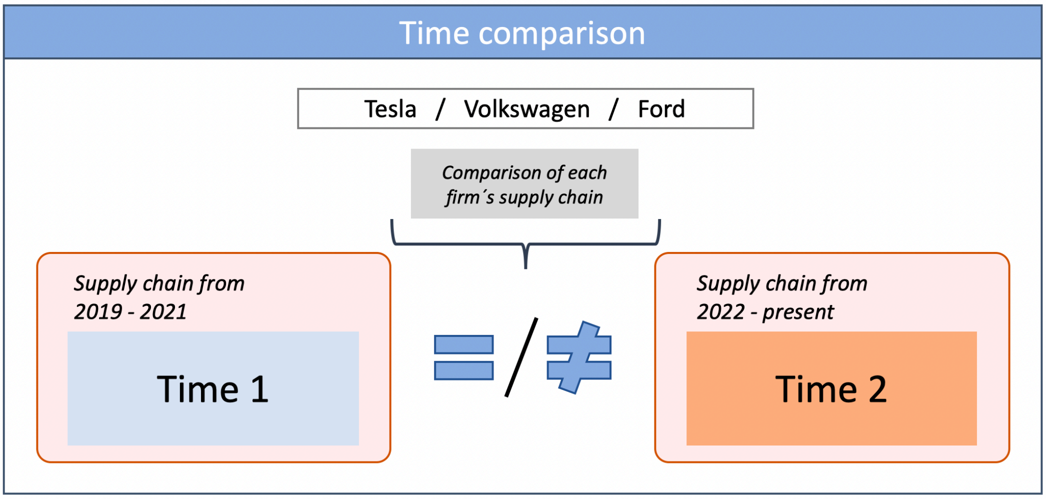
4.4 Data analysis

This study's analytic and interpretive components entail a methodical scrutiny of the secondary data sources delineated in the results chapter. The comparison will span each case study organization at pre-Covid, during Covid, and post-Covid junctures. An inter-firm comparison will also be conducted to discern any disparities in their supply chain strategies. The theoretical scaffolding provided by Transaction Cost Economics (TCE) and the Resource-Based View (RBV) will also be deliberated. These theoretical perspectives elucidate the influence of specific firm attributes and resources on supply chain strategy and their efficacy in navigating unpredictable market conditions.

4.4.1 Time comparison of supply chains

In the succeeding segment, a meticulous examination and comparison of the firms focus on their supply chains before, during, and after the Corona pandemic. A systematic comparison of each firm's supply chain dynamics across these periods will facilitate the illumination of any discernible changes if they exist.

Figure 9: Time comparison



Source 9: Own construction

4.4.1.1 Tesla

Several substantial modifications and adaptations become evident when examining Tesla's supply chain status pre- and post the Covid-19 pandemic.

Before the Covid-19 outbreak, Tesla's supplier relationships were characterized by close connections with global suppliers. However, it was conspicuous that for crucial components, Tesla often relied on a single supplier, a risk factor identified in its risk analysis, prompting it to adopt countermeasures. These included maintaining alternative suppliers for critical components and safety stock for essential parts (Tesla, 2020a). Tesla also instituted long-term contracts to stabilize its supply chain and mitigate risks (Tesla, 2020a). Post-pandemic, Tesla's long-term supply agreement strategy needs to be more balanced, with some contracts, like that with Ganfeng Lithium, extended from 2022 to 2025 (Werwitzke, 2021). However, one discernible change is Tesla's shift towards junior mining companies. Whereas Tesla primarily entered supply agreements with large, established mining firms pre-pandemic, post-pandemic saw the automaker commencing off-take agreements with junior miners. This illustrates the importance of securing future supplies of raw materials. Thus, off-take agreements are formulated to ensure the future provision of resources like lithium (Barrera, 2023). Additionally, CEO Musk considered the possibility of company-owned mining operations if they prove to be the optimal method for secure and sustainable supply (Campbell & Musk, 2022).

Tesla holds several joint ventures in battery production, such as those with Panasonic and CATL, with the former being a long-standing collaboration (Panasonic Group, 2013). Reflecting on the shortages in the supply chain, the company notes a paucity of suppliers capable of meeting Tesla's battery cell requirements. The viable solution to safeguard the production of high-demand vehicles is to augment in-house production (Tesla, 2020b). Tesla, a company known for its high degree of integration, already announced plans in 2020 to slash battery costs by half through vertical integration into its supply chain, enabling better risk management (Jin, 2022b). Post-pandemic, the car manufacturer relentlessly pursues this trailblazing strategy. The future strategy emphasizes expanding the Gigafactories to minimize previously encountered risks and uncertainties (Shead, 2022). Completing the Berlin Gigafactory and the operational Texas factory, coupled with the Shanghai location's expansion, is anticipated to boost output significantly. Concurrently, Tesla's plan for its Megapack battery manufacturing factories is in motion, with the first factory operational since 2022 and further expansion anticipated as early as 2024 (Weaver, 2023).

4.4.1.2 Volkswagen

Throughout and preceding the Covid-19 pandemic, Volkswagen persistently evaluated its supply chain. It forecasted escalating and unpredictable commodity markets in 2019, perceiving this as an impending risk. Volkswagen took preventive action to circumvent potential supply chain disruptions, notably implementing enduring and consistent supply contracts (Volkswagen, 2019). Another threat cited by the auto conglomerate in its 2019 annual report was financial instability among suppliers. To counteract this, Volkswagen employed regional diversification strategies and meticulous analysis of each potential supplier before contract finalization (Volkswagen, 2019). The global restrictions imposed during the pandemic led to considerable supply chain disruptions and delivery issues for Volkswagen. However, their diversification strategy regarding suppliers proved advantageous during the Russia-Ukraine conflict. While the escalation triggered additional supply chain complications for many corporations, Volkswagen successfully mitigated these problems via its worldwide network of suppliers (Volkswagen, 2022a).

Volkswagen prioritizes long-term supply contracts and directly procures critical raw materials, such as lithium. Given the company's long-term vision to electrify its entire vehicle range, the auto group pre-emptively ensures ample raw materials and establishes strategic alliances. This approach is especially relevant considering the increased demand stimulated by the industry's shift toward electric mobility (Volkswagen, 2019, 2021a). Volkswagen persists with this strategy post-pandemic, renewing or continuing specific supply contracts in 2021, such as the one with Vulcan Resources for carbon-neutral lithium procurement (Werwitzke, 2021).

During the Covid-19 crisis, Volkswagen unveiled its intentions for more robust supply chain integration. Through joint ventures like the one with Swedish battery expert Northvolt AB, Volkswagen seeks to shield itself from the surging demand for battery cells (Volkswagen, 2021g). The group plans to build a battery factory in Salzgitter with Chinese partner Gotion (Volkswagen, 2021d). Volkswagen perceives such partnerships as crucial for its success in the electric vehicle market. Accordingly, it has formed three additional strategic partnerships with firms specializing in various segments of the battery value chain (Volkswagen, 2021f). As announced during the pandemic, Volkswagen intends to manufacture its batteries in the future. With the implementation of the New Auto strategy, Volkswagen aims to control and integrate the battery supply chain through its collaborative efforts and partnerships (Volkswagen, 2021e). Two years later, these plans have become more ingrained in the organization. In 2023, CEO Herbert Diess announced Volkswagen's aspiration to control the entire supply chain for battery production internally. This development instills fear among suppliers of potential business loss, but the automaker needs to minimize costs and risks (Hollinger, 2022). For this endeavor, Volkswagen established its subsidiary, PowerCo, in 2022, which will handle all battery-related matters. PowerCo is also responsible for the factory built in Salzgitter during the pandemic, which is expected to become the company's inaugural battery hub and commence battery cell production in 2025 (Günnel, 2022). The long-term goal involves constructing battery cell factories worldwide and ensuring regional supply chains for required materials. A recent advancement is the auto group's memorandum of understanding with the Canadian government, indicating plans to establish a local supply chain for the raw materials required for battery production (Volkswagen, 2022a). This mirrors Volkswagen's intent to construct Canada's first new battery factory, with construction scheduled to start in 2023 to supply batteries to vehicle manufacturing plants in the North American market (Nilsson, 2023a).

4.4.1.3 Ford

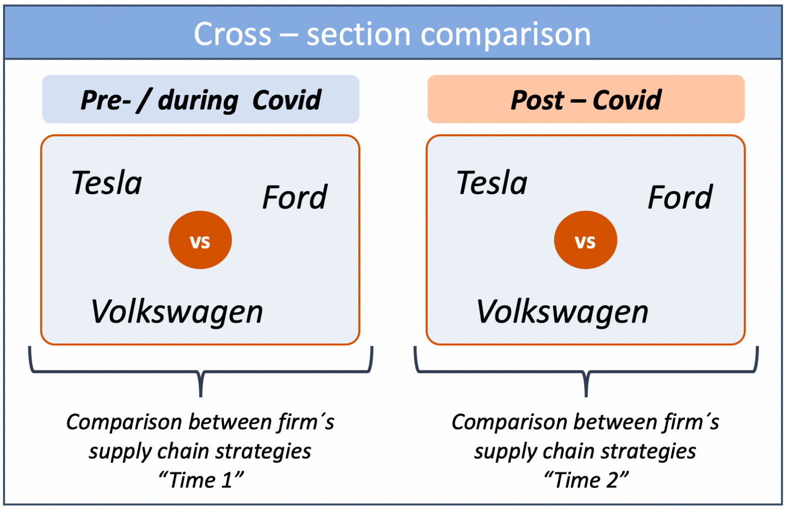
Before the coronavirus outbreak, Ford globally sourced materials for its supply chain. Remarkably, the company relied heavily on a single source supplier model for most parts, creating a significant risk of delivery failure. Despite the high dependency and consequent risk, Ford deemed its material procurement cost-effective and adequate (Ford, 2019). The shortcomings of this supply chain strategy surfaced during the semiconductor crisis, leading to substantial disruptions in Ford's supply chain. In response, Ford's CEO, Jim Farley, critiqued the direct procurement strategy during the pandemic, proposing a structural overhaul in the supply chain and materials procurement process (Donati, 2021). In the post-Covid era, an official statement was released in September 2022, following over 1 billion losses attributed to supply chain issues. The proposed pathway focuses on cost reduction and disruption minimization (Wayland, 2022). Ford revealed that this could be achieved through long-term sourcing deals for raw materials, ensuring price stability and material security. As outlined in its 2022 annual report, Ford plans to hedge its future with these long-term supply agreements, incorporating off-take agreements to secure stable prices and guard against potential future price hikes (Ford, 2022a).To buffer against future failures, Ford has also started procuring specific materials, possibly increasing its inventory post-Covid (Ford, 2022a).

During the pandemic, Ford also announced its intentions to manufacture its battery cells. The American automaker aims to create a vertically integrated ecosystem to produce cars in the BlueOval City project and batteries in partnership with SK Innovation under the BlueOval SK project (Ford, 2023a; Handelsblatt, 2021). Post-Covid, construction of the two planned manufacturing plants has commenced, with completion and operational dates slated for 2025, furthering Ford's vertical integration strategy (Lehbrink, 2022). Another step towards battery production and knowledge acquisition from the Chinese company CATL is the planned joint venture starting in 2023. The pandemic exposed the weaknesses of the existing system, but Ford's CEO responded swiftly by deciding to strengthen the company's vertical integration in electric vehicles. Even if the construction of its production facilities will last until 2025, Ford has quickly pivoted its orientation and adapted to the market situation (Weber, 2020).

4.4.2 Cross-section comparison

The cross-sectional analysis contrasts the supply chains of the companies pre-Covid and post-Covid. By identifying similarities and differences, the analysis allows for a comparison of the approaches employed by these companies.

Figure 10: Cross-section comparison



Source 10: Own construction

4.4.2.1 Pre- and during Covid

A comparative analysis of the three automotive brands – Ford, Volkswagen, and Tesla – reveals distinct overlaps and disparities in their strategic alignment, both prior to and during the global pandemic. However, this analysis indicates that Ford emerged as the least integrated and, hence, least prepared to contend with pandemic-induced disruptions. Ford, as indicated in its 2022 annual report, historically procured raw materials directly from the market. While this strategy was cost-effective pre-pandemic, the surge in raw material prices diminished its attractiveness. Furthermore, Ford's dependence on a single supplier for key components rendered the company highly vulnerable to delivery disruptions (Ford, 2022a).

Conversely, Volkswagen, foreseeing potential inflation in raw material markets as early as 2019, secured its interests through long-term supply agreements. The automaker also diversified its supplier base locally to mitigate supply risks, thereby ensuring disruption-free SC operations (Volkswagen, 2019). Similarly, Tesla procures crucial materials and components from a broad network of global suppliers. The company does grapple with the risk of single-source dependence for some components. However, Tesla has adopted a policy of maintaining a larger inventory of these components as a buffer against delivery issues. Furthermore, like Volkswagen, Tesla has established long-term supply agreements to secure raw materials, thereby enhancing predictability (Tesla, 2020a).

With the onset of the pandemic, there has been a discernible shift towards vertical integration in the electro-mobility segment among automakers. Tesla has been a pioneer in this field, capitalizing on its direct sales and charging networks and its in-house production facilities (Jin, 2022a). Volkswagen and Ford, by comparison, demonstrate less vertical integration. However, a significant focus on electro mobility and vertical integration lies within the realm of the battery value chain. Since batteries represent the most substantial cost factor, substantial savings can be achieved by manufacturers controlling this process themselves, thereby leveraging economies of scale. Tesla was the first to acknowledge this potential, announcing plans to reduce costs via in-house battery manufacturing (Jin, 2022b). However, in-house production currently accounts for a minimal proportion of the total batteries required, with most being procured from strategic partnerships with Panasonic, CATL, and LG Energy Solutions (Panasonic Group, 2013).

Volkswagen also recognizes the strategic importance of more robust control over the battery supply chain, leading to the announcement of strategic partnerships in 2019 to meet the high demand for battery cells. Through its joint venture with Northvolt, Volkswagen intends to achieve a partial self-supply of batteries from 2023 (Volkswagen, 2021g). Under its NEW AUTO strategy, the company aims to control more elements of the battery value chain, both in-house and via partnerships (Volkswagen, 2021a). A significant push in this direction during the pandemic was the announcement of the construction of its first battery production facility in Salzgitter in partnership with Gotion (Volkswagen, 2021d). Additionally, Volkswagen has established further strategic partnerships along the battery value chain to secure a robust positioning (Volkswagen, 2021f).

Contrarily, Ford commenced the pandemic period with almost no implementation of vertical integration strategies. However, the international SC complications ignited by the pandemic stimulated Ford's recognition of the associated challenges and requisite solutions, prompting a strategic pivot towards a more integrative approach (Weber, 2020). In 2021, Ford delineated its strategy with the announcement of BlueOval SK's battery cell production initiative. Despite their initial indifference toward vertical integration, the pandemic persuaded the automaker to prioritize the battery value chain as a business imperative (Halvorson, 2021).

In retrospect, Tesla, compared to the other automotive manufacturers, had already established a robust vertical integration framework both prior to and throughout the pandemic. The disruptions induced by the pandemic validated Tesla's approach, resulting in further integration and uniquely positioning the company to produce its batteries independently. Conversely, Volkswagen's strategy has been consistently risk-averse, seeking to minimize potential disruptions through long-term supply agreements. In response to the pandemic, Volkswagen swiftly transitioned towards vertical integration, exemplified by the construction of its first battery factory in collaboration with Gotion during the ongoing pandemic. Ford, initially the least future-oriented due to its reliance on raw material procurement, demonstrated a swift response to the global crisis by recognizing the need for increased integration. Ford's strategic adjustments included a transition to long-term supply agreements to ensure secure supply chains and the announcement of new car and battery manufacturing facilities in collaboration with SK Innovation during the pandemic. These facilities are projected to be operational by 2025 and will supply the Ford Group with its batteries (Sodhi & Tang, 2012).

Figure 11: Cross-section comparison Pre- and during Covid

Pre- and during Covid

	Risk assessment	*Supplier relationships*	*Joint ventures*	*Vertical integration*
Tesla	Risk identification → implementation of counter measures	Long-term supply agreements – mostly single-source supplier	Raw materials & battery production	Strong vertical integration
VW	Early risk identification → implementation of counter measures	Long-term supply agreements – supplier diversification	Raw materials & **During** Covid in the field of batteries for knowledge capabilities	Building capabilities and facilities for vertical integration
Ford	Risks identification → no counter measures	Short-term relationships – single source supplier → quick response then to long-term contracts	**During** Covid for raw materials & batteries for knowledge capabilities	Building capabilities and facilities for vertical integration

Source 11: Own construction

4.4.2.2 Post-Covid

In the aftermath of the 2022 pandemic, there is a striking similarity in the strategic directions pursued by all three automobile manufacturers. All are keenly focused on controlling the battery supply value chain for electric vehicle (EV) production. Batteries represent the most significant cost factor in EV manufacturing, and thus, control over this segment affords considerable cost savings through integration and economies of scale. Ford announced a company-wide SC restructuring in a press release in September 2022, initiating long-term supply agreements with raw material suppliers to secure stable prices and the necessary quantities (Ford, 2022a; Wayland, 2022).

Tesla and Volkswagen, having recognized the benefits of long-term supply agreements pre-pandemic, have maintained this strategy and are entering new partnerships. Notably, in the post-pandemic era, Tesla is pioneering innovative approaches to secure contracts for future production from emerging companies, particularly within the junior mining sector (Barrera, 2023). Elon Musk disclosed in a Financial Times interview that Tesla might even venture into raw material extraction, provided this accelerates sustainable energy transition and vertical integration (Campbell & Musk, 2022). Tesla has pushed the boundaries of vertical integration post-pandemic through its Gigafactories. The completion of its Berlin factory in March 2022 signified a significant step into its next phase of production growth.

The inauguration of Tesla's first battery factory in California in 2022 signals the start of a series of similar facilities, with the next slated for completion in Shanghai in 2024 (Weaver, 2023). In parallel, Volkswagen is also mapping a similar course, albeit from a lagging position. In 2022, Volkswagen established PowerCo, a subsidiary, to oversee all battery-related ventures. Emulating Tesla, Volkswagen's Salzgitter-based battery factory, due for completion in 2025, will be the first of several battery facilities planned for construction by 2030 (Günnel, 2022; Volkswagen, 2022b). Volkswagen aims to establish battery supply chains proximal to their respective sales markets, like Europe, North America, and China, to provide their manufacturing plants with locally produced batteries. Until such time as it is self-sufficient, Volkswagen will fulfill its battery requirements via joint ventures, such as Northvolt.

Following the pandemic, Ford has rapidly transitioned from a non-vertical integration model to a significantly integrated one. In 2023, Ford's CEO, Jim Farley, reiterated this strategic pivot, announcing a definitive move towards insourcing (Yoon, 2023b). The company's planned automobile and battery manufacturing facilities are under construction and are projected to be fully operational by 2025 (Lehbrink, 2022). Although further factories are yet to be announced, it is reasonable to expect that such plans are on the horizon. Furthermore, a joint venture with CATL to supply Ford with batteries from 2026 onwards is expected to enhance Ford's capabilities in the battery domain (Huang, 2023).

Notably, all three automobile manufacturers are advancing their vertical integration strategies. Given its consistent commitment to vertical integration, Tesla is conspicuously ahead, already producing its batteries and having a well-defined roadmap for establishing additional battery production facilities to ensure a steady supply of battery cells. Post-pandemic, Ford has rapidly pivoted towards vertical integration, constructing two facilities in America dedicated to car and battery production.

Volkswagen has made the most significant leap towards vertical integration with the inception of its subsidiary, PowerCo. The company is already constructing its battery factory and has given a clear indication of its strategic vision: establishing a network of battery factories worldwide. These factories will supply the group's car manufacturing plants, shortening and strengthening supply chains.

Figure 12: Cross-section comparison Post-Covid

Post-Covid

	Risk assessment	*Supplier relationships*	*Joint ventures*	*Vertical integration*
Tesla	Risk identification → implementation of counter measures	Long-term supply agreements – supplier diversification	Raw materials & battery production	Continuing its path of vertical integration with even higher speed
VW	Early risk identification → implementation of counter measures	Long-term supply agreements – supplier diversification	Raw materials & battery production	Building multiple battery plants to incorporate whole value chain vertically
Ford	Risks identification → no counter measures	Long-term supply agreements	Raw materials & battery production	Construction of first battery plants

Source 12: Own construction

4.4.3 TCE framework analysis

In alignment with the principles of Transaction Cost Theory, firms tend to favor internal organization when the costs of undertaking activities in the market exceed the in-house performance costs. Using the TCE framework, the analysis will focus on the following two elements to investigate the governance structures of the car manufacturers Tesla, Volkswagen, and Ford.

Uncertainty: The extent to which the companies face uncertain market conditions, such as fluctuations in demand or disruptions in supply, and the strategies employed to address such uncertainties (Williamson, 1985).

Governance structures: The mechanisms by which the companies manage and coordinate their supply chains, including vertical integration, strategic alliances, or contracts (Williamson, 1985).

4.4.3.1 TCE framework analysis of Tesla

In the historical context anteceding the advent of the Covid-19 pandemic, the approach Tesla adopted towards supply chain management and vertical integration was notably strategic, differentiated by dependencies on external supplier networks, a heightened emphasis on risk management mechanisms, and a pronounced inclination towards bolstering in-house manufacturing competencies. Seen through the prism of the transaction cost theory, Tesla's adoption of a global, and often, a single-source supplier model served as an effective tool for curtailing costs intrinsically associated with supplier management, procurement strategies, and quality control protocols, an observation validated by the Tesla annual report (Tesla, 2020a). Concurrently, this model assured consistency in product quality and standardized production methodologies across Tesla's complex supply chains. However, this strategic approach was full of inherent risks. Any failure cascading from a single-source supplier could impede production processes, vividly exemplifying asset specificity risk, a central tenet in transaction cost economics (Coase, 1937; Williamson, 1981).

To buffer against such systemic risks, Tesla adopted a defensive strategy encapsulating diversification of suppliers for specific critical components, maintaining safety stock levels, and entering into long-term contractual agreements, especially for critical raw materials, as highlighted in the Tesla annual report (Tesla, 2020a). While these counteractive measures imposed additional transaction costs, they underscore Tesla's acute awareness of the potentially magnified transaction costs intertwined with uncertainty, underlining the necessity for implementing robust contractual safeguards. This is consistent with TCT principles, underscoring the need for robust contractual safeguards to manage uncertainty-related transaction costs (Williamson, 1981). It is paramount, however, to emphasize that such measures mitigate rather than serve as eliminators of supply disruption risks.

Tesla's commitment to vertical integration is prominent in the automobile manufacturing industry, particularly noticeable in their hardware and software production spheres. Preceding the pandemic, Tesla demonstrated robust indications of vertical integration, with the domestic production spectrum not only encapsulating software and hardware but also extending to infrastructure auxiliary to vehicles such as charging stations and service facilities (Jin, 2022a). Such a high degree of ownership autonomy allowed Tesla to respond promptly and effectively to emergent demands or innovative requirements. Such ownership autonomy aligns with TCT, which assumes that intra-firm control will minimize transaction costs by reducing reliance on market transactions and their uncertainties (Williamson, 1981).

Furthermore, it gives Tesla an enhanced adaptability quotient, enabling it to respond to changing requirements or new developments more swiftly, facilitating expedited decision-making. However, this stance also exposes Tesla to potential risks affiliated with technological evolution, market variability, and production failures.

A notable intensification of Tesla's vertical integration strategy was manifested in its decision to undertake in-house production of batteries. By attenuating the cost of batteries, which form a significant fraction of a car's total cost, Tesla potentially possesses the capability to reduce its overall production costs, thus amplifying its competitive edge and exercising more substantial control over its most critical supply chain (Bleakley, 2023). The encroachment of the Covid-19 pandemic introduced a slew of novel considerations to Tesla's supply chain management paradigm and vertical integration stratagem. The pandemic laid bare Tesla's susceptibility to severe supply chain disruptions, compelling the company to develop more inventive and proactive procurement strategies while emphasizing its dependence on critical raw materials.

In the view of TCT, these changes reflect the increased environmental uncertainty triggered by the pandemic (Williamson, 1981).

In response, Tesla embraced a more holistic approach to supply chain management, incorporating supplier diversification tactics and entering into off-take agreements with junior mining enterprises (Barrera, 2023). These agreements represent a proactive strategy to hedge against uncertainty and compress transaction costs by securing a future supply of raw materials. Tesla's vertical integration strategy underwent a metamorphosis throughout the pandemic, contemplating extensions from raw material extraction. By considering acquiring stakes in mining enterprises or even operating mines directly (Hook & Dempsey, 2022) & (Campbell & Musk, 2022), Tesla aims to curtail uncertainty and dependencies on external suppliers further, effectively dampening transaction costs.

In addition, Tesla accelerated the establishment and operation of its manufacturing facilities, with an intensified focus on in-house battery production (Weaver, 2023). Such a strategic shift towards further vertical integration is consistent with TCT, which aims to minimize transaction costs associated with quality control, contract enforcement, and supplier dependence while increasing production efficiency (Williamson, 1981). The resilience Tesla displayed during the semiconductor shortage, including using alternative parts and reprogramming software, was unparalleled by any other automaker (Tesla, 2022b). This is further evidence of the importance of vertical integration in the company's strategy, as it reduces dependence on external suppliers and gives the company the flexibility to modify its production processes in response to changing circumstances. In summary, while the Covid-19 pandemic created significant challenges for Tesla's supply chain management, it also accelerated the company's evolution towards a governance structure of vertical integration as a strategy to reduce transaction costs and improve resilience and adaptability in a volatile business environment.

4.4.3.2 TCE framework analysis of Volkswagen

Examining Volkswagen's 2019 annual report reveals that the company foresaw potential price volatility and escalation in commodities, subsequently increasing the transaction costs related to raw material procurement. To circumvent these costs, complying with the transaction cost theory perspective on dealing with uncertainty (Williamson, 1981), Volkswagen instated steady and long-term supply contracts, thus ensuring an uninterrupted supply chain and increased cost control. By diversifying its supplier base, Volkswagen staved off potential transaction cost surges resulting from economic or geopolitical disruptions.

Simultaneously, the company identified the impending pivot towards electric vehicles and increased demand for specific raw materials such as lithium. Understanding the potential high transaction costs and scarcity associated with procuring these materials from the market, Volkswagen adopted vertical integration, an essential mechanism, as proposed by transaction cost theory, to reduce costs and risks (Coase, 1937). It collaborated with Ganfeng to guarantee a steady lithium supply, thus managing transaction costs and risks associated with this pivotal raw material, as outlined in the annual report (Volkswagen, 2019).

Moreover, Volkswagen pursued a multi-supplier strategy for battery supply, strengthening its endeavors to reduce transaction costs further (Volkswagen, 2019). This strategic move ensured a constant battery supply, notwithstanding the escalating interest in electric vehicles, which could potentially inflate transaction costs associated with this crucial component - effectively applying the tenets of transaction cost theory to reduce the uncertainty and frequency of transactions (Williamson, 1981).

Following the advent of Covid-19, consequent supply chain disruptions, and geopolitical conflicts, Volkswagen redoubled efforts to minimize transaction costs. This was prominently displayed in its response to the semiconductor sector's supply chain disruptions and the Russia-Ukraine conflict. The company's emphasis on securing supply and predicting shortages translated into measures such as conducting supplier audits to validate delivery contract adherence, thereby minimizing transaction costs and guaranteeing a constant supply of necessary materials, as delineated in the annual report 2022 (Volkswagen, 2022a). This is consistent with TCT's view regarding the role of contracts in coping with uncertainty (Williamson, 1981).

As a component of its post-pandemic strategy, Volkswagen persistently maintained long-term supply agreements with its suppliers, ensuring its supply of carbon-neutral lithium through contracts with entities such as Vulcan Energy Resources (Volkswagen, 2022a). Such collaborations stabilized the supply chain, aiding in transaction cost containment despite the global disruption instigated by the pandemic.

The decision of Volkswagen to establish its subsidiary PowerCo to manage all battery-related operations, from raw material extraction to recycling at the end of the life cycle, epitomizes vertical integration in consonance with the Transaction Cost Theory (Günnel, 2022; Williamson, 1981). The company can control costs, assure quality, and avoid market volatility by possessing the entire process, potentially leading to unpredictable transaction costs.

The company's foray into direct purchasing agreements, as articulated by Chief Purchasing Officer Murat Aksel, according to Reuters (2022b), exhibits its endeavor to eliminate intermediaries, thereby further decreasing transaction costs. This strategic move underscores a distinct emphasis on controlling costs and risks linked to raw material procurement.

In conclusion, the pre-and post-Covid strategies of Volkswagen are in harmony with the TCT. Through diverse initiatives such as enduring partnerships, direct purchasing agreements, and the creation of PowerCo, the company has made significant progress in controlling and reducing transaction costs, thereby reducing supply chain risk and facilitating a steady transition towards electric vehicle production.

4.4.3.3 TCE framework analysis of Ford

Drawing upon the theoretical underpinnings of transaction cost theory (Williamson, 1981), this treatise explores how Ford Motor Company's strategic transformations respond to escalating transaction costs within its supply chain triggered by market uncertainties.

Ford's conundrum revolves around the intricate web of international suppliers that provide the essential raw materials and components required for its production processes. As evidenced in the annual reports 2019 (Ford, 2019) and 2020 (Ford, 2020), this complex supply chain has become a crucible of considerable uncertainty. Exacerbated by the sole sourcing of components (Ford, 2019), disruptions caused by the global semiconductor crisis, and the lingering effects of the COVID-19 pandemic (Ford, 2020), these uncertainties manifest in the potential for production disruptions. This layer of complexity is consistent with the transaction cost theory's assertion that uncertainty and complexity increase transaction costs (Williamson, 1981).

The reverberations of these uncertainties echo beyond the boundaries of direct transaction costs, such as those associated with the procurement of supplies and negotiation with suppliers (Ford, 2020). The risk of production halts also incites substantial opportunity costs. Ford's efforts to mitigate these costs, including maintaining elevated inventory levels (Ford, 2022a) and establishing long-term agreements with suppliers to secure raw material procurement (Ford, 2022a) underscore the elevated transaction costs associated with external uncertainties.

In response to the escalating transaction costs, Ford has initiated a strategic pivot in its governance structure, transitioning from a reliance on the market to a more vertically integrated framework, consistent with the transaction cost theory's proposition that firms can reduce transaction costs through vertical integration when market uncertainties are high (Coase, 1937; Williamson, 1981). This strategic evolution emerges from the need to attenuate supply chain vulnerabilities, gain autonomy over crucial components, and curtail transaction costs.

As articulated by Ford's CEO, Jim Farley, the degree of vertical integration within the company is being re-evaluated (Weber, 2020). The manifestation of this shift is most apparent in the decision to internalize the production of critical components such as battery cells and inverters

(Weber, 2020), a strategy emphasized by the transaction cost theory for mitigating transaction costs (Williamson, 1981). The establishment of the Ford Ion Park and alliances with battery manufacturers, such as Global Foundries (Nellis & Klayman, 2021) and SK Innovation (Handelsblatt, 2021), under the BlueOval SK initiative further exemplify Ford's journey towards vertical integration (Halvorson, 2021).

This shift empowers Ford to diminish its dependence on external suppliers (Whalen & Gregg, 2021), attenuate supply chain uncertainties (Donati, 2021), and commandeer the supply of critical components. Consequently, this strategy mitigates transaction costs affiliated with procurement, negotiation, contract enforcement, and risk management (Wayland, 2022).

In addition, Ford's collaborative endeavors with semiconductor manufacturers and raw material miners, including Liontown Resources for lithium (Leonard, 2021) and BHP for nickel (Irwin-Hunt, 2022) demonstrate a move towards a hybrid governance structure. These alliances reflect Ford's strategic intent to exert more control over its downstream supply chain, reducing the uncertainty about raw material procurement and, thus, curtailing transaction costs (Ford, 2022a).

In summation, the strategic trajectory of Ford Motor Company provides a lucid illustration of transaction cost theory in action. When confronted with a market fraught with uncertainty and the resultant escalation in transaction costs, firms such as Ford find it economically beneficial to once again transition towards vertical integration (Ford, 2022b). By internalizing the production of critical components, firms can reduce their reliance on the vagaries of the external market, thereby minimizing transaction costs. This case study underscores the efficacy of transaction cost theory in understanding and predicting strategic shifts in response.

4.4.4 RBV framework analysis

In the context of a Resource-Based View (RBV) analysis, this study will perform an exhaustive assessment of Tesla, Volkswagen, and Ford, with particular emphasis on the pivotal resources of each entity and their strategic value. The theoretical underpinnings of this analysis are rooted in the frameworks of Wernerfelt (1984). and Barney (1991), which argue that a firm's resources are foundational to its competitive edge and strategic direction.

The assessment will delve deeply into both tangible and intangible resources, in line with Barney (1991), encompassing a wide array of assets from financial and physical resources to human capital. Of equal importance, the examination will extend to intangible resources such as brand equity, technological expertise, and innovative capacities, as they are recognized as fundamental drivers of organizational performance and competitive dominance (Wernerfelt, 1984). Upon resource identification, the VRIN framework - encapsulating Value, Rarity, Inimitability, and Non-substitutability - will be applied (Barney, 1991) to gauge the competitive potential each resource harbors. This evaluative process will illustrate how these resources afford a strategic advantage to automobile manufacturers, especially in their endeavors toward vertical integration.

The comparative analysis of Tesla, Volkswagen, and Ford's resource portfolios will shed light on their individual strategic positions and their level of preparedness for upcoming industry transformations. It will also offer valuable insights into potential strategic paths and the feasibility of vertical integration. Ultimately, the analysis will lead to strategic recommendations on how they can leverage their distinctive resources to achieve sustained competitive advantage (Peteraf & Barney, 2003).

4.4.4.1 RBV framework analysis for Tesla

Utilizing the Resource-Based View (RBV) framework to scrutinize Tesla's supply chain management strategy based on the compiled data, the initial stage involves identifying Tesla's key resources and differentiating between tangible and intangible assets. According to the RBV, these resources are considered the primary catalysts for competitive advantage (Barney, 1991). The tangible resources encompass Tesla's pre-established global supply chain complemented by enduring supplier relationships and existing supply agreements. Given its physical presence, this extant infrastructure is characterized as a tangible resource. Furthermore, inventory is also classified as a tangible resource, which significantly bolstered Tesla, particularly during the supply chain disruptions of the pandemic. Tesla effectively mitigated supply shortages by leveraging its safety stock and above-average inventory levels (Tesla, 2020a). This strategic management of tangible resources aligns with Barney´s (2001) RBV principles and contributes to the firm's competitive advantage.

Another critical resource is Tesla's manufacturing facilities, epitomized by the Gigafactories, designed explicitly for mass production and vertical integration. This resource is a substantial asset, with the factories playing an indispensable role in promoting further vertical integration in response to supply chain interruptions (Tesla, 2022b). Moreover, Tesla owns an in-house battery manufacturing facility, an integral tangible resource for securing required batteries and enhancing its internal production (Bleakley, 2023).

Equally significant, if not more, are the intangible resources that Tesla has cultivated over the years. The established supply chain and the relationships Tesla has fostered with hundreds of suppliers endow Tesla with experience and a diverse supplier portfolio, reinforcing supply chain security and risk minimization. This strategy resonates with the tenets of the RBV, whereby managing intangible resources like relational assets facilitates competitive advantage (Barney, 1991).

Moreover, Tesla's competencies, particularly in technology and vertical integration, constitute a crucial resource that sets the company apart from other automakers in their supply chain. Tesla's longstanding integration practice in its production and other facets has endowed it with experience in managing such endeavors, facilitating more seamless implementation in the future. The final intangible resource is Tesla's adaptive capability, exhibited during Covid-19. Tesla's vertical integration has rendered the company more agile and flexible in responding to challenges such as shortages, demonstrated by reprogramming software to obviate the need for missing parts (Tesla, 2020b). Such a capability is invaluable for a supply chain amid volatile market conditions. It aligns with the RBV's emphasis on a firm's internal capabilities to adapt and innovate, contributing to a competitive advantage (Barney, 2001).

Assessing the cited resources of Tesla's supply chain based on the VRIN attributes reveals immense value, primarily driven by vertical integration. Leveraging its factories, supply chain relationships, existing vertical integration, and internal capabilities, Tesla has maintained superior control amid uncertainty and managed shortages reasonably well. The resources' rarity is also evident regarding vertical integration among auto OEMs, as the concept of vertical integration was less prominent before the pandemic. Tesla's trailblazing role in this area establishes it as the possessor of a rare resource among American automakers (Barney, 1991). This also contributes to the resource's inimitability. Even though it can be replicated, it requires a substantial time investment, and the accumulated experience can only be emulated with long-term expertise.

Consequently, the resource is non-substitutable within a shorter timeframe in the automotive market, aligning with the RBV's emphasis on inimitability and non-substitutability, contributing to a sustainable competitive advantage (Barney, 1991). Tesla is competitive in its supply chain, mainly through its vertical integration and adaptability. Both factors enable rapid adaptation to new requirements, reduce supplier dependency, and expedite response to chip shortages.

4.4.4.2 RBV framework analysis for Volkswagen

Volkswagen, an internationally recognized giant in the automotive sector, possesses a wealth of tangible and intangible resources. Applying the Resource-Based View (RBV) to evaluate Volkswagen's assets, which posits resources as the primary source of a firm's competitive advantage (Barney, 1991), allows us to analyze these resources.

When examining Volkswagen Group's resources, a robust SC is complete with existing long-term supply agreements comparable to Tesla's, which serves as a tangible resource. Furthermore, Volkswagen maintains a global network of production sites, enabling the Group to produce close to its respective sales markets, thereby reducing costs (Volkswagen, 2022a). Barney (1991) argues that such a strategic geographic allocation of production facilities represents a critical tangible resource contributing to a competitive advantage. Volkswagen also possesses substantial financial resources derived from its consistent and significant sales. This financial strength enables the Group to make significant strides toward its strategic shift into the burgeoning EV market and the vertical integration of its electric car production. The German carmaker has taken an important step by establishing its subsidiary, PowerCo, to separate its battery production from its traditional business model and reboot it via a subsidiary with new structures and processes (Günnel, 2022). This strategic decision aligns with the RBV premise of leveraging tangible resources to maintain a competitive advantage (Barney, 2001).

The Group's intangible resources also contribute significantly to Volkswagen's potential competitive advantage in its supply chain. Volkswagen is highly innovative, pivoting its entire organization towards electrifying its entire fleet and establishing structures to produce EVs optimally. This innovative drive and ability to identify trends are crucial for staying relevant in the market. Additionally, Volkswagen's effective risk management is a vital intangible resource, allowing the Group to optimally prepare for the Covid-19 pandemic and the resulting supply shortages (Volkswagen, 2022a). The German automaker's high reputation encourages customers to purchase their cars and makes the company attractive for partnerships. In collaborations, Volkswagen also aims for solid relationships with its suppliers via long-term supply agreements and clear communication, which is advantageous for a stable and secure supply chain.

When analyzing Volkswagen's resources according to the VRIN attributes, the German automaker has valuable resources due to its global network, efficient supply chain, and robust risk assessment and innovation capabilities. The rarity of these resources varies, with the company's unparalleled risk assessment and other intangible resources, such as the reputation and innovative spirit of such a well-established car company, yet to be replicated. Barney (1991) emphasizes that such unique resources are crucial for a firm's sustainable competitive advantage. This is also reflected in their inimitability. While many companies can be innovative, coupling innovation with Volkswagen's car manufacturing knowledge and financial resources makes imitation more challenging. This is also true for the non-substitutability of the automaker's resources, as it takes time for competitors to develop similar capabilities, brand names, and financial resources. This aligns with the RBV's emphasis on inimitability and non-substitutability for sustained competitive advantage (Barney, 1991). Volkswagen is well-positioned to leverage its resources to capture market share in the expansion of its EVs and successfully implement further vertical integration.

4.4.4.3 RBV framework analysis for Ford

Ford Motor Company, a household name in the global automotive industry, boasts vast resources that are pivotal to its operations and strategic positioning. A thorough appraisal of Ford's resources through the Resource-Based View (RBV) lens elucidates the criticality of these resources in engendering a competitive edge for the corporation (Barney, 1991).

Regarding tangible resources, Ford's vast network of manufacturing facilities globally is integral to its supply chain management. These facilities facilitate proximal production, enabling Ford to minimize distribution costs and tailor offerings to specific regional markets (Ford, 2022a). Within the RBV's parameters, physical resources such as infrastructure and production facilities are potent contributors to competitive advantage (Barney, 1991). Complementing these physical resources is Ford's robust financial corpus, allowing it to funnel significant investments into reconfiguring its operational focus, notably towards electro mobility and battery production. The planned inauguration of BlueOval City and BlueOval SK epitomizes Ford's commitment to augmenting its resource base to navigate the ripple effects of the pandemic, a strategy coherent with the RBV's principle of leveraging financial resources to cultivate new capabilities (Barney, 2001; Ford, 2022b, 2023a). Ford uses joint ventures for its rapid SC transition to achieve vertical integration as quickly as possible. The planned battery factory BlueOval SK with its partner SK Innovation is not only a tangible resource in the near future, but the partnership also provides Ford with important intangible resources in the area of battery manufacturing expertise.

Ford's intangible resources, the company's historical legacy, and extensive expertise accumulated over a century of automobile production equip it with invaluable industry insight. According to the RBV, this long-standing institutional knowledge is a potent competitive advantage that is difficult for competitors to emulate (Barney, 1991). Despite the severe repercussions of the pandemic due to Ford's short-term supply agreements, the company showcased commendable resilience and adaptability. In response to these challenges, Ford transitioned from short-term procurement to long-term supply agreements and strategic partnerships, fortifying its access to critical raw materials. This malleability, an indispensable intangible resource within the RBV framework, equips Ford with a robust resilience mechanism to navigate volatile market conditions (Barney, 2001). Additionally, the company's shift towards fostering greater transparency in supplier and subcontractor engagements fortifies its supplier relationships and mitigates potential risks (Ford, 2022a). These intangible resources are instrumental in bolstering Ford's strategic ambitions within the electric vehicle value chain and will significantly influence its trajectory.

In light of the VRIN model, Ford's resources exhibit decent value. The company's adaptability and ability to forge long-term supply relationships in response to the supply chain crisis are highly instrumental. This adaptability is unique because Ford successfully reoriented its supply chain amidst adverse pre-pandemic conditions, unlike Volkswagen and Tesla. While not exclusive to Ford, the company's formidable global reputation and substantial financial resources are rare. The extent to which Ford's adaptability can be replicated remains conjectural due to the absence of comparative data. However, given the time and investment required to cultivate these resources, its knowledge base, financial resources, and brand equity provide Ford with a notable advantage over smaller automotive manufacturers. The non-substitutability of Ford's resources, when contrasted with a competitor like Volkswagen, remains a topic of ongoing debate.

5. Discussion

Supply chains are integral parts of the business for companies in the manufacturing sector. They provide the company with the needed raw materials, and components that the company purchases. Due to uncertainties in the supply chain, recently caused by the Covid-19 pandemic, and severe restrictions and shortages, the supply chain management of the last years had to be questioned. With the research question *"Which supply chain adaptations in the manufacturing industry are required moving forward in the face of uncertain market conditions?"* this paper aimed to investigate whether and how the SC in the manufacturing industry has adapted. The companies Tesla, Volkswagen, and Ford from the automotive industry, with their widely ramified SCs, were examined to identify possible adaptations and possibly also trends based on their SCs.

5.1 Summary of key findings

A distinctive pattern emerges after scrutinizing the data from all three automotive manufacturers. It becomes clear that alterations to supply chains are necessary and have indeed been implemented, as demonstrated by the modifications these case study companies enacted in response to the pandemic.

An overall strategy among all three entities entails establishing long-term procurement of raw materials and components. These automakers have executed long-term supply agreements or fostered joint ventures to stabilize supplies and mitigate price volatility induced by market uncertainties. The scarcities deeply impacted the provision of raw materials needed for electric car production, primarily those used for batteries. Consequently, a critical success determinant in the electric mobility market was securing the availability of these raw materials. This objective was attained through enduring agreements, including offtake agreements, which ensured the future supply amid a burgeoning and uncertain market.

Moreover, a conspicuous similarity among all three automotive manufacturers lies in their collective ambition to possess a larger share of the value chain for electric cars, specifically within the realm of the battery supply chain. Tesla, Volkswagen, and Ford are each keen on expanding vertical integration within the electric vehicle sector. Although the degree of vertical integration varies among these companies, a collective aspiration exists to control the battery value chain as comprehensively as possible in the long term.

In pursuit of this objective, all three automakers are strategizing to internalize battery production and either own or construct factories. Since batteries represent the most substantial cost factor in an electric vehicle, reducing these costs via mass-scale in-house production could significantly decrease overall expenses. Simultaneously, such an approach fortifies the supply chain and could offer consumers a cost-reduced model, thereby augmenting the company's competitiveness and reducing its exposure to uncertainties in supply chains.

5.2 Discussion of key findings

The key findings of the research revealed that car manufacturers are reorganizing their SC and preparing for uncertain and changing market conditions. To achieve this, they rely on long-term solutions, including long-term supply agreements and increased vertical integration.

5.2.1 Long-term supply agreements

Before the pandemic, Tesla and Volkswagen had already recognized the value of long-term supply agreements, a reliance that heightened during the global health crisis. Ford, which had previously obtained its raw materials via short-term market contracts, swiftly adapted its strategy in response to the onset of the pandemic, escalating inflation, and surging commodity prices. Long-term supply agreements afford companies certainty regarding the volumes of a specific raw material they will acquire and facilitate the negotiation of fixed prices, presenting an advantage amidst expanding demand and inflationary prices. For electric vehicle production, critical raw materials such as Lithium, Nickel, and Cobalt, integral to battery manufacturing, are subject to potential shortages or steep price rises due to demand escalation. The three case-study companies anticipated such a scenario or adapted to it, preparing themselves through multi-year contracts to procure raw materials from mining corporations, thereby safeguarding predicted demand and price stability for the years to come.

Tesla has maintained for instance a supply agreement with Ganfeng since 2018 for Lithium, supplemented by additional smaller providers. This agreement was extended in 2022 for another three years until 2025, assuring Tesla of a consistent, predictable Lithium supply (Werwitzke, 2021). Moreover, Tesla's ventures within the junior mining sector underline the growing importance of such agreements for automotive manufacturers. Tesla primarily secured supply agreements with sizeable international mining entities such as Ganfeng pre-pandemic. However, since the pandemic's onset, Tesla initiated discussions with junior miners like Piedmont Lithium regarding future supply agreements via offtake arrangements (Barrera, 2023). Such agreements function by Tesla pledging payment to the non-producing mine for future mined raw materials at a predetermined price, securing a future supply from its yet-to-be-developed mine. Though these agreements harbor higher risks, they offer lower prices to the participating company, demonstrating Tesla's strategic direction to hedge against future shortages and severe price inflation.

Similar strategic moves are evident in Volkswagen's pursuit of long-term supply agreements to secure competitive prices and thus minimize costs. Volkswagen, akin to Tesla, has upheld an agreement for Lithium with Chinese raw material producer Ganfeng since 2019. This ten-year supply agreement substantially aids Volkswagen's ambition to expand its electric fleet extensively. Volkswagen has highlighted securing raw materials as a crucial success factor and a top priority (Volkswagen, 2019). Furthermore, Volkswagen's 2022 annual report indicates that supply challenges and volatility within the raw materials sector are expected to become the norm, with the organization prepared to make necessary adjustments (Volkswagen, 2022a).

Ford's shift towards long-term agreements is most stark. Before the pandemic, the US automaker procured its raw material supply directly from the market but quickly identified the problems linked to pandemic-related disruptions (Ford, 2019). In 2022 alone, Ford recorded over a billion dollars in additional costs due to supplier expenses within the third quarter alone, prompting a thorough reconsideration of its SC and a subsequent restructuring announcement (Wayland, 2022). Consequently, the same year, Ford declared it would pursue long-term, multi-year sourcing deals for raw materials to hedge against volatility and inflation. Examples of such agreements include Ford's supply agreement with Australian mining company Liontown Resources, ensuring a five-year Lithium supply. Additional agreements with SQM for further Lithium deliveries (Bloomberg, 2023b) and BHP for Nickel and other raw materials were also signed (Irwin-Hunt, 2022). This dramatic shift in SC strategy by a traditional American manufacturer like Ford underscores the crucial importance of securing essential raw materials. The stark contrast between Ford's pre-Covid supply strategy and its current approach to securing raw materials reflects the rapidly evolving market dynamics.

According to Covid-19, all three SC strategies of each automaker aligned on long-term supplier relationships to increase safety and secure prices, as well as demand. The market phase of oversupply and fierce competition that depressed prices is over, and increasing demand, as well as more difficult demand, is causing the companies to reshape their strategies in procurement with suppliers.

However, a risk factor that remains, even with long-term supply agreements, is any supply difficulties or failures caused by geopolitical reasons, quality deficiencies, or logistical problems. These can only be further limited by the automotive manufacturers' raw material production, i.e., vertical integration.

5.2.2 Vertical integration

Vertical integration within the SC is seldom the strategy for automotive manufacturers. Historically, cost-effective outsourcing possibilities in the global marketplace have prompted reductions in expenses due to surplus supply and heightened competition. Volkswagen and Ford have capitalized on this market condition, whereas Tesla has partly leaned toward vertical integration, leveraging it as a foundational principle. However, the landscape has altered with the onset of the pandemic, supply constraints, geopolitical unrest, and rising prices, transforming the hitherto favorable market environment for outsourcing. Companies have come to realize the manifold benefits of partial in-house component production. For instance, with battery cell production – a significant cost factor in electric vehicle manufacturing – automakers identified the merits of undertaking this manufacturing step themselves.

From its early days, Tesla has embraced vertical integration, incorporating elements such as software and seat manufacturing, along with sales and charging infrastructure, into its business structure. Tesla produces more in-house hardware and software than most competitors in the automotive industry (Jin, 2022a). In 2020, Elon Musk's enterprise announced concrete plans to reduce battery costs by half, unveiling its self-produced battery in September of the same year (Bleakley, 2023). Two years later, in 2022, Tesla started producing its inaugural batteries in its California-based Megapack factories, with another under construction, slated for completion in 2024, to decrease reliance on Tesla's battery suppliers (Weaver, 2023). Tesla has confirmed that

such a move is crucial for gaining more control over this crucial SC element and implementing necessary modifications (Yoon, 2023b). The firm substantiated these claims during the pandemic with its in-house developed software, which, as a vertically integrated component, allowed for swift responses to missing parts and software rewriting to utilize available alternative parts and tackle other challenges (Tesla, 2022a).
The German manufacturer Volkswagen, despite not being vertically integrated before the pandemic, has since 2020 placed its bets on rapid SC integration in the battery sector. By 2021, it had already laid plans for its future battery production facilities. The Volkswagen Group identifies vertical integration as a success factor for electric vehicles, as evidenced by its specifically designed strategy, NEW AUTO, which envisages an in-house approach to all steps of the battery value chain (Volkswagen, 2021a). The first stride in this direction was taken in the summer of 2022 when Volkswagen established its subsidiary, PowerCo, to oversee all battery-related activities. The initial battery production plant is also under construction, scheduled for operation by 2025 (Günnel, 2022). However, Volkswagen's blueprint for PowerCo by 2030 reveals grander aspirations beyond battery production. Six battery production facilities will be erected in Europe and North America to manufacture batteries close to their markets, thus supplying car factories with minimal delivery complications. This approach reduces supply chain risks and could curtail costs by up to 50%, as projected by Volkswagen (PowerCo, 2023).
Similarly, Ford, which had relied on direct market purchases throughout the Covid-19 pandemic, acknowledged the need for a reassessment of its approach to vertical integration (Weber, 2020). While it expressed skepticism about vertical integration before the pandemic, Ford is now investing considerable efforts in this direction (Halvorson, 2021). In 2021, Ford announced plans to manufacture its battery cells and revealed the development of BlueOval City – a vertically integrated ecosystem – and BlueOval SK (Ford, 2023a; Handelsblatt, 2021). CEO Jim Farley also confirmed Ford would control its battery SC (Yoon, 2023a). The construction of their factories is expected to be completed by 2025, after which they will commence their battery production (Ford, 2022b).

The analysis of the supply chains of all three car manufacturers indicates identical findings. It shows a solid strategic focus and reorientation towards vertical integration in battery production. This serves to secure battery SC and minimize costs.

5.3 SC adaptability of case study firms

The three case-study companies – Tesla, Volkswagen, and Ford – have exhibited pronounced adaptability and transformations in their SCM strategies in response to the disruptions instigated by the pandemic. While the companies occupied varying starting positions at the beginning of the observed period (Time 1), they exhibited very similar strategic orientations in their reactions to the ongoing disturbances in Time 2. This convergence of strategic orientation can primarily be ascribed to the escalating costs of disruptions linked with their pre-pandemic SC strategies.

In the context of TCE, Williamson's influential theory provides a compelling explanation for the strategic changes observed (Williamson, 1981). According to Williamson, uncertainty directly impacts transaction costs, which, in turn, shapes the governance model of an organization. The case-study companies' evolution manifests this interplay quite evidently. The car manufacturers have been steadily shifting their structures toward greater control, implying a heightened degree of integration, which can be interpreted as an adaptive response to minimize transaction costs in an environment of heightened uncertainty.

From a RBV perspective, the flexibility of the firms, particularly Tesla's, can be appreciated in light of their existing resources and capabilities (Barney, 1991). Tesla's established expertise in vertical integration and its integrated processes – such as software development – have given the company an edge in navigating the disruptions. Tesla has demonstrated this advantage by adapting its software to accommodate alternative chips or exclude specific components altogether, thereby managing shortages more efficiently (Jin, 2022a). Furthermore, Tesla's existing vertical processes expedite its SC integration since the firm can optimally leverage its resources to build a competitive advantage in vertical SC integration.

However, Tesla's competitors, too, have displayed remarkable agility in adapting their SCs. Volkswagen, which had previously mostly outsourced its supply chain in the battery sector, has shifted gears and adopted an integrated approach. By establishing its subsidiary PowerCo, Volkswagen has devised a structure to handle the value chain of batteries exclusively. Volkswagen's strategy involves swiftly rolling out its battery factories worldwide. The concentrated competence in this new company division suggests that Volkswagen aims to cultivate its capabilities and resources in battery value chains following the VRIN model (Barney, 1991). The goal is to secure a competitive position in the evolving electric vehicle market.

Lastly, Ford has made significant strides in adjusting to the new SC orientation. The company's evolution from relying on short-term market purchases in 2019 to planning its battery factories in 2021 requires impressive adaptability. Even though the company has so far only started its internal battery production through joint venture this transformation underscores organizations' need to realign their strategies and adapt to the new market situation to gain more control over their supply chains.

The three case-study firms exemplify the necessity for automotive manufacturers to adjust their SCM strategies in the face of unprecedented market disruptions. Following TCT and the RBV, these firms have recognized the value of increased control and integration within their supply chains. While they each embarked on this journey from different starting points, their typical trajectory underlines the pivotal role of strategic adaptability in today's dynamic and uncertain business environment.

5.4 Link to existing literature

The empirical revelations from this study, set against the backdrop of Tesla, Volkswagen, and Ford's strategies, significantly contribute to the rich tapestry of knowledge around SCM and GVCs. The strategies, characterized by their affinity for long-term supply contracts and vertical integration within the realm of battery production, pose intriguing juxtapositions to certain existing narratives within academia.

Notably, a contrarian view is found in vertical disintegration or outsourcing, which has been generously explored in the academic arena (Buckley & Strange, 2015; Harrigan, 1984; T. J. Sturgeon, 2002). This seminal contribution, Harrigan put forth the premise that by strategically outsourcing certain production facets, firms could cultivate superior economies of scale and concentrate on their central competencies. This proposition is at odds with the vertical integration approach observed in the current study. Buckley & Strange further reinforced this assertion in their discourse on the eclectic paradigm and global value chains, emphasizing the pivotal role of outsourcing in the contemporary global business strategy.

Similarly, the study by (Ponte & Ewert, 2009) on the governance of global value chains, focusing on wine production, offers an alternative view. A balanced mix of various supplier relationships could offer flexibility and resilience in the face of potential supply chain disruptions. The researchers make a case for a blend of short-term, medium-term, and long-term supplier contracts to provide firms with the necessary agility to navigate market fluctuations.

However, the present study's findings also reverberate with the echoes of previous literature. The strategic move by Tesla, Volkswagen, and Ford towards long-term supply agreements and a pivot to in-house battery production aligns with the underpinnings of traditional theories around vertical integration as a potent tool to secure critical resources and mitigate risks

(Harland et al., 2003; Tang, 2006). Nevertheless, it is essential to concede that vertical integration introduces its unique challenges, including higher capital requirements and potential loss of flexibility (Harrigan, 1985). Thus, Tesla, Volkswagen, and Ford's strategies should be viewed broadly, contemplating both the potential benefits and the inherent trade-offs.

At the heart of these findings is the GVC paradigm developed by Gereffi, Humphrey, and Sturgeon (Gereffi et al., 2005; Humphrey & Schmitz, 2002; T. J. Sturgeon, 2001). These field luminaries have constructed a matrix that offers a deeper understanding of governance patterns' role within GVCs. Their work eloquently outlines how different modes of governance can significantly influence the distribution of risk and value along the chain. With its complex and geographically diverse supply chains, the automotive industry serves as a template for understanding global value chains. The strategic pivot towards vertical integration and securing long-term supply agreements reflect what Gereffi and his colleagues call a "captive" governance model. This model, characterized by a high degree of explicit coordination and control, provides the lead firm with considerable oversight over their suppliers. Within the automotive sector, the shift towards vertical integration for battery production is a calculated response designed to mitigate supply chain disruptions and ensure a stable supply in an uncertain market.

This current scenario resonates strongly with the findings of Christopher & Towill (2001) who asserted that SC responsiveness is integral to managing and navigating uncertain markets effectively. In the present context, the pandemic has introduced unprecedented uncertainty, necessitating such responsiveness in supply chain management.

The pre-existing SC strategies of the examined companies need to be revised to maintain a competitive edge in this radically altered market landscape. These traditional strategies were optimized for different market conditions, typically characterized by relatively stable demand and supply situations. In contrast, the current market environment, marred by uncertainty and volatility, demands agility and stable supply. This discrepancy between the requirements of the new market environment and the capabilities of the traditional SC strategies points to an urgent need for adaptation.

The ongoing developments underline the validity and relevance of Christopher & Towill (2001) assertion about the centrality of SC responsiveness in uncertain markets. The adaptations being undertaken by Tesla, Volkswagen, and Ford – driven by the need to bolster SC responsiveness – corroborate this proposition. It is thus evident that SC strategies are dynamic entities that need to evolve in line with market shifts to ensure continued competitiveness. The responsiveness of these strategies to the prevailing market environment could be a determining factor in the survival and success of firms in such uncertain times.

5.5 Implications

The elucidated findings from this research project offer an excellent springboard for contemplating future strategies within the automotive and broader manufacturing industries. These conclusions are particularly poignant when considering the complexities of an uncertain operational environment.

In the arena of the automotive industry, the strategic choices made by industrial powerhouses Tesla, Volkswagen, and Ford hold the potential to reshape the industry's landscape. Their commitment to long-term supply agreements and a drive for vertical integration in battery production could position these companies as forerunners in pioneering a new industry standard in risk mitigation and SCM. As the exponential growth in battery technology and the insatiable demand for electric vehicles is witnessed, this approach may unlock a competitive advantage by promoting SC stability and commandeering crucial aspects of production. However, it is pertinent to note that such a strategy requires a robust upfront investment and the orchestration of in-house production processes. This feat is not without its challenges.

Furthermore, the influence of these industry leaders cannot be underestimated, and their strategic choices could catalyze a ripple effect within the sector. Other automotive manufacturers may find themselves at the crossroads, reevaluating their existing SC structures in response to these changes. This, in turn, could instigate a more widespread shift towards vertical integration within the industry, consequently altering the dynamics of supplier relationships and the competitive landscape.

Broadening the lens to the broader manufacturing industry, this research brings to the forefront the potential of vertical integration and long-term supplier agreements as viable strategies for mitigating supply chain uncertainties. Manufacturers operating in various sectors, who face similar challenges in critical raw material scarcity or geopolitical instability, may glean insightful lessons from these case studies. However, it remains vital for companies to critically scrutinize these strategies within their industry-specific dynamics, as the benefits and drawbacks can exhibit significant variance, contingent on the specificities of their products, markets, and SC.

Beyond the immediate sphere of SCM, these unfolding trends could precipitate broader implications. For instance, a marked shift towards vertical integration could recalibrate the balance of power within GVCs, tilting it back towards manufacturers after an extended period of supplier ascendancy. Companies contemplating vertical integration may also find themselves on the precipice of developing new competencies. These may span from direct raw material sourcing, as mentioned by Tesla and Volkswagen already, to developing advanced battery production technologies, leaving a large imprint on their innovation strategies and human resource management paradigms.

To conclude, the trends unearthed in this research project hold the potential to recalibrate strategic thought in the automotive and broader manufacturing sectors. These findings underscore the importance of building SC structures that are adaptable and resilient in the face of an increasingly unpredictable global economic milieu. The choices made by Tesla, Volkswagen, and Ford serve as instructive examples for other firms grappling with SC uncertainties. They could guide the way toward more integrated and secure operational strategies.

5.6 Limitations

Acknowledging the constraints inherent to a study forms a crucial facet of the scholarly inquiry, as it illuminates the potential avenues for enhancement and paves the way for future explorations. As such, several potential limitations pertinent to this master's thesis warrant mention.

To begin with, the research under scrutiny here concentrates on three prominent entities in the automotive arena: Tesla, Volkswagen, and Ford. While these corporations are significant players within the industry, their strategic maneuvers may serve as inaccurate proxies for the holistic automotive industry, notably smaller manufacturers or those operating outside Western markets. These selected companies' unique historical trajectories, resource pools, and market positions could exert significant influence over their strategic choices. These factors might not extrapolate seamlessly to other corporations, rendering the findings potentially ungeneralizable to all automotive manufacturers.

Secondly, another potential limitation is the highly dynamic and swiftly evolving milieu of the electric vehicle and battery production industries. The data harvested, and strategic approaches witnessed during the research timeline may swiftly metamorphose in response to technological advancements, flux in market demand, alterations in policy landscapes, or shifts in the availability of raw materials. This reality could circumscribe the continued relevance of the study's findings.

Thirdly, the study's reliance on secondary data introduces another potential source of limitation. The concomitant biases potentially ingrained in the secondary data sources could limit the depth and breadth of the subsequent analysis. The availability and veracity of the data are subject to the rigor applied by the original data collectors. Confident strategic choices or internal operations of the companies in question may not find their way into the public domain, creating potential lacunas in the available data.

Finally, the strategic lens of this study is tuned to the management of SC primarily from a risk mitigation perspective. While this perspective yields a rich tapestry of insights, it overlooks other critical aspects integral to SC strategy. These could include considerations for cost-effectiveness, operational efficiency, agility, or sustainability measures.

Despite these potential limitations, the study holds merit in its in-depth examination of current trends shaping the strategic landscape of SCM in the automotive industry under uncertainty. Furthermore, these identified limitations accentuate the potential avenues for future research, such as broadening the analysis to encompass a broader range of companies or delving into other facets of supply chain strategy.

5.7 Future research

Delving deeper into the complexities of GVCs specifically in the automotive sector and the broader manufacturing sphere, an evident gap within the current academic literature is recognizable. This uncharted territory offers a promising vista for future scholarly pursuits.

Much of the present literature focuses on specific industrial sectors, often neglecting the interconnectedness of the broader economic landscape. While this thesis primarily focuses on the automotive industry, numerous other sectors, including electronics and renewable energy, are similarly intertwined within the vast networks of GVCs. These industries also grapple with decisions about vertical integration or securing long-term supply agreements. Broadening the academic focus to encompass these sectors could offer critical insights, highlighting similarities and differences that could enhance our understanding of GVCs.

Further, GVCs do not operate in isolation; national and international policies invariably shape their trajectory. However, the current academic discourse needs a comprehensive examination of how trade, environmental, and labor policy shifts impact the structure and strategic direction of GVCs. As we continue to navigate a time characterized by rapid policy changes, understanding their effects on GVCs is a crucial area for scholarly exploration.

Emerging technologies such as AI and blockchain present a new era for GVCs with the potential to revolutionize these global networks. However, there needs to be more academic discourse on how these technologies might reshape governance structures, risk management strategies, and fundamental shifts like vertical integration. This presents a fertile area of research for scholars interested in the intersection of technology and global commerce.

In addition, the intersection of GVCs and sustainability, a key concern in today's world, still needs to be defined in academic literature. As industries grapple with the implications of their environmental impact and societal responsibilities, a closer examination of how these considerations influence their supply chain strategies is warranted.

In the wake of recent global disruptions, such as the COVID-19 pandemic and geopolitical unrest, the stability of GVCs has come to the forefront. This thesis only scratches the surface of this vast field, exploring risk mitigation through vertical integration and supply agreements. However, a broader range of strategies to enhance resilience within GVCs awaits academic exploration.

Finally, this research captures a moment, yet the dynamic nature of industries like the automotive sector demands ongoing analysis. Longitudinal studies could provide a more profound understanding of how vertical integration and supply procurement strategies evolve.

These identified gaps in the scholarship offer promising avenues for researchers looking to deepen the collective understanding of GVCs, SCM, and the intricate interplay between industry, technology, and policy changes. By striving to bridge these gaps, we can contribute to a more nuanced academic picture of the global economic landscape.

6. Conclusion

In embarking on the final chapter of this comprehensive exploration, reflecting upon the transformations and strategic shifts that have rippled through the automotive industry is paramount. Notably, the landscape has been fundamentally reshaped in the face of burgeoning uncertainties and market instabilities in electric vehicle production. The pandemic, oscillating patterns of inflation, coupled with mounting geopolitical tensions, have served as catalysts for a notable disruption in SCs. The chaos has compelled leading automotive manufacturers to fundamentally reconsider their SCM strategies. As a response, a distinct shift towards long-term supply agreements and an increased leaning towards vertical integration have become prominent features of the industry's evolving tableau. This concluding chapter encapsulates the essence of these transformations and attempts to foresee potential future developments within this domain under the shadow of mounting global uncertainty.

6.1 Summary of the key findings of the study

The principal findings of this investigation significantly enrich our comprehension of supply chain management dynamics within the auto industry, specifically concerning unexpected disruptions, as exemplified by the COVID-19 pandemic.

The investigation has shown that Tesla, Volkswagen, and Ford, three major players in the automotive industry, underwent strategic realignments in response to the supply chain disturbances instigated by the pandemic. These modifications significantly departed from their conventional strategies, signaling a clear trend toward enhancing control and predictability within their supply chains.

Essential findings denote that these automakers have adapted their strategies toward procuring long-term supply agreements for critical raw materials. This shift primarily aims to secure a steady inflow of crucial battery production components such as Lithium, Nickel, and Cobalt. Such measures insulate these firms from future raw material shortages and volatile pricing scenarios.

Furthermore, a propensity towards vertical integration has been noticed, notably in battery cell manufacturing. This strategic move seems motivated by the intent to curtail costs and increase control over this key segment of their supply chains.

In essence, the strategic realignments observed among these automakers emphasize the growing importance of supply chain resilience and flexibility in an environment marked by uncertainties and disruptions. These insights accentuate the urgent necessity for automakers to reevaluate and readjust their supply chain strategies, thereby ensuring more controlled and reliable resource procurement in an increasingly unpredictable market landscape.

6.2 Contribution to the literature

The contribution of this study to the existing literature is manifold. Firstly, it enhances the understanding of SCM strategies within the automotive industry under the lens of disruptive events such as a global pandemic. Although the concept of SC adaptation and risk mitigation is extensively discussed in the literature, this study delves into how major automakers – Tesla, Volkswagen, and Ford – have navigated an unprecedented situation and altered their strategies to respond to SC disruptions.

Secondly, it offers a comparative analysis of the strategic shifts among these automakers in reaction to global market changes. From adopting long-term supply agreements to ensuring raw material availability and opting for vertical integration, this study illustrates the dynamic responses of these companies. It maps their strategic trajectory throughout the pandemic. The implications of such shifts, particularly regarding vertical integration and controlling the battery supply chain, are pivotal in contributing to the discourse on future SC strategies in the e-mobility sector.

Furthermore, the research findings exemplify the embodiment of TCE theory, as initially proposed by Williamson (1981), within real-world business decisions. It provides empirical evidence for the theoretical assertion that rising transaction costs and uncertainties instigate companies to seek more control and integration. This study not only upholds this theory but also bridges it with the RBV theory to comprehensively understand how internal and external factors interplay to shape an organization's SC strategy.

Moreover, the analysis of Tesla's vertical integration strategy and quick response to shortages validates Barney (1991) argument about the importance of resource leveraging for creating a competitive advantage. By demonstrating how Tesla's existing resources and competencies facilitated its SC adaptation, the study enriches the RBV literature in crisis management.

Lastly, the research aligns with and further substantiates the assertion by Christopher & Towill (2001) about the importance of supply chain responsiveness in uncertain markets. It underscores the need for a flexible and resilient SC strategy that adapt effectively to market disruptions.

Overall, this study extends the academic conversation on supply chain management and strategic decision-making in times of crisis, providing valuable insights for scholars and industry practitioners alike.

6.3 Final thoughts

As a concluding reflection on this comprehensive analysis, the dynamic shifts in supply chain management within the automotive industry must be underscored, with particular reference to electric vehicle production. The world finds itself on a roller coaster of swift transformation, grappling with unprecedented uncertainty fueled by escalating inflation and geopolitical discord. This turbulence is triggering considerable disruptions within supply chains.

This investigation has presented evidence of significant strategic modifications in the SC landscape among leading automotive manufacturers. This underscores the imperative for these entities to establish increased certainty, command, and predictability in their sourcing protocols. The shift towards long-term supply agreements and the drive towards vertical integration strategies are predominantly informed by an urgent necessity to safeguard supply chains from unexpected disruptions and market fluctuations.

This movement towards more significant vertical integration will most likely persist and gain momentum in the forthcoming period. With an increasingly unpredictable global environment,

there is a strong likelihood that the strategic inclination towards internalized production and control over crucial SC sectors, such as battery cell production, will be further pronounced. Vertical integration appears as a tactical fortification against disruption, offering manufacturers a semblance of stability amidst tumultuous times.
However, the trajectory toward increased integration may be full of obstacles. Greater control frequently demands substantial investment – financial and operational. It also means adopting the risks associated with these sectors that suppliers previously shouldered. Nonetheless, these challenges might be mitigated by the benefits of consolidating SCs and reducing reliance on external dynamics, especially in a climate characterized by soaring uncertainties.

In essence, the trajectory of an uncertain future underscores the crucial requirement for agility, stability, and adaptability within SC strategies. As the world wrestles with unpredictable economic, geopolitical, and environmental conditions, the proactive and strategic recalibrations manifested by Tesla, Volkswagen, and Ford may provide a strategic framework for other automotive or manufacturing entities navigating these uncertain waters. Hence, future research should monitor the continuous metamorphosis within this sector, possibly uncovering additional strategies and practices that may surface in response to evolving adversities.

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8. Appendix

Open coding process

Open coding process						
Automotive company	Supply chain before Covid		Supply chain during Covid		Supply chain post Covid	
	Text	Reference	Text	Reference	Text	Reference
Tesla	Our products use thousands of purchased parts that are sourced from hundreds of suppliers across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assemblies. Certain components purchased from these suppliers are shared or are similar across many product lines, allowing us to take advantage of pricing efficiencies from economies of scale. As is the case for most automotive companies, most of our procured components and systems are sourced from single suppliers.	Tesla annual report 2019 - Page 9	We sell retrofit solar energy systems to customers and channel partners and also make them available through lease and power purchase agreement ("PPA") arrangements and a subscription-based sale of solar power, which is currently available in limited U.S. markets. We purchase most of the components for our retrofit solar energy systems from multiple sources to ensure competitive pricing and adequate supply. We also design and manufacture certain	Tesla annual report 2020 - Page 5	On the other hand, infection rates and regulations continue to fluctuate in various regions and there are ongoing global impacts resulting from the pandemic, including challenges and increases in costs for logistics and supply chains, such as increased port congestion, intermittent supplier delays and a shortfall of semiconductor supply. We have been affected by temporary manufacturing closures, employment and compensation adjustments an impediments to administrative activities sup	Tesla-quarterly-Sept.22
	Certain key components we use have multiple available sources, and we work to qualify multiple suppliers for each such component where it is sensible to do so, in order to minimize production risks owing to disruptions in their supply. We also mitigate risk by maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2019 - Page 9	Among other things, we maintain extensive testing and R&D capabilities for battery cells, packs and systems, and have built an expansive body of knowledge on lithium-ion cell chemistry types and performance characteristics. In order to enable a greater supply of cells for our products with higher energy density at lower costs, we are currently using our expertise to develop a new proprietar	Tesla annual report 2020 - Page 5	We are dependent on our suppliers, including single source suppliers, and the inability of these suppliers to deliver necessary components of our products in a timely manner at prices, quality levels and volumes acceptable to us, or our inability to efficiently manage these components from these suppliers, could have a material adverse effect on our business, prospects, financial condition and operating results	Tesla-quarterly-Sept.22
	Our products use various raw materials including aluminum, steel, cobalt, lithium, nickel and copper. Pricing for these materials is governed by market conditions and may fluctuate due to various factors outside of our control, such as supply and demand and market speculation. We currently believe that we have adequate access to raw materials supplies in order to meet the needs of our operations.	Tesla annual report 2019 - Page 9	Supply Chain Our products use thousands of purchased parts that are sourced from hundreds of suppliers across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assemblies. Certain components purchased from these suppliers are shared or	Tesla annual report 2020 - Page 9	Panasonic has partnered with us on Gigafactory Nevada with investments in the production equipment that it uses to manufacture and supply us with battery cells. Under our arrangement with Panasonic, we plan to purchase the full output from their production equipment at negotiated prices. As the terms of the arrangement convey a finance lease under ASC 842, Leases, we account fo	Tesla-quarterly-Sept.22
	Our products contain thousands of purchased parts that we source globally from hundreds of direct suppliers. We attempt to mitigate our supply chain risk by entering into long-term agreements where it is practical and beneficial to do so, including agreements we entered into with Panasonic to be our manufacturing partner and supplier; qualifying and obtaining components from multiple sources where sensible, such as the PV panels for our retrofit solar installations that we purchase from a variety of suppliers; and maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2019 - Page 18	Similarly, increased demand for personal electronics has created a shortfall of microchip supply, and it is yet unknown how we may be impacted. Sustaining our production trajectory will require the readiness and solvency of our suppliers and vendors, a stable and motivated production workforce and ongoing government cooperation, including for travel and visa allowances. The contingencies inherent in the construction of and ramp at new facilities such as Gigafactory Shanghai, Gigafactory Berlin and Gigafactory Texas may be exacerbated by these challenges	Tesla annual report 2020 - Page 14	We are focused on growing our manufacturing capacity, which includes ramping all of our production vehicles to their installed production capacities as well as increasing production rate and capacity at our current factories. Our production continues to be affected by the industry-wide semiconductor and other component shortages, requiring additional workaround manufacturing and production design solutions to be implemented which may be difficult to sustain. The next phase of production growth will depend on the ramp at Gigafactory Berlin-Brandenburg and Gigafactory	Tesla-quarterly-Sept.22
	However, our limited, and in most cases single-source, supply chain exposes us to multiple potential sources of delivery failure or component shortages for our production, such as those which we experienced in 2012 and 2016 in connection with our slower-than-planned Model S and Model X ramps. Furthermore, unexpected changes in business conditions, materials pricing, labor issues, wars, governmental changes, tariffs, natural disasters such as the March 2011 earthquakes in Japan, health epidemics and other factors beyond our and our suppliers' control could also affect these suppliers' ability to deliver components to us on a timely basis. The loss of any supplier, particularly a single- or limited-source supplier, or the disruption in the supply of components from our suppliers, could lead to product design changes, production delays of key revenue-generating products, idle manufacturing facilities, and potential loss of access to important technology and parts for producing, servicing and supporting our products, any of which could result in negative publicity, damage to our brand and a material and adverse effect on our business, prospects, financial condition and operating results.	Tesla annual report 2019 - Page 18	Global trade conditions and consumer trends that originated during the pandemic continue to persist and may also have long-lasting adverse impact on us and our industries independently of the progress of the pandemic. For example, pandemic-related issues have exacerbated port congestion and intermittent supplier shutdowns and delays, resulting in additional expenses to expedite delivery of critical parts. Similarly, increased demand for personal electronics has created a shortfall of semiconductors, which has caused challenges in our supply chain and production. In addition, labor shortages resulting from the pandemic, including worker absenteeism, may lead to increased difficulty in hiring and retaining manufacturing and service workers, as well as increased labor costs. Sustaining our production trajectory will require the ongoing readiness and solvency of our suppliers and vendors, a stable and motivated production workforce and government cooperation, including for travel and visa allowances. The contingencies inherent in the construction of and ramp at new facilities such as Gigafactory Berlin and Gigafactory Texas may be exacerbated by these challenges	Tesla annual report 2021 - Page 14	For example, a global shortage of semiconductors has been reported since early 2021 and has caused challenges in the manufacturing industry and impacted our supply chain and production as well. In addition, a spike in COVID-19 cases in Shanghai in early 2022 led to temporary manufacturing shutdowns of certain of our suppliers. We have used alternative parts and programmed software to mitigate certain challenges caused by these shortages, but there is no guarantee we may be able to continually do so as we scale production to meet our growth targets. Additionally, if our suppliers do not accurately forecast and effectively allocate production or if they are not willing to allocate sufficient production to us, it may reduce our access to components and require us to search for new suppliers. The unavailability of any component or supplier could result in production delays, idle manufacturing facilities, product design changes and loss of access to important technology and tools for producing and supporting our products, as well as impact our capacity expansion and our ability to fulfill our obligations under	Tesla-quarterly-Sept.22 - page 44
	We may also be impacted by changes in our supply chain or production needs. We have experienced in the past, and may experience in the future, cost increases from certain of our suppliers in order to meet our quality targets and development timelines as well as due to our design changes. Likewise, any significant increases in our production, such as for Model 3 and our expectations for Model Y, has required and/or may in the future require us to procure additional components in a short amount of time. Our suppliers may not ultimately be able to sustainably and timely meet our cost, quality and volume needs, requiring us to replace them with other sources. While we believe that we will be able to secure additional or alternate sources of supply for most of our components in a relatively short time frame, there is no assurance that we will be able to do so or develop our own replacements for certain highly customized components. Additionally, we continuously negotiate with existing suppliers to obtain cost reductions and avoid unfavorable changes to terms, seek new and less expensive suppliers for certain parts, and attempt to redesign certain parts to make them less expensive to produce. If we are unsuccessful in our efforts to control and reduce supplier costs, our operating results will suffer.	Tesla annual report 2019 - Page 18	Our products use thousands of purchased parts that are sourced from hundreds of suppliers across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assemblies. Certain components purchased from these suppliers are shared or are similar across many product lines, allowing us to take advantage of pricing efficiencies from economies of scale. As is the case for most automotive companies, most of our procured components and systems are sourced from single suppliers. Where multiple sources are available for certain key components, we work to qualify multiple suppliers for them where it is sensible to do so in order to minimize production risks owing to disruptions in their supply. We also mitigate risk by maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2021 - Page 8	We will need to maintain and significantly grow our access to battery cells, including through the development and manufacture of our own cells, and control our related costs. We are dependent on the continued supply of lithium-ion battery cells for our vehicles and energy storage products, and we will require substantially more cells to grow our business according to our plans. Currently, we rely on suppliers such as Panasonic and Contemporary Amperex Technology Co. Limited (CATL) for these cells. We have to date fully qualified only a very limited number of such suppliers and have limited flexibility in changing suppliers. Any disruption in the supply of battery cells from our suppliers could limit production of our vehicles and energy storage products. In the long term, we intend to supplement cells from our suppliers with cells manufactured by us, which we believe will be more efficient, manufacturable at greater volumes and more cost-effective than currently available cells. However, our efforts to develop and manufacture such battery cells have required, and may continue to require, significant investments, and there can be	Tesla-quarterly-Sept.22 - page 46
	In addition, beginning in late 2019, the media has reported a public health epidemic originating in China, prompting precautionary government-imposed closures of certain travel and business. Gigafactory Shanghai was closed for a brief time as a result, before it reopened in February 2020 and rejoined our U.S. factories, which had continued to operate. It is unknown whether and how global supply chains, particularly for automotive parts, may be affected if such an epidemic persists for an extended period of time. We may incur expenses or delays relating to such events outside of our control, which could have a material adverse impact on our business, operating results and financial condition.	Tesla annual report 2019 - Page 33	We have previously experienced and may in the future experience launch and production ramp delays for new products and features. For example, we encountered unanticipated supplier issues that led to delays during the initial ramp of our first Model X and experienced challenges with a supplier and with ramping full automation for certain of our initial Model 3 manufacturing processes. In addition, we may introduce in the future new or unique manufacturing processes and design features for our products. There is no guarantee that we will be able to successfully and timely introduce and scale such processes or features.	Tesla annual report 2021 - Page 14	Cylindrical battery cells, the third type on the market, have long been considered the less attractive option because empty gaps between the round cells when stacked together was seen as wasted space. These made up just a fifth of the global market last year. Yet Tesla is betting big that these will become the future industry standard. Its cylindrical 4680 battery cells, named after their size, with a diameter of 46mm and length of 80mm, have been developed to supply energy up to five times that of the batteries currently used in most Tesla cars.	Tesla is disrupting the car battery industry - Financial Times April, 2023
			Our products contain thousands of parts purchased globally from hundreds of suppliers, including single-source direct suppliers, which exposes us to multiple potential sources of component shortages. Unexpected changes in business conditions, materials pricing, labor issues, wars, trade policies, natural disasters such as the March 2011 earthquakes in Japan, health epidemics such as the global COVID-19 pandemic, trade and shipping disruptions, port congestions and other factors beyond our or our suppliers' control could also affect these suppliers' ability to deliver components to us or to remain solvent and operational. For example, a global shortage of semiconductors has been	Tesla annual report 2021 - Page 16	An electric car using a battery fully manufactured in Tesla's Austin and Nevada plants would enable Tesla to qualify for subsidies as well as a sales boost from the thousands of dollars in tax credits for its US buyers. Tesla has ramped up battery production in the US in recent months. Its $2.9bn order to South Korea's L&F to supply it with battery materials — instead of fully made batteries —	Tesla is disrupting the car battery industry - Financial Times April, 2023
			Additionally, if our suppliers do not accurately forecast and effectively allocate production or if they are not willing to allocate sufficient production to us, it may reduce our access to components and require us to search for new suppliers. The unavailability of any component or supplier could result in production delays, idle manufacturing facilities, product design changes and loss of access to important technology and tools for producing and supporting our products, as well as impact our capacity expansion and our ability to fulfill our obligations under customer contracts. Moreover, significant increases in our production, such as for Model 3 and Model Y, or	Tesla annual report 2021 - Page 16	There is nothing new about tensions between manufacturer and supplier. But supplier anxiety is heightened by signs that carmakers want a greater share of the EV value chain, bringing more systems, manufacturing and software design under their control. "From raw material procurement to battery recycling, we want to keep everything in our hands," said Volkswagen chair Herbert Diess recently. "We are increasingly sourcing in, not out." Ford's chief executive Jim Farley in March said he intended to control battery supply chains "all the way back to the mines". The world's big carmakers understandably want to exploit opportunities offered by	Tesla is disrupting the car battery industry - Financial Times April, 2023
			We are dependent on the continued supply of lithium-ion battery cells for our vehicles and energy storage products, and we will require substantially more cells to grow our business according to our plans. Currently, we rely on suppliers such as Panasonic and Contemporary Amperex Technology Co. Limited (CATL) for these cells. We have to date fully qualified only a very limited number of such suppliers and have limited flexibility in changing suppliers. Any disruption in the supply of battery cells from our suppliers could limit production of our vehicles and energy storage products. In the long term, we intend to supplement cells from our suppliers with cells manufactured by us, which we believe will be more efficient, manufacturable at greater volumes and more cost-effective than currently available cells. However, our efforts to develop and manufacture such battery cells have required, and may continue to require, significant investments, and there can be no assurance that we will be able to achieve these targets in the timeframes that we have planned or at all. If we are unable to do so, we may have to curtail our planned vehicle and energy storage product production or procure additional cells from suppliers at potentially greater costs, either of which may harm our business and operating results.	Tesla annual report 2021 - Page 16/17	Tesla held talks with Glencore about taking a stake in the Swiss commodities group, in a sign of how global carmakers are seeking to build ties with the mining industry to secure materials needed for the rollout of electric vehicles. Preliminary discussions about Elon Musk's electric car and battery maker buying 10-20 per cent of Glencore began last year, according to two people familiar with the matter. They continued in March this year, when Glencore chief executive Gary Nagle visited Tesla's factory in Fremont, California, as part of a roadshow for the mining company's annual results. However, the discussions ended with no deal reached, according to the two people. Tesla had concerns over whether Glencore's extensive coal mining business was compatible with the carmaker's environmental goals, and was reluctant to take a minority equity stake. The rise of electric vehicles has prompted concern among carmakers and battery makers about securing supplies of raw materials such as cobalt, lithium and nickel that are needed to manufacture batteries.	Tesla held discussions over taking stake in Glencore
			Our mission to accelerate the world's transition to sustainable energy, engineering expertise, vertically integrated business model and focus on user experience differentiate us from other companies.	Tesla annual report 2021 - Page 4	Elon Musk has indicated he is willing to sacrifice Tesla's profits in the short term in an aggressive push for market share, with the aim of making more money later when the company's cars are fully autonomous and can earn extra fees by operating as "robotaxis". The Tesla chief executive's unconventional justification for why shareholders should stomach lower profits came as the US electric-car maker reported that price cuts this year had driven its profits margins in the first quarter below already-reduced forecasts. Musk's comments on an earnings call on Wednesday pushed Tesla shares lower in after-market trading, adding another 6 per cent to the 10 per cent decline they had suffered since the start of the month on worries about falling demand.	Elon Musk signals willingness to sacrifice Tesla margins for market share
			Tesla was the first carmaker to venture down this path at its landmark battery Day in 2020, with founder Elon Musk saying the company would intervene directly, where necessary, to supplement Public evidence of Tesla moving up the supply chain has so far been relatively muted. But filings last month showed the EV maker has applied for tax breaks to build a potential lithium refinery in Texas or Louisiana. Such a move is seen by many industry observers as necessary to achieve Tesla's ambition of 20mn electric car sales by 2030.	Carmakers take control of supply sourcing as battery costs rise	PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll just tackle whatever set of things are needed to accelerate sustainable energy and doing	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					"PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll just tackle whatever set of things are needed to accelerate sustainable energy and doing mining and refining or buying a mining company provided we think we can change that mining company's trajectory significantly are possibilities. Yeah.""	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					PC: Thank you. Of all the other EV start-ups, which one has impressed you the most? EM: I think the company making the most progress besides Tesla is actually VW which is not a start-up, but could be viewed in some ways as a start-up from an electric vehicle standpoint. So VW is doing the most on the electric vehicle front. I think there will be some very strong companies coming out of China. There's just a lot of super talented and hardworking people in China that strongly believe in manufacturing. And they won't just be burning the midnight oil. They'll be burning the 3am oil. So they won't even leave the factory type of thing. Whereas in America, people are trying to avoid going to work at all.	Transcript: FT interview with Elon Musk - Financia Times May, 2022

					“We were frankly not expecting a multi billion-dollar investment under the current administration. Thus, this is proof that despite some of the bottlenecks and restrictions, companies are still finding Mexico attractive,” Rodolfo Ramos, an economist at Banco Bradesco, wrote in a research note. “This will have an appealing inward-drawing effect for other companies including auto suppliers to consider Mexico for their production needs.” Of course, geography and geopolitics play a massive role in this boom.With China in a new Cold War against the US, and with Russia likely isolated for years to come, many companies are relocating from Asia and Europe to Mexico to tap the benefits of the US-Mexico-Canada trade agreement and export to the US market tariff-free, a process known as nearshoring.By some measure, Mexico's industrial parks are already almost fully occupied and the challenge is to find free space with reliable electricity supply.	New Tesla Gigafactory Marks Mexico's Manufacturing Golden Moment - March 2023
					Tesla Inc.'s Mexican plant will probably require $10 billion in investments in several phases, a game changer for the Nuevo Leon state where it will be based, as global companies rush to relocate to the country's north, Governor Samuel Garcia said. Tesla picked Nuevo Leon, Mexico's industrial cluster hub close to the Texan border, because of its lower costs, availability of workforce and presence of key parts suppliers.	Tesla Mexico Plant Means $10 Billion Investment, Garcia Says - Bloomberg March 2023
					Tesla fired the first shots in the skirmish about three weeks ago. It cut prices by up to a fifth in the US and Europe after first reducing prices in China a second time. The price for models sold in the US fell by $13,000. Tesla dominates EV sales in the US, but more competitors are entering the market. Elon Musk's company accounted for 72 per cent of the 487,000 new EVs sold in 2021, according to research from Kelley Blue Book. A year later the manufacturer's market share fell to 65 per cent of 810,000 electric vehicles, even as its	Electric vehicles defy price war after Ford and Tesla discounts - February 2023
	COMMODITY PRICE TRENDS Geopolitical and economic uncertainty in different forms caused the prices for many raw and input materials to vary in 2019. For example, average prices for raw materials such as crude oil, aluminum, lead, copper and coking coal fell, while prices for iron ore, rare earths, natural rubber and the precious metals palladium and rhodium, among others, rose. Prices for the raw materials that are relevant for e-mobility also developed unevenly: average prices for lithium and cobalt fell, while nickel prices were up on the prior-year level. Based on analyses of factors of influence and trends in the commodity markets, we expect the prices of most commodities to rise in 2020. For the years 2021 to 2024, we continue to expect volatility in the commodity markets with prices trending upwards. We preventively analyze and limit these risks using system-based procurement methods. Long-term, stable supply agreements ensure that the Group's needs are satisfied and guarantee a high degree of supply reliability.	Volkswagen annual report 2019 - page 160	There is a risk of bottlenecks or disruption in supply, as is currently being seen in the case of semiconductor components. Here, the rapid recovery in demand starting in the fourth quarter of 2020, following the pandemic-induced drop in production and sales volumes in the first half of 2020, and the insufficient market capacity of the semiconductor industry combined with high demand from the consumer, IT and telecommunications industries have led to bottlenecks in supply. We intend to safeguard supplies for our production plants by implementing short-term measures and intensifying relationship management and monitoring across the entire supply chain.	Volkswagen annual report 2020 - page 183	In 2022, Volkswagen founded the battery company PowerCo SE that will be responsible for the Group's global battery activities. From the new European battery hub in Salzgitter, this company will manage the development of international factory operations, continuous development of cell technology, vertical integration of the value chain and supplies of machinery and equipment to factories. Other products such as large-scale storage systems for the energy grid are planned for further down the line.	Volkswagen annual report 2022 - page 187
	Operational risks and opportunities The most significant risks from the regular GRC process and QRP lie particularly in the area of cyber security and new regulatory requirements for IT, in quality problems as well as in volatile commodity markets.	Volkswagen annual report 2019 - page	Risks in battery cell production arise particularly from the rising demand for battery cells and the resulting reliance on suppliers, from technological change and from the service life of battery cells. To counter these risks, the Group maintains multiple strategic supplier relationships in order to ensure its supply of batteries in every region.	Volkswagen annual report 2020 - page 183	Vertical integration of value creation is one of the main components of the battery strategy. By building up its own cell production, Volkswagen will progressively take charge of further stages of the value chain so that it can exercise greater influence over the availability, cost and sustainability of key raw materials and other items. Examples include a long-term supply agreement with Vulcan Energy Resources for carbonneutral lithium from the Rhine Rift Valley and a memorandum of understanding with the Canadian government for accelerating the development of sustainable, regional raw material supply chains in North America. Cathode materials have a key role to play in the transformation to e-mobility as a major cost factor and one of the main components in batteries. PowerCo and the Belgian materials technology group Umicore have formed a joint venture that aims to supply cathode and primary materials to the European cell factories starting in 2025. The partners aim to be producing materials for 160 GWh of cell capacity per year by the end of the decade.	Volkswagen annual report 2022 - page 187
	The number of crises and insolvencies among suppliers worldwide increased in 2019. Specialists in restructuring and supply reliability in procurement continuously monitor the financial situation of our suppliers all over the world and take targeted measures to avoid supply bottlenecks. Potential resource shortages, possible speculations on the market as well as current trends in the automotive industry, such as the growing share of electrified vehicles, may also affect the availability and prices of certain raw materials. The raw material and demand trend was continuously analyzed and assessed on an interdisciplinary basis over the reporting year to enable steps to be taken at an early stage in the event of potential bottlenecks.	Volkswagen annual report 2019 - page	The spread of the SARS-CoV-2 virus had a negative impact on business development in fiscal year 2020. Any infectious diseases occurring in the future may also pose a risk of high infection rates among the workforce, resulting in process disruptions in production and non-production areas, for example production stoppages. In the event of the future spread of such diseases, emergency plans to tackle this risk for the purpose of business continuity management will be developed for critical processes, based on the experience of 2020, and incorporated into the risk management systems.	Volkswagen annual report 2020 - page 186	Volkswagen AG sold a total of 1,882,535 (1,775,556) vehicles in fiscal year 2022. During the reporting period, demand recovered from the declines in sales in the prior-year period precipitated by the Covid-19 pandemic. However, the limited vehicle availability due to bottlenecks in the supply of parts caused by the shortage of semiconductors and the Russia-Ukraine conflict had a detrimental impact. In addition, disrupttions in the supply chain resulted in delays. Vehicles sold abroad accounted for a share of 64.1 (66.3) %.	Volkswagen annual report 2022 - page 165
	In addition to financial difficulties, supply risks may arise, for example, as a result of fires or accidents at suppliers. Epidemics such as the current spread of the coronavirus may also cause bottlenecks. Supply risks are identified without delay in procurement through early warning systems and mitigated immediately by applying derived measures. Additional measures were taken to safeguard supply and avert future assembly line stoppages caused by suspensions of deliveries. Specialists in procurement systematically investigate risks resulting from antitrust violations by suppliers and file claims for any damages that arise	Volkswagen annual report 2019 - page 173	The Volkswagen Group's planning is based on the assumption that global economic output will recover overall in 2021, provided successful, lasting containment of the Covid-19 pandemic is achieved. Estimates and assumptions by management were based in particular on assumptions relating to the development of the general economic environment, the automotive markets and the legal environment. These and further assumptions are explained in detail in the Report on Expected Developments, which is part of the group management report.	Volkswagen annual report 2020 - page 244	Supply chain management activities at Procurement are focused on safeguarding supplies during start-up phases and for series production. This entails providing support in our suppliers' industrialization processes, monitoring series production and managing supply crises, for example energy and raw material shortages related to the Covid-19 pandemic and the Russia-Ukraine conflict. Even in the early stages of new projects, we conduct audits to ensure that our suppliers will be able to deliver. Furthermore, we provide support for purchased parts along the individual project milestones up to the start of production. Complex components in particular frequently require onsite support from our supplier management team. Finally, an acceptance test of production capacities is carried out to facilitate the timely start of series production of the vehicles at our plants.	Volkswagen annual report 2022 - page 185
	Short-term changes in customer demand for specific equipment features in our products, and the decreasing predictability of demand, may lead to supply bottlenecks. We minimize this risk, for example, by continuously comparing our available resources against future demand scenarios. If bottlenecks in the supply of materials are indicated, we can introduce countermeasures far enough in advance.	Volkswagen annual report 2019 - page 174	At the same time, we were able to ensure safe working conditions in production with a 100-point plan, maintain global supply chains, and safeguard our liquidity, primarily through targeted warehouse management. Volkswagen showed itself to be robust and capable of excellent performance in a year that saw the biggest crisis in decades. As of the close of the year, the Group recorded around 15% fewer deliveries year-on-year, but saw its global market share increase slightly. Operating profit before special items came to €10.6 billion in 2020. Net liquidity of €26.8 billion – an increase of 25.9% year-on-year – underscores the Group's outstanding solidity.	Volkswagen annual report 2020 - page 9	Thanks to our established crisis management structure and global supplier network, we are able to overcome complex challenges along the supply chain and have access to a wide range of locations and technologies. This structure has been instrumental in helping us cope in particular with the impact of the Russia-Ukraine conflict, which has necessitated the construction of backup sites. Cross-divisional work among Procurement, Quality Assurance, Development, Production and Logistics reduced short-term losses and successfully industrialized the backup sites. The measures pursued as a consequence of the Russia-Ukraine conflict demonstrate that global supplier management is working effectively. However, the precarious supply situation, especially for semiconductors, resulted in limited vehicle availability for customers.	Volkswagen annual report 2022 - page 185
	Battery technology is to become a core competency of the Volkswagen Group. The battery accounts for 20% to 30% of the cost of materials in electric vehicles; in future, it will be one of the most important components when differentiating between products. We have already pooled our in-house expertise in battery cells in a Center of Excellence and at the same time intend to accelerate technological change and the development of expertise through intelligent partnerships. We anticipate that we will need a battery capacity of more than 150 GWh a year in the period to 2025 just to equip our own electric fleet with lithium-ion batteries. To cover this enormous demand, we have defined strategic battery cell suppliers for our most important markets and the first MEB models, and we aim to initiate further long-term strategic partnerships in China, Europe	Volkswagen annual report 2019 - page 139	Vertical integration, which is a strategic component of the newly created Board position, targets key success criteria of the electrification strategy, such as maximizing customer benefit, ensuring competitive cost structures and achieving transparency in the supply chain to safeguard channels critical for supply and crucial to sustainability. In the current business model, overall responsibility for all input materials in the battery cell lies with the battery cell manufacturers. Volkswagen's involvement in the supply chain gives it access to costs and capacity for the materials and raw materials needed for battery production, particularly for lithium, nickel, manganese and cobalt (vertical integration). The objective of intervening in the supply chain is to influence costs and capacity so as to maximize the	Volkswagen annual report 2021 - page 151	Volkswagen will build its first North American battery plant in Canada, as US president Joe Biden's multibillion-dollar package of green incentives speeds up its plans for the rollout of electric vehicles on the continent. Thomas Schmall, head of VW's components unit, said during a visit to the carmaker's factory in Salzgitter, Germany that the “IRA is a big tailwind for us, as it decreases the cost of cells and makes possible a faster ramp-up of EV cars in the US”. Batteries produced at the Canadian factory will supply VW's $2bn electric vehicle plant in South Carolina, which it announced two weeks ago.	Financial Times - volkswagen picks Canada for battery plant after beinglured by US green incentives
	With the FAST (Future Automotive Supply Tracks) initiative, Group Procurement is instrumental in advancing the Volkswagen Group and its supply network with a view to partnerships and future-viability. FAST facilitates the regular exchange of information so that both sides are strongly positioned to cope with the future challenges facing the automotive industry. Based on a set of criteria, a comprehensive assessment of the previous year is disclosed to the suppliers so that improvements can be made together. Alongside the existing supply relationships, strategic agreements on globalization and innovation are still core issues of this exchange. To this end, we take steps to ensure diversification and localization of the supplier portfolio in an effort to reduce economic and geopolitical risks.	Volkswagen annual report 2019 - page 141	As part of our new strategy NEW AUTO, we are stepping up our efforts to forge partnerships, both for the transformation of our core business and for the establishment of the new mobility solutions business. In the field of battery cells, possible risks could arise from potential disagreement with our partners, possible delays in battery cell development or delayed battery cell production. Close interaction with partners in the field of e-mobility in the form of partnerships and joint ventures supports technological change. Examples include the development of a comprehensive charging infrastructure. This cooperation involves risks such as an increased coordination workload, more complex decision-making processes and the loss of expertise. At the same time, opportunities are presented by the	Volkswagen annual report 2021 - page 212	“Our North America strategy is a key priority in our 10-point-plan that we've laid out last year,” said VW chief executive Oliver Blume, referring to the plan he announced when taking over as the head of Europe's largest carmaker. VW has gone further than most rival carmakers to secure resources for batteries by deciding to manufacture cells itself, rather than just assemble batteries.	Financial Times - volkswagen picks Canada for battery plant after beinglured by US green incentives
	Today's market environment is characterized by persistent segmentation, diversification and globalization. We face these challenges with our purchased parts and supplier management, which supports and supervises the supplier processes. From development to series production, we focus on safeguarding the industrialization processes of the purchased parts at the individual supplier locations.	Volkswagen annual report 2019 - page 142	There is a risk of bottlenecks or disruption in supply, as is currently being seen in the case of semiconductor components. Here, the rapid recovery in demand starting in the fourth quarter of 2020, following the pandemic-induced drop in production and sales volumes in the first half of 2020, and the insufficient market capacity of the semiconductor industry combined with high demand from the consumer, IT and telecommunications industries, led to bottlenecks in supply. We intend to safeguard supplies for our production plants by implementing short-term measures along with the use of our relationship management and monitoring across the entire	Volkswagen annual report 2021 - page 194	VW, which has gone beyond most other carmakers to secure increasingly volatile supply chains by announcing plans to not only assemble batteries but also manufacture cells, said two years ago that it would build six gigafactories. Arno Antlitz, VW's chief financial officer, last week said the carmaker “would have done [a North American battery plant] anyway”, but that the new subsidies accelerated its plans.	Financial Times - VW puts European battery plant on hold as it seeks €10bn from US
	Our global, cross-brand production network safeguards the processes from the supplier to the factory and assembly line, and from the factory to dealers and customers. Enduring efficiency is a prerequisite for our competitiveness. We meet challenges of the future with holistic optimizations, forwardlooking innovations, flexible supply streams and structures, and an agile team.	Volkswagen annual report 2019 - page 143	There is also the risk that the latest developments in the Russia-Ukraine conflict will have a negative impact on the supply chain and lead to supply bottlenecks. A global economic slowdown exacerbated by trade disputes and especially the consequences of the Covid-19 pandemic, including sharply increased commodity prices, is impacting the financial situation of many suppliers. This is also giving rise to risks of bottlenecks and disruption in supply.	Volkswagen annual report 2021 - page 194	Volkswagen is ramping up its investments in electric vehicles, committing €180bn over the next five years to manufacture its own batteries and expand in the world's biggest markets in the US and China.	Financial Times - VW ramps up investments in electric car transition with €180bn injection
	Volkswagen is creating its industrial cloud as an open platform with the goal of incorporating companies from the entire value chain. In the long term, the Volkswagen Group aims to integrate its global supply chain with over 30,000 sites of more than 1,500 suppliers and partner companies into the cloud, creating a constantly growing, worldwide ecosystem	Volkswagen annual report 2019 - page 145	Government support measures have stabilized the position of suppliers experiencing financial difficulties as a result of the pandemic. In Germany, for example, new rules on short-time working (Kurzarbeit) and loan support schemes, but also the suspension of the obligation to file for insolvency, have prevented companies from becoming insolvent.	Volkswagen annual report 2021 - page 195	Despite pressure to diversify both supply chains and sales away from China following rising geopolitical tensions, VW aims to use investments to strengthen its position in the country, where it makes half its profits. It has taken the view that China is unlikely to invade Taiwan in the short term because of the shock this would cause to its own economy, according to one person who has been part of internal discussions. Blume said that VW had to “listen to the Chinese customer more strongly”, adding that in-car karaoke machines and the ability to craft avatars were among trends its China-based software division Cariad was developing.	Financial Times - VW ramps up investments in electric car transition with €180bn injection
			Risks in battery cell production arise particularly from the rising demand for battery cells and the resulting reliance on suppliers, from technological change and from the service life of battery cells. Additional risks may arise from the long-term relation to cell manufacturers and the direct responsibility of Volkswagen in the supply chain. To counter these risks, the Volkswagen Group maintains multiple strategic supplier relationships while also increasing its own battery production within the value chain (raw material extraction, cell production).	Volkswagen annual report 2021 - page 195	“Challenges to our supply chains will become the rule, not the exception,” said chief executive Oliver Blume in his first earnings call since taking over nearly two months ago.	Financial Times - VW says supply chain problems are becoming the norm
			Commodity risks can be partially mitigated through backward integration of the supply chain. For example, partnerships and long-term supply agreements with commodity suppliers can be used to ensure supply of the relevant material while also achieving competitive prices. Demand for resources, possible speculations on the market and current trends in the automotive industry, such as the growing share of electrified vehicles, may affect the availability and prices of certain raw materials. Trends in raw materials and demand are continuously analyzed and assessed on an interdisciplinary basis to enable steps to be taken at an early stage in the	Volkswagen annual report 2021 - page 195	VW also logged a €1.9bn non-cash impairment charge related to Argo AI, a USbased driverless car venture that it had backed jointly with Ford, which abruptly shut this week. Blume said VW would continue research and development in the field of autonomous driving with Bosch in Europe and cited its recent €2.4bn investment in Chinese AI chip specialist Horizon Robotics. He added that VW was currently in talks with a further partner in the race to develop self-driving cars	Financial Times - VW says supply chain problems are becoming the norm
			We minimize this risk, for example, by continuously comparing our available resources against future demand scenarios. If bottlenecks in the supply of materials are indicated, we can introduce countermeasures far enough in advance. Production capacity is planned several years in advance based on long-term sales planning for all vehicle projects. This involves a degree of risk as it is subject to market momentum and changes in demand. If forecasts are too optimistic, there is a risk that capacity will not be fully utilized. However, forecasts that are too pessimistic pose a risk of undercapacity, as a result of which, it may not be possible to meet customer demand.	Volkswagen annual report 2021 - page 196	Volkswagen will form joint ventures with Huayou Cobalt and Tsingshan Group to secure nickel and cobalt supplies forelectric vehicles in China, the world's No. 1 car market, and to slash costs at a time of surging raw material prices. The move is part of a 30 billion euro ($33 billion) push by the world's second-largest carmaker to build a network of battery cell factories and secure more direct access to vital raw materials that are needed to supply them.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply
			With our NEW AUTO strategy, we have set the course to make our Group fit for the future. We are transforming ourselves from an automobile manufacturer with fascinating brands and excellent engineering to a vertically integrated mobility company. Battery and charging will become our core competence and source of revenue. By founding our own company under European law, we are bundling our battery activities and occupying all the stages of the value chain that are critical to success. In future, third parties will also be able to become involved in the company – we are not ruling out an IPO.	Volkswagen annual report 2021 - page 5	Volkswagen (VOWG_p.DE) , Huayou Cobalt (603799.SS) and Tsingshan have signed a memorandum of understanding for a joint venture in Indonesia, where more than 10% of the world's laterite nickel ore reserves are located, to focus on nickel and cobalt raw material production. At the final expansion stage of the venture, it will be able to supply raw materials for 160 gigawatt hours worth of electric vehicle batteries, Volkswagen China Group said in a statement.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply
			In the reporting period the Volkswagen Group produced 8,282,954 vehicles (including the Chinese joint ventures), 6.9% less than in the same period of the previous year. The prior year had been marked by the impact of national measures to contain the pandemic, which had led to the disruption of supply chains with production subsequently being halted in the Volkswagen Group. In fiscal year 2021 as well, supply shortages, especially for semiconductors, resulted in production cutbacks so that the total annual production volumes dropped even further.	Volkswagen annual report 2021 - page 112	"The cooperation aims to achieve significant cost advantages, secure the raw material supply and achieve a transparent and sustainable supply chain," it said. "The two partnerships target to contribute to the Group's long term target of a 30-50% cost reduction on each battery." Global nickel prices have surged almost 400% this year due to the Ukraine crisis, as Russia is a major supplier and its invasion of Ukraine and the subsequent imposition of sanctions on Moscow by the West lit a fire under an already hot market.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply

			Whether the higher inflation rates currently being seen in many countries are judged to be temporary or lasting will be crucial here. Base effects resulting from the Covid-19 pandemic and disruption to supply chains could be seen as grounds to assume that they are a temporary phenomenon. We expect interest rates to increase slightly for the years 2023 to 2026.	Volkswagen annual report 2021 - page 113	In a press statement, Volkswagen said: "The cooperation aims to achieve significant cost advantages, secure the raw material supply and achieve a transparent and sustainable supply chain. "The two partnerships target to contribute to the Group's long-term target of a 30%-50% cost reduction on each battery." Volkswagen signed a memorandum of understanding with Huayou Cobalt and Tsingshan to form a JV in Indonesia to focus on the production of nickel and cobalt raw materials. Indonesia is said to hold more than 10% of the laterite nickel ore reserves in the world. Volkswagen expects the JV, at the final expansion stage, to supply raw materials for 160GWh worth of EV batteries. In the second JV with Huayou in China, Volkswagen will focus on refining nickel and cobalt sulfates, precursor and cathode material production. In a press statement, Volkswagen said: "Huayou will utilize its integrated production process to support Volkswagen to further optimize the battery cost and to further reduce CO_2 emissions in the company's Chinese supply chain of new energy vehicles (NEVs)."	Volkswagen plans JVs in Indonesia and China
			The global spread of the SARS-CoV-2 virus has also affected commodity markets. As a result of the imbalance between supply and demand both during the pandemic and during economic recovery the increase in the price of many raw and input materials was very high in relative terms during 2021. Compared with the previous year, there was a rise in the average prices of the commodities coking coal, lithium, crude oil, cobalt, copper, iron ore, natural rubber, aluminum, nickel and lead. The price of the precious metals platinum and palladium, and especially of rhodium, also rose on average over the year. Based on analyses of factors of influence and of trends in the commodity markets, we expect the prices of most commodities to continue to increase in 2022. There is a risk that this will be exacerbated as a result of the RussiaUkraine conflict. For the years 2023 to 2026, we anticipate continued volatility in the commodity markets with prices trending both upwards and downwards.	Volkswagen annual report 2021 - page 180	Upstream Joint Venture with Huayou and Tsingshan in Indonesia Volkswagen, together with Huayou and Tsingshan, intends to form a JV in Indonesia, where more than 10% of the world's laterite nickel ore reserves are located. The partners agreed to jointly invest their respective advantages and resources for battery raw materials production. At the final expansion stage, the total production capacity of raw materials is equal to the supply of 160 GWh battery's demand for nickel and cobalt raw materials.	Volkswagen Group China intends strategic partnerships for battery raw material supply chain
			Volkswagen presented its plan for transforming the Group into a software-driven mobility company with a strong focus on its powerful brands and global technology platforms, providing synergies and scale as well as opening up new profit pools. "We set ourselves a strategic target to become global market leader in electric vehicles – and we are well on track. Now we are setting new parameters," said CEO Herbert Diess during the presentation of NEW AUTO, the Group's strategy through 2030.	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	Downstream Joint Venture with Huayou in Guangxi, China Volkswagen also plans to establish a JV with Huayou for the refining of nickel and cobalt sulfates, precursor and cathode material production. Huayou will utilize its integrated production process to support Volkswagen to further optimize the battery cost and to further reduce CO2 emissions in the company's Chinese supply chain of new energy vehicles (NEVs).	Volkswagen Group China intends strategic partnerships for battery raw material supply chain
			Proprietary battery tech, charging infrastructure and energy services are key success factors in the new mobility world. Therefore, power will be a Volkswagen Group core competency by 2030, with the two pillars "battery cell and system" and "charging and energy" under the roof of the new Group division Technology.Volkswagen Group plans to establish a controlled battery supply chain by setting up new partnerships and tackling all aspects from raw material to recycling. The goal is to create a closed loop in the battery value chain as the most sustainable and cost-	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	"We never used to talk to mining operators -- now we know their business model," VW's Murat Aksel told the ***Automobilwoche* Kongress in Berlin.**	VW tackles the worst supply chain shortages it has seen, purchasing chief says
			Thomas Schmall, CEO Group Components, said: "A Volkswagen-controlled battery supply chain will enable us to have authority over the biggest cost block, offer the best and most sustainable batteries to our customers and secure BEV success. BEVs will become mobile power banks that can be fully integrated in the energy grid through bi-directional charging. This will enable us to generate additional profits from participation in the energy market by 2030."	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	Volkswagen Group is entering into direct purchase agreements in unprecedented areas to tackle the worst supply chain shortages the automaker has seen, its purchasing chief Murat Askel said. VW is also building a database to help predict geopolitical, natural and supply chain risks ahead of time, as it did for financial risks after the 2008 financial crisis, Aksel said. "We never used to talk to mining operators -- now we know their business model," Aksel said. "It is no longer enough to rely on Tier 1 suppliers - we need to look behind the	VW tackles the worst supply chain shortages it has seen, purchasing chief says
			The Volkswagen Group will be a founding member of the Catena-X Automotive Network. The union, which currently consists of 25 partners from the fields of business and science, is pursuing the goal of creating uniform standards for the flow of data and information in the automotive value chain. This should serve as the basis for a digital ecosystem in which automobile manufacturers and suppliers, dealer associations as well as technology suppliers can take part. Volkswagen expects the cross-company, secure and antitrust law compliant data exchange to result in new opportunities for increased efficiency and transparency for production and supply chains	Volkswagen builds supply chain efficiency through industry-wide data exchange - April, 2021		
Volkswagen			The Volkswagen Group has entered into three more strategic partnerships, further strengthening its position in the field of batteries. The new partners are the leading materials technology group Umicore, the battery specialist 24M Technologies, and cleantech company Vulcan Energy Resources Ltd. Although these three partnerships are independent from each other, they share a common goal: The industrialization of battery technology and the volume production of even more sustainable, cutting-edge batteries. The Volkswagen Group is consistently implementing its technology roadmap for the in-house development and production of battery cells, as presented at its Power Day earlier this year. In Europe alone, the Group plans to build six Gigafactories by 2030	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Joint venture with Umicore Volkswagen AG and Umicore, a leader in clean mobility materials, plan to establish a joint venture designed to supply Volkswagen AG's European cell factories with cathode materials. For Volkswagen AG, this is the next logical step towards vertical integration of the supply chain, having already decided to set-up large-scale, in-house production of the unified cell. One key pillar is establishing a long-term partnership that includes the sharing of investments and having a framework to develop next generation technologies, among other things. Moreover, the joint venture aims at jointly building up precursor and cathode material production capacities in	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			In order to develop cutting-edge production technology for its cell plants, Volkswagen AG is investing into Cambridge-based battery start-up 24M, a spin-off from the Massachusetts Institute of Technology (MIT). The goal is to industrialize the 24M technology, a semi-solid process that is an improvement over the dry coating process, in the automotive battery area.	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Volkswagen AG and Vulcan Energy Resources Ltd have signed an agreement regarding the supply of CO2-neutral lithium from the Upper Rhine Valley in Germany. The binding contract focuses on providing lithium hydroxide over a period of five years starting 2026. The product will contribute to securing Volkswagen demand for future in-house cell production both in Germany and Europe. Further aspects of a possible strategic partnership are under negotiation.	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Volkswagen is planning to establish six gigafactories in Europe to cover the growing demand for battery cells within the Group. Battery cell production in Salzgitter is set to start in 2025. The gigafactory in Lower Saxony will produce unified battery cells for the Volkswagen Group's volume segment. In its initial phase, the factory is set to have an annual capacity of 20 gigawatt hours; this is planned to double to 40 gigawatt hours at a later stage. On the basis of the current planning round, the Volkswagen Group is investing heavily in developing battery cell	Volkswagen Group creates European company for its battery business - December, 2021		
			Parallel to the development of these five gigafactories by the newly formed European company, the Swedish start-up Northvolt AB – in which Volkswagen has a stake of around 20 percent – will be building a further factory in Skellefteå in northern Sweden. This will produce battery cells for the premium automotive segment starting in 2023. Northvolt already has an established partnership with the Volkswagen Group in the area of premium battery cells.Volkswagen is forging ahead with the industrialisation of battery technology at all levels of the value chain. This week, the company agreed two strategic partnerships with Umicore and 24M as well as a long-term supply agreement with Vulcan Energy Resources.The goal of the partnerships is to aid the manufacture and procurement of primary materials as well as to optimise battery cell manufacture at the planned gigafactories. The partnerships are designed to build know-how in battery technology and optimize cost management.	Volkswagen Group creates European company for its battery business - December, 2021		
			The Volkswagen Group is pursuing what probably ranks as the most comprehensive electric strategy in the global automotive industry. Over the next five years, the Group will be investing around €52 billion in the development and production of new electric vehicles. The NEW AUTO strategy also covers the development of the new business fields batteries, charging and energy. In addition, the Group is creating dedicated technology platforms that enable cross-brand synergies, including the	Volkswagen Group creates European company for its battery business - December, 2021		
			Dr. Stefan Sommer, Group Board Member for Components and Procurement at Volkswagen Aktiengesellschaft, said: "Over the next ten years the Volkswagen Group will be launching 70-plus new pure electric vehicles. That means approximately a quarter of the vehicles we deliver in 2025 will be powered by electricity. Consequently, there will be a rapid increase in our raw material demand for cell production in the coming years. We must make sure we cover this demand at an early stage. Long-term agreements like the one for lithium, a key raw material, that we have just concluded with Ganfeng are therefore of crucial strategic significance for implementing our electric offensive."	Volkswagen Group secures lithium supplies - April, 2019		
			Michael Bäcker, Head of Corporate Purchasing e-Mobility at Volkswagen Aktiengesellschaft, explained: "With Ganfeng as a strategic partner we are creating a secure basis for planning capacities and costs. The strategic collaboration is the result of an extensive market analysis executed by Volkswagen's e-Raw Material Team. This specialized team is focusing on building close relationships with the raw material industry. Together with	Volkswagen Group secures lithium supplies - April, 2019		
			Several companies have initiated a "Responsible Lithium Partnership" aiming to work towards responsible natural resource management, including lithium, in Chile's Salar de Atacama. This cross-industry partnership is funded at its inception by Volkswagen Group, BASF, Daimler AG, and Fairphone. The partnership intends to foster a dialogue among local stakeholders, generating and synthesizing scientific facts and seeking solutions in a participatory manner.	Volkswagen Group, BASF, Daimler AG and Fairphone start partnership for sustainable Lithium mining in Chile - June 2021		
			Safeguarding supplies of raw materials is a success factor One key success factor is safeguarding supplies of raw materials. The Group is well positioned in this regard. As things currently stand, Volkswagen is confident that it will have sufficient quantities of all the raw materials required to ensure ramp-up of the e-fleet. The Group recently signed a Memorandum of Understanding with Ganfeng on a 10-year agreement relating to Lithium, the main component of a battery. This agreement alone will secure a major part of our lithium needs. Further negotiations with other providers are ongoing. In the meantime, the Group is working systematically to reduce the share of cobalt in batteries – which would also successively reduce the volume of this raw material that would need to be procured. That share is to be cut from the current level of 12 to 14 percent (weight proportion in the cathode) to five percent in the next three to five years. Volkswagen is	Volkswagen - Background: Volkswagen Group's battery strategy - 2021		

			Volkswagen erwartet eine schrittweise Verschiebung der Umsatz- und Profit-Pools: Zunächst von Autos mit Verbrennungsmotor (ICEs) hin zu batterieelektrischen Fahrzeugen (BEVs) und später stärker in Richtung Software und Dienstleistungen. Dieser Trend wird durch das autonome Fahren beschleunigt. Der ICE-Markt dürfte in den nächsten zehn Jahren um über 20 Prozent zurückgehen. Gleichzeitig wird der Absatz von Elektrofahrzeugen schnell wachsen und Verbrennerfahrzeuge als führende Technologie überholen. Mit einem geschätzten Umsatz von 1,2 Billionen Euro könnte Software bis 2030 zusätzlich zum erwarteten Geschäft mit BEVs und ICEs rund ein Drittel des gesamten Mobilitätsmarktes ausmachen. Dieser könnte sich von heute rund zwei auf dann voraussichtlich fünf Billionen Euro mehr als verdoppeln. Individuelle Mobilität wird auch in 2030 voraussichtlich rund 85 Prozent dieses Marktes sowie des Geschäfts von Volkswagen ausmachen.	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität		
			Eigene Batterietechnologie, Ladeinfrastruktur und Energiedienstleistungen sind zentrale Erfolgsfaktoren in der neuen Mobilitätswelt. Deshalb wird Energie bis 2030 eine Kernkompetenz des Volkswagen Konzerns sein, mit den beiden Säulen „Batteriezelle und System" sowie „Laden und Energie" unter dem Dach des neuen Konzernbereichs „Technologie".	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität	The Volkswagen Group and its battery company PowerCo SE founded in July 2022 intend to accelerate the build-up of their global battery business through rapid expansion to North America. Volkswagen CEO Oliver Blume and the Canadian Minister for Innovation, Science and Industry, François-Philippe Champagne, signed in Wolfsburg today an Addendum to the non-binding Memorandum of Understanding (MoU) of August this year to identify suitable sites for a cell factory in Canada. The two parties will continue their cooperation in the areas of battery value creation, raw material supply chains and cathode material production which had been established in August. Furthermore, PowerCo and materials technology group Umicore have agreed to investigate a strategic supply agreement on cathode material for North America. In September, the two companies had announced that they would cooperate in Europe by forming a joint venture for precursor and cathode material production	Volkswagen - Volkswagen Group and PowerCo SE launch site search for first gigafactory in North America - December, 2022
			Der Volkswagen Konzern plant, durch den Aufbau neuer Partnerschaften und die Abdeckung aller Teilbereiche von den Rohstoffen bis zum Recycling eine selbst kontrollierte Batterielieferkette aufzubauen. Das Ziel: Ein geschlossener Kreislauf in der Wertschöpfungskette als nachhaltigster und kostengünstigster Weg zur Herstellung von Batterien. Um dieses Ziel zu erreichen, baut der Volkswagen Konzern seine Batteriekompetenz aus und reduziert die Komplexität. Dazu führt das Unternehmen eine Einheitszelle ein, mit einem Kostensenkungspotenzial von bis zu 50	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität	Additional cathode material agreement between PowerCo and Umicore For the development of the cell production supply chains required in North America, PowerCo SE and Belgian materials technology group Umicore are intensifying their existing cooperation on the development of regional supply chains for sustainable battery materials. The partners today signed an MoU concerning a long-term strategic partnership to secure cathode materials for future cell production in North America.	Volkswagen - Volkswagen Group and PowerCo SE launch site search for first gigafactory in North America - December, 2022
			Volkswagen hatte sich im Juni 2019 mit rund 900 Millionen Euro an Northvolt beteiligt und im Gegenzug rund 20 Prozent der Anteile sowie einen Sitz im Aufsichtsrat erhalten. Die Produktion von Volkswagen Premium-Zellen wird in Zusammenarbeit mit Northvolt in Skellefteå konzentriert. Die Fertigung dieser Zellen soll 2023 starten und das für Volkswagen vorgesehene Volumen schrittweise auf bis zu 40 GWh Jahreskapazität ausgebaut werden. Die zweite Volkswagen Gigafabrik wird in Salzgitter ab 2025 die Einheitszelle für das Volumensegment produzieren und perspektivisch ebenfalls bis zu 40 GWh pro Jahr fertigen. Beide Gigafabriken sollen mit Strom aus erneuerbaren Energien betrieben werden.	Volkswagen investiert weitere 500		
			Nur gut drei Monate später folgte die Kehrtwende. Grund dafür ist Konzerninsidern zufolge das hohe Tempo, das VW von seinem schwedischen Partner verlangte. Volkswagen sei zunehmend frustriert gewesen über die zähen Fortschritte beim Aufbau der Fabrik. Sie sollte den ursprüngliche Planungen zufolge ab 2024 Batteriezellen im großen Umfang produzieren. Volkswagen sei zu der Überzeugung gelangt, dass das junge schwedische Unternehmen mit dem gleichzeitigen Bau einer Fabrik in Schweden überfordert sei und sich besser auf dieses konzentrieren solle. Genau das sieht die neue Strategie nun vor: Northvolt soll für den VW-Konzern in einer neuen Fabrik in Schweden „Premium-Batteriezellen" herstellen, die etwa in Porsche-Modellen Verwendung finden. VW erklärte: Die Produktion der Premium-Zellen werde „in Zusammenarbeit mit Northvolt in der schwedischen Gigafabrik" konzentriert. Die Produktion	Volkswagen in salzgitter		

			Volkswagen has now completed the increase in its stake in Chinese battery cell partner Gotion High-Tech announced last year. Volkswagen is now the largest shareholder in the Chinese battery specialist. The number of Gotion shares held by Volkswagen China rose to 441 million and the shareholding to 26.47 per cent as of 15 December. VW had previously held only a minority stake, as the private placement now completed means VW China has acquired 384 million shares. Since the announcement of the VW investment, Gotion has made enormous progress in expanding its business activities. In September, it announced that it would reach a production capacity of 300 GWh by 2025 – three times as much as previously planned. The company also demonstrated an LFP cell with an energy density of 210 Wh/kg and also started series production of a cell with high nickel content. This is to achieve an energy density of 302 Wh/kg at cell level. While the relationship with Volkswagen has become increasingly close – Gotion has replaced Northvolt as its partner for battery cell production in Salzgitter and is possibly to build VW's unified cell in China – the company has also entered into collaborations with other carmakers. In November, a battery deal was signed with Great Wall, and there has also been a partnership with VinFast since August 2021.	VW is now majority owner of Gotion High-Tech		
			Volkswagen's (VOWG_p.DE) planned European battery cell plants and securing vital raw materials will cost as much as 30 billion euros ($34 billion), board member Thomas Schmall said, putting a price tag on the expansion for the first time. Schmall, who is in charge of technology at Europe's largest carmaker, said in an interview at the Reuters Next conference that Volkswagen would seek outside partners to fund it."We are talking about 25 to 30 billion (euros) ... including the vertical chain of raw materials, not only the factories," the 57-year old said, adding VW would not have to take the lead on funding and was not aiming for a 50/50 investment split. "It depends on the partnership model we will establish in the next months. We're open to discuss it. For us it's necessary that we can control ... the technology roadmap, the timing, the costs and the availability to enable our rollout." Schmall is overseeing Volkswagen's ambitious plan to build six large battery cell plants in Europe by the end of the decade, a strategic pillar in its bid to overtake Tesla (TSLA.O) and become the world's top electric vehicles seller.	VW expects battery, raw material drive to cost up to $34 bln		
			But production capacity is only one part of the equation, Schmall said, adding that Volkswagen also had to make sure it gets enough raw materials, such as lithium and nickel. This requires a more proactive approach and Schmall said that Volkswagen was looking to strike partnerships, with cooperation announcements due "in some weeks". Volkswagen, which plans to submit its next five-year investment plan to the supervisory board on Dec. 9, is pursuing a mix of strategies, which might even include becoming a shareholder in a mining firm. "You will see the full range," Schmall said, also referring to fixed and mixed price contracts with suppliers. "You have to tailor-fit solutions, necessarily, to specific raw materials."	VW expects battery, raw material drive to cost up to $34 bln		

	We are exposed to a variety of market and other risks, including the effects of changes in foreign currency exchange rates, commodity prices, and interest rates, as well as risks to availability of funding sources, hazard events, and specific asset risks. These risks affect our Automotive and Ford Credit segments differently. We monitor and manage these exposures as an integral part of our overall risk management program, which includes regular reports to a central management committee, the Global Risk Management Committee ("GRMC"). The GRMC is chaired by our Chief Financial Officer, and the committee includes our Controller and Chief Financial Officer, Automotive, our Treasurer, and other members of senior management.	Ford annual report - 2019 page 78	Accordingly, any significant future disruption to our production schedule, whether as a result of our own or a supplier's suspension of operations, could have a substantial adverse effect on our financial condition, liquidity, and results of operations. Further, government-sponsored liquidity or stimulus programs in response to COVID-19 may not be available to our customers, suppliers, dealers, or us, and if available, may nevertheless be insufficient to address the impacts of COVID-19. Moreover, our supply and distribution chains may be disrupted by supplier or dealer bankruptcies or their permanent discontinuation of operations.	Ford annual report - 2020 page 16	Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule and specifications, and a shortage of or inability to acquire key components, such as semiconductors, or raw materials, such as lithium, cobalt, nickel, graphite, and manganese, can disrupt Ford's production of vehicles; • To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material suppliers that subject Ford to risks associated with lower future demand for such materials as well as costs that fluctuate and are difficult to accurately forecast	Ford annual report - 2022 page 74
	A work stoppage or other limitation on production could occur at Ford's or its suppliers' facilities for any number of reasons, including as a result of labor issues, including disputes under existing collective bargaining agreements with labor unions or in connection with negotiation of new collective bargaining agreements, absenteeism, public health issues, or in response to potential restructuring actions (e.g., plant closures); as a result of supplier financial distress or other production constraints, quality issues, or other difficulties; as a result of a natural disaster (including climate-related physical risk); or for other reasons.	Ford annual report - 2019 page 13	Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule, and a shortage of key components, such as semiconductors, can disrupt Ford's production of vehicles. Our products contain components that we source globally from suppliers who, in turn, source components from their suppliers. If there is a shortage of a key component in our supply chain, and the component cannot be easily sourced from a different supplier, the shortage may disrupt our production. For example, the automotive industry is facing a significant shortage of semiconductors. With up to fifty modules on a vehicle, we and our competitors who need integrated circuits are experiencing various levels of semiconductor impact. The semiconductor	Ford annual report - 2020 page 16	COVID-19 and Supplier Disruptions. The impact of COVID-19, including changes in consumer behavior, pandemic fears and market downturns, and restrictions on business and individual activities, has created significant volatility in the global economy. Outbreaks in certain regions continue to cause intermittent COVID-19-related disruptions in our supply chain and local manufacturing operations. We also continue to face supplier disruptions due to labor shortages and other production issues, in addition to the continuing semiconductor shortage. Our inconsistent production schedule has been disruptive to our suppliers' operations, which, in turn, has led to higher costs and production shortfalls. Further, actions taken by Russia in Ukraine have impacted and could further impact our suppliers, particularly our lower tier	Ford annual report - 2022 page 35
	Many components used in our vehicles are available only from a single supplier and, therefore, cannot be resourced quickly or inexpensively to another supplier (due to long lead times, new contractual commitments that may be required by another supplier before ramping up to provide the components or materials, etc.). Such single-source suppliers also could threaten to disrupt our production as leverage in negotiations. In addition, when we undertake a model changeover, significant downtime at one or more of our production facilities may be required, and our ability to return to full production may be delayed if we experience production difficulties at one of our facilities or a supplier's facility. Moreover, as vehicles, components, and their integration become more complex, we may face an increased risk of a delay in production of new vehicles. A significant disruption to our production schedule could have a substantial adverse effect on our financial condition or results of operations	Ford annual report - 2019 page 13	Ford's long-term competitiveness depends on the successful execution of its Plan. We previously announced our plan for the global redesign of our business, pursuant to which we are working to turn around automotive operations, compete like a challenger, and capitalize on our strengths by allocating more capital, more resources, and more talent to our strongest business and vehicle franchises. We plan to do so by becoming more customer centric, embracing technology, and adopting processes that emphasize simplicity, speed and agility, efficiency, and accountability.	Ford annual report - 2020 page 16	Commodity and Energy Prices. Prices for commodities remain volatile. In some cases, spot prices for various commodities have recently diverged somewhat, as anticipated weakening in global industrial activity mitigates price increases for base metals such as steel and aluminum, while precious metals (e.g., palladium), and raw materials that are used in batteries for electric vehicles (e.g., lithium, cobalt, nickel, graphite, and manganese, among other materials, for batteries) remain high. The net impact on us and our suppliers has been higher material costs overall. To help ensure supply of raw materials for critical components (e.g., batteries), we, like others in the industry, have entered into multi-year sourcing agreements and may enter into additional agreements.	Ford annual report - 2022 page 35
	Raw Materials. We purchase a wide variety of raw materials from numerous suppliers around the world for use in production of our vehicles. These materials include base metals (e.g., steel and aluminum), precious metals (e.g., palladium), energy (e.g., natural gas), and plastics/resins (e.g., polypropylene). We believe we have adequate supplies or sources of availability of raw materials necessary to meet our needs; however, there always are risks and uncertainties with respect to the supply of raw materials that could impact availability in sufficient quantities and at cost effective prices to meet our needs. See the "Overview" section of Item 7 for a discussion of commodity and energy price trends, and "Item 7A. Quantitative and Qualitative Disclosures about Market Risk" ("Item 7A") for a discussion of commodity price risks.	Ford annual report - 2019 page 3	With the increasing interconnectedness of the global economy, a financial crisis, economic downturn or recession, natural disaster, geopolitical crisis, or other significant event in one area of the world can have an immediate and material adverse impact on markets around the world. Changes in international trade policy can also have a substantial adverse effect on our financial condition or results of operations. For example, steps taken by the U.S. government to apply or consider applying tariffs on automobiles, parts, and other products and materials have the potential to disrupt existing supply chains, impose additional costs on our business, affect the demand for our products, and make us less competitive.	Ford annual report - 2020 page 19	In response to, or in anticipation of, supplier disruptions, we may stockpile certain components or raw materials to help prevent disruption in our production of vehicles. Such actions could have a short-term adverse impact on our cash and increase our inventory. Moreover, in order to secure critical materials for production of electric vehicles, we have entered into and plan to continue to enter into offtake agreements with raw material suppliers and make investments in certain raw material and battery suppliers, including contributing up to $6.6 billion in capital to BlueOval SK, LLC over a five-year period ending in 2026. Such investments, which are part of our plan to invest over $50 billion in electric vehicles through 2026, could have an additional adverse impact on our cash in the near-term.	Ford annual report - 2022 page 63
			The full impact of COVID-19 on future results depends on future developments, such as the ultimate duration and scope of the outbreak (including any potential future waves and the success of vaccination programs) and its impact on our customers, dealers, and suppliers. Despite the successful restart of our manufacturing operations in 2020, we continue to experience higher than normal levels of absenteeism at our manufacturing facilities and intermittent COVID-19-related disruptions in our supply chain. Moreover, new restrictions could have an adverse effect on production, supply chains, distribution, and demand for vehicles.	Ford annual report - 2020 page 32	For the production of our electric vehicles, we are dependent on the supply of batteries and the raw materials (e.g., lithium, cobalt, nickel, graphite, and manganese) used by our suppliers to produce those batteries. As we increase our production of electric vehicles, we expect our need for such materials to increase significantly. At the same time, other companies are increasing their production of electric vehicles, which will further increase the demand for such raw materials. As a result, we may be unable to acquire raw materials needed for electric vehicle production in sufficient amounts that are responsibly sourced or at reasonable prices. As described below under "To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material	Ford annual report - 2022 page 17

			The shortage is due in large part to strong cross-industry demand, which has presented challenges and production disruptions globally, including at our assembly plants. In addition, Renesas Electronics Corporation, a key supplier of semiconductors for the automotive industry and for us in particular, experienced a significant fire at its Naka Factory in March 2021, and COVID-related work restrictions in Southeast Asia have further impacted semiconductor production.	Ford annual report - 2021 page 18	To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material suppliers that subject Ford to risks associated with lower future demand for such materials as well as costs that fluctuate and are difficult to accurately forecast. We have announced plans to significantly increase our electric vehicle production volumes; however, our ability to produce higher volumes of electric vehicles is dependent upon the availability of raw materials necessary for the production of batteries, e.g., lithium, cobalt, nickel, graphite, and manganese, among others. As described above under "Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule and specifications, and a shortage of or inability to acquire key components, such as semiconductors, or raw materials, such as lithium, cobalt, nickel, graphite, and manganese, can disrupt Ford's production of vehicles," to facilitate our access to such raw materials, we have entered into, and expect to continue to enter into, offtake agreements and other long-term purchase contracts. Such agreements obligate us, subject to certain conditions such as quality or minimum output, to purchase a certain percentage or minimum amount of output from raw material suppliers over an agreed upon period of time pursuant to an agreed upon purchase price mechanism that is typically based upon the market price of the material at the time of delivery. Unlike our historical arrangements with suppliers, which are typically annual commitments, under multi-year offtake agreements and other long-term purchase contracts, the risks associated with lower-than-expected electric vehicle production volumes or changes in battery technology that reduce the need for certain raw materials are borne by Ford rather than our suppliers. In the event we do not purchase the materials pursuant to the terms of these agreements, even if	Ford annual report - 2022 page 18
			We previously announced our plan for growth and value creation – Ford+. Ford+ is focused on delivering distinctive and increasingly electric products plus "Always-On" customer relationships and user experiences. Our Ford+ plan is designed to leverage our foundational strengths to build new capabilities – enriching customer experiences and deepening loyalty. As we undertake this transformation of our business, we must integrate our strategic initiatives into a cohesive business model, and balance competing priorities, or we will not be successful. To facilitate this transformation, we are making substantial investments, recruiting new talent, and optimizing our business model, management system, and organization.	Ford annual report - 2021 page 18	In order to secure critical materials for production of electric vehicles, we have entered into and plan to continue to enter into offtake agreements and other long-term purchase contracts with raw materials suppliers and make investments in certain raw material and battery suppliers; however, we may not realize the anticipated benefits of these actions and our efforts to have such suppliers, particularly those in less developed markets, adopt Ford's sustainability and other standards may be unsuccessful, which could have an adverse impact on our reputation. In addition, a restructuring or the implementation of a new or different business strategy may lead to the disruption of our existing business operations, including distracting management from current operations.	Ford annual report - 2022 page 19
			Supplier Disruptions. The automotive industry has a complex supply network with each manufacturers' products containing components sourced from suppliers who, in turn, source components from their suppliers. When there is a shortage of a key component in our supply chain, and the component cannot be easily sourced from a different supplier, the shortage can disrupt production. Since early 2021, we and others in the automotive industry have faced a significant shortage of semiconductors. The global semiconductor shortage is due in large part to makers of semiconductors having allocated their capacity to meet surging demand for consumer electronics during the COVID-19 pandemic while automotive OEMs experienced industry-wide plant closures. At the same time, wafer foundries	Ford annual report - 2021 page 33	The terms of the offtake agreements we have entered into, and those we may enter into in the future, vary by transaction, though they generally obligate us to purchase a certain percentage or minimum amount of output produced by the counterparty over an agreed upon period of time. The purchase price mechanism included in the offtake agreement is typically based on the market price of the material at the time of delivery. The terms also may include conditions to our obligation to purchase the materials, such as quality or minimum output. Subject to satisfaction of those conditions, we will be obligated to purchase the materials at the cost determined by the purchase price mechanism. Based on the offtake agreements we have entered into thus far, the earliest date by which we could be obligated to purchase any output, subject to satisfaction of the	Ford annual report - 2022 page 63
			Pricing Pressure. Over the last year, prices of both new and used vehicles have increased substantially due to both rising demand and supply shortages. It is likely that the rate of price increases will slow down as auto production slowly recovers from the semiconductor shortage, but it is unclear whether prices will decline fully to pre-COVID-19 pandemic levels. Over the long term, intense competition and excess capacity are likely to put downward pressure on inflationadjusted prices for similarly-contented vehicles and contribute to a challenging pricing environment for the automotive industry in most major markets.	Ford annual report - 2021 page 35	June 29 (Reuters) - Liontown Resources Ltd (LTR.AX) signed a lithium supply agreement with Ford Motor Co (F.N), the Australian miner's latest after similar deals earlier this year with Tesla (TSLA.O) and electric vehicle (EV) battery maker LG Energy (373220.KS). Liontown said on Wednesday it will supply Ford with 150,000 dry metric tonnes (DMT) of lithium spodumene concentrate each year for five years from its flagship Kathleen Valley project in Western Australia. The concentrate is a source of lithium essential for making EVs.	Australia's Liontown inks lithium deal with Ford after Tesla, LG agreements

Ford			Our outlook for 2022 assumes the following operating environment: • Supply constraints will remain fluid reflecting a variety of factors, including semiconductor availability and COVID-19 impacts • Wholesales are expected to be up about 10% - 15% year over year • Pricing environment is expected to remain strong, although the interplay between volume and pricing will be dynamic • Inflationary pressures will impact a broad range of costs • Commodity costs will be $1.5 - $2.0 billion higher year over year	Ford annual report - 2021 page 73	At the same time, Ford is transforming its global supply chain management capability to support efficient and reliable sourcing of components, internal development of key technologies and capabilities, and world-class cost and quality execution. John Lawler, Ford's chief financial officer, will lead Ford's global supply chain organization on an interim basis until a chief supply chain officer is selected. Jonathan Jennings, vice president, supply chain, will also take additional responsibility for supplier technical assistance and quality. He will report to Lawler.	Ford Announces Leadership Changes to Strengthen Product Creation and Transform Global Supply Chain Management
					Ford is poised to cut its dependence on Volkswagen technology for its next generation of electric cars in Europe, unravelling a core part of the alliance formed between the rival carmakers two years ago.But from the middle of the decade Ford expects to launch vehicles that use its own in-house system, which is being engineered by Ford in the US, said Martin Sander, the head of electric vehicles in Europe.The two global carmakers formed an alliance in 2020 in order to join forces on electric cars, self-driving technology and commercial vehicles, one of several partnerships across the industry as auto groups team up in the face of rising development bills.	Ford to cut dependence
			GlobalFoundries Inc. (Nasdaq: GFS) (GF), a global leader in feature-rich semiconductor manufacturing, and Ford Motor Company (NYSE: F) today announced a strategic collaboration to advance semiconductor manufacturing and technology development within the United States, aiming to boost chip supplies for Ford and the U.S. automotive industry. The companies have signed a non-binding agreement that opens the door for GF to create further semiconductor supply for Ford's current vehicle lineup and joint research and development to address the growing demand for feature-rich chips to support the automotive industry.	Ford Global foundries - News release - November, 2021	Ford discounted the price on its plug-in Mustang Mach-E car last Monday, weeks after Tesla slashed prices by up to 20 per cent across models. The motor industry seemed on the brink of further reductions for electric vehicles. Headlines declared a price war was on. Then other carmakers stayed on the sidelines. General Motors chief executive Mary Barra said on Tuesday that the company's EVs were priced correctly. Volkswagen declined to cut prices, as did Hyundai and Kia.	Electric vehicles defy price war after Ford and Tesla discounts - February 2023
			"It's critical that we create new ways of working with suppliers to give Ford – and America – greater independence in delivering the technologies and features our customers will most value in the future," said Jim Farley, Ford president and CEO. "This agreement is just the beginning, and a key part of our plan to vertically integrate key technologies and capabilities that will differentiate Ford far into the future."	Ford Global foundries - News release - November, 2021	The three-way nickel processing project – together with a separate supply agreement under development with Ford and Huayou for a precursor cathode active material critical to manufacturing lithium-ion batteries – collectively will combine with Ford's other sourced nickel, significantly contributing to support its EV production targets by the end of 2026.	PT val Indonesia and Huayou sign nickel, March 2023
					"This framework gives Ford direct control to source the nickel we need – in one of the industry's lowest-cost ways – and allows us to ensure the nickel is mined in line with our company's sustainability targets, setting the right ESG standards as we scale," said Lisa Drake, vice president for Ford Model e EV industrialization. "Working this way puts Ford in a position to help make EVs more accessible for millions *and* to do it in a way that helps better protect people and the planet."	PT val Indonesia and Huayou sign nickel, March 2023

Aixle and Selective Coding process

Aixle coding process

Automotive company	Supply chain before Covid		Supply chain during Covid		Supply chain post Covid	
	Text	Reference	Text	Reference	Text	Reference
	Our products use thousands of purchased parts that are sourced from hundreds of suppliers across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assemblies. Certain components purchased from these suppliers are shared or are similar across many product lines, allowing us to take advantage of pricing efficiencies from economies of scale. As is the case for most automotive companies, most of our procured components and systems are sourced from single suppliers.	Tesla annual report 2019 - Page 9	We sell retrofit solar energy systems to customers and channel partners and also make them available through lease and power purchase agreement ("PPA") arrangements and a subscription-based sale of solar power, which is currently available in limited U.S. markets. We pu rchase most of the components for our retrofit solar energy systems from multiple sources to ensure competitive pricin g and adequate supply. We also design and manufacture certain	Tesla annual report 2020 - Page 5	On the other hand, infection rates and regulations continue to fluctuate in various regions a nd there are ongoing global impacts resulting from the pandemic, including challenges and increases in costs for logistics and supply chains, such as increased port congestion, intermittent supplier delays and a shortfall of semiconductor supply. We have b een affected by temporary manufacturing closures, employment and compensation adjustments an impediments to administrative activities sup	Tesla-quarterly-Sept.22
	Certain key components we use have multiple available sources, and we work to qualify multiple suppliers for each such component where it is sensible to do so, in order to minimize production risks owing to disruptions in their supply. We also mitigate risk by maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2019 - Page 9	Among other things, we maintain extensive testing and R&D capabilities for battery c ells, packs and systems, and have built an expansive body of knowledge on lithium-ion cell chemistry types and performance characteristics. In order to enable a greater supply of cells for our products with higher energy density at lower costs, we are currently using our expertise to develop a new proprietar	Tesla annual report 2020 - Page 5	We are dependent on our suppliers, including single source suppliers, and the inability of th ese suppliers to deliver necessary components of our products in a timely manner at prices, quality levels and volumes acceptable to us, or our i nability to efficiently manage these components from these suppliers, could have a material adverse effect on our business, prospects, financial conditio n and operating results	Tesla-quarterly-Sept.22
	Our products use various raw materials including aluminum, steel, cobalt, lithium, nickel and copper. Pricing for these materials is governed by market conditions and may fluctuate due to various factors outside of our control, such as supply and demand and market speculation. We currently believe that we have adequate access to raw materials supplies in order to meet the needs of our operations.	Tesla annual report 2019 - Page 9	Supply Chain Our products use thousands of purchased parts that are sourced from hundreds of supplie rs across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assem blies. Certain components purchased from these suppliers are shared or	Tesla annual report 2020 - Page 9	Panasonic has partnered with us on Gigafactory Nevada with investments in the production e quipment that it uses to manufacture and supply us with battery cells. Under our arrangement with Panasonic, we plan to purchase the full outp ut from their production equipment at negotiated prices. As the terms of the arrangement convey a finance lease under ASC 842, Leases, we account fo	Tesla-quarterly-Sept.22
	Our products contain thousands of purchased parts that we source globally from hundreds of direct suppliers. We attempt to mitigate our supply chain risk by entering into long-term agreements where it is practical and beneficial to do so, including agreements we entered into with Panasonic to be our manufacturing partner and supplier; qualifying and obtaining components from multiple sources where sensible, such as the PV panels for our retrofit solar installations that we purchase from a variety of suppliers; and maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2019 - Page 18	Similarly, increased demand for personal electronics has created a shortfall of microc hip supply, and it is yet unknown how we may be impacted. Sustaining our production trajectory will req uire the readiness and solvency of our suppliers and vendors, a stable and motivated production workforce and ongoing government cooperation, including f or travel and visa allowances. The contingencies inherent in the construction of and ramp at new facilities such as Gigafactory Shanghai, Gigafactory Berlin and Gigafactory Texas may be exacerbated by these challenges.	Tesla annual report 2020 - Page 14	We are focused on growing our manufacturing capacity, which includes ramping all of our production vehicles to their installed production capacities as well as increasing production rate and capacity at our current factories. Our pr oduction continues to be affected by the industry-wide semiconductor and other component shortages, requiring additional workaround manufacturi ng and production design solutions to be implemented which may be difficult to sustain. The next phase of production growth will depend on the r amp at Gigafactory Berlin-Brandenburg and Gigafactory	Tesla-quarterly-Sept.22
	However, our limited, and in most cases single-source, supply chain exposes us to multiple potential sources of delivery failure or component shortages for our production, such as those which we experienced in 2012 and 2016 in connection with our slower- than-planned Model S and Model X ramps. Furthermore, unexpected changes in business conditions, materials pricing, labor issues, wars, governmental changes, tariffs, natural disasters such as the March 2011 earthquakes in Japan, health epidemics, and other factors beyond our and our suppliers' control could also affect these suppliers' ability to deliver components to us on a timely basis. The loss of any supplier, particularly a single- or limited- source supplier, or the disruption in the supply of components from our suppliers, could lead to product design changes, production delays of key revenue-generating products, idle manufacturing facilities, and potential loss of access to important technology and parts for producing, servicing and supporting our products, any of which could result in negative publicity, damage to our brand and a material and adverse effect on our business, prospects, financial condition and operating results.	Tesla annual report 2019 - Page 18	Global trade conditions and consumer trends that originated during the pandemic continue to persist and may also have long-lasting adverse impact on us and our industries independently of the progress of the pandemic. For example, pandemic-related issues have exacerbated port congestion and intermittent supplier shutdowns and delays, resulting in additional expenses to expedite delivery of critical parts. Similarly, increased demand for personal electronics has created a shortfall of semiconductors, which has caused challenges in our supply chain and production. In addition, labor shortages resulting from the pandemic, including worker absenteeism, may lead to increased difficulty in hiring and retaining manufacturing and service workers, as well as increased labor costs. Sustaining our production trajectory will require the ongoing readiness and solvency of our suppliers and vendors, a stable and motivated production workforce and government cooperation, including for travel and visa allowances. The contingencies inherent in the construction of, and ramp at, new facilities such as Gigafactory Berlin and Gigafactory Texas may be exacerbated by these challenges.	Tesla annual report 2021 - Page 14	For example, a global shortage of semiconductors has been reported since early 2021 and has caused challenges in the manufacturing industry and impacted our supply chain and production as well. In addition, a spike in COVID-19 cases in Shanghai in early 2022 led to temporary manufacturing shutdowns of certain of our suppliers. We have used alternative parts and programmed software to mitigate certain challenges caused by these shortages, but there is no guarantee we may be able to continually do so as we scale production to meet our growth targets. Additionally, if our suppliers do not accurately forecast and effectively allocate production or if they are not willing to allocate sufficient production to us, it may reduce our access to components and require us to search for new suppliers. The unavailability of any component or supplier could result in production delays, idle manufacturing facilitie s, product design changes and loss of access to important technology and tools for producing and supporting our products, as well as impact our capac ity expansion and our ability to fulfill our obligations under	Tesla-quarterly-Sept.22 - page 44
	We may also be impacted by changes in our supply chain or production needs. We have experienced in the past, and may experience in the future, cost increases from certain of our suppliers in order to meet our quality targets and development timelines as well as due to our design changes. Likewise, any significant increases in our production, such as for Model 3 and our expectations for Model Y, has required and/or may in the future require us to procure additional components in a short amount of time. Our suppliers may not ultimately be able to sustainably and timely meet our cost, quality and volume needs, requiring us to replace them with other sources. While we believe that we will be able to secure additional or alternate sources of supply for most of our components in a relatively short time frame, there is no assurance that we will be able to do so or develop our own replacements for certain highly customized components. Additionally, we continuously negotiate with existing suppliers to obtain cost reductions and avoid unfavorable changes to terms, seek new and less expensive suppliers for certain parts, and attempt to redesign certain parts to make them less expensive to produce. If we are unsuccessful in our efforts to control and reduce supplier costs, our operating results will suffer.	Tesla annual report 2019 - Page 18	Our products use thousands of purchased parts that are sourced from hundreds of suppliers across the world. We have developed close relationships with vendors of key parts such as battery cells, electronics and complex vehicle assemblies. Certain components purchased from these suppliers are shared or are similar across many product lines, allowing us to take advantage of pricing efficiencies from economies of scale. As is the case for most automotive companies, most of our procured components and systems are sourced from single suppliers. Where multiple sources are available for certain key components, we work to qualify multiple suppliers for them where it is sensible to do so in order to minimize production risks owing to disruptions in their supply. We also mitigate risk by maintaining safety stock for key parts and assemblies and die banks for components with lengthy procurement lead times.	Tesla annual report 2021 - Page 8	We will need to maintain and significantly grow our access to battery cells, including throu gh the development and manufacture of our own cells, and control our related costs. We are dependent on the continued supply of lithium-ion battery cells for our vehicles and energy storage products, and we will require substantially more cells to grow our business according to our plans. Currently, we rely on s uppliers such as Panasonic and Contemporary Amperex Technology Co. Limited (CATL) for these cells. We have to date fully qualified only a ver y limited number of such suppliers and have limited flexibility in changing suppliers. Any disruption in the supply of battery cells from our suppliers could li mit production of our vehicles and energy storage products. In the long term, we intend to supplement cells from our suppliers with cells manufactured by us, which we believe will be more efficient, manufacturable at greater volumes and more cost-effective than currently available cells. However, our efforts to develop and manufacture su ch battery cells have required, and may continue to require, significant investments, and there can be	Tesla-quarterly-Sept.22 - page 46
	In addition, beginning in late 2019, the media has reported a public health epidemic originating in China, prompting precautionary government-imposed closures of certain travel and business. Gigafactory Shanghai was closed for a brief time as a result, before it reopened in February 2020 and rejoined our U.S. factories, which had continued to operate. It is unknown whether and how global supply chains, particularly for automotive parts, may be affected if such an epidemic persists for an extended period of time. We may incur expenses or delays relating to such events outside of our control, which could have a material adverse impact on our business, operating results and financial condition.	Tesla annual report 2019 - Page 33	We have previously experienced and may in the future experience launch and production ramp delays for new products and features. For example, we encountered unanticipated supplier issues that led to delays during the initial ramp of our first Model X and experienced challenges with a supplier and with ramping full automation for certain of our initial Model 3 manufacturing processes. In addition, we may introduce in the future new or unique manufacturing processes and design features for our products. There is no guarantee that we will be able to successfully and timely introduce and scale such processes or features.	Tesla annual report 2021 - Page 14	Cylindrical battery cells, the third type on the market, have long been considered the less attractive option because empty gaps between the round cells when stacked together was seen as wasted space. These made up just a fifth of the global market last year. Yet Tesla is betting big that these will become the future industry standard. Its cylindrical 4680 battery cells, named after their size, with a diameter of 46mm and length of 80mm, have been developed to supply energy up to five times that of the batteries currently used in most Tesla cars.	Tesla is disrupting the car battery industry - Financial Times April, 2023

Tesla			Our products contain thousands of parts purchased globally from hundreds of suppliers, including single-source direct suppliers, which exposes us to multiple potential sources of component shortages. Unexpected changes in business conditions, materials pricing, labor issues, wars, trade policies, natural disasters such as the March 2011 earthquakes in Japan, health epidemics such as the global COVID-19 pandemic, trade and shipping disruptions, port congestions and other factors beyond our or our suppliers' control could also affect these suppliers' ability to deliver components to us or to remain solvent and operational. For example, a global shortage of semiconductors has been	Tesla annual report 2021 - Page 16	An electric car using a battery fully manufactured in Tesla's Austin and Nevada plants would enable Tesla to qualify for subsidies as well as a sales boost from the thousands of dollars in tax credits for its US buyers. Tesla has ramped up battery production in the US in recent months. Its $2.9bn order to South Korea's L&F to supply it with battery materials — instead of fully made batteries —	Tesla is disrupting the car battery industry - Financial Times April, 2023
			Additionally, if our suppliers do not accurately forecast and effectively allocate production or if they are not willing to allocate sufficient production to us, it may reduce our access to components and require us to search for new suppliers. The unavailability of any component or supplier could result in production delays, idle manufacturing facilities, product design changes and loss of access to important technology and tools for producing and supporting our products, as well as impact our capacity expansion and our ability to fulfill our obligations under customer contracts. Moreover, significant increases in our production, such as for Model 3 and Model Y, or	Tesla annual report 2021 - Page 16	There is nothing new about tensions between manufacturer and supplier. But supplier anxiety is heightened by signs that carmakers want a greater share of the EV value chain, bringing more systems, manufacturing and software design under their control. "From raw material procurement to battery recycling, we want to keep everything in our hands," said Volkswagen chair Herbert Diess recently. "We are increasingly sourcing in, not out." Ford's chief executive Jim Farley in March said he intended to control battery supply chains "all the way back to the mines". The world's big carmakers understandably want to exploit opportunities offered by	Tesla is disrupting the car battery industry - Financial Times April, 2023
			We are dependent on the continued supply of lithium-ion battery cells for our vehicles and energy storage products, and we will require substantially more cells to grow our business according to our plans. Currently, we rely on suppliers such as Panasonic and Contemporary Amperex Technology Co. Limited (CATL) for these cells. We have to date fully qualified only a very limited of such suppliers and have limited flexibility in changing suppliers. Any disruption in the supply of battery cells from our suppliers could limit production of our vehicles and energy storage products. In the long term, we intend to supplement cells from our suppliers with cells manufactured by us, which we believe will be more efficient, manufacturable at greater volumes and more cost-effective than currently available cells. However, our efforts to develop and manufacture such battery cells have required, and may continue to require, significant investments, and there can be no assurance that we will be able to achieve these targets in the timeframes that we have planned or at all. If we are unable to do so, we may have to curtail our planned vehicle and energy storage product production or procure additional cells from suppliers at potentially greater costs, either of which may harm our business and operating results.	Tesla annual report 2021 - Page 16/17	Tesla held talks with Glencore about taking a stake in the Swiss commodities group, in a sign of how global carmakers are seeking to build ties with the mining industry to secure materials needed for the rollout of electric vehicles. Preliminary discussions about Elon Musk's electric car and battery maker buying 10-20 per cent of Glencore began last year, according to two people familiar with the matter. They continued in March this year, when Glencore chief executive Gary Nagle visited Tesla's factory in Fremont, California, as part of a roadmap for the mining company's annual results. However, the discussions ended with no deal reached, according to the two people. Tesla had concerns over whether Glencore's extensive coal mining business was compatible with the carmaker's environmental goals, and was reluctant to take a minority equity stake. The rise of electric vehicles has prompted concern among carmakers and battery makers about securing supplies of raw materials such as cobalt, lithium and nickel that are needed to manufacture batteries.	Tesla held discussions over taking stake in Glencore
			Our mission to accelerate the world's transition to sustainable energy, engineering expertise, vertically integrated business model and focus on user experience differentiate us from other companies.	Tesla annual report 2021 - Page 4	Elon Musk has indicated he is willing to sacrifice Tesla's profits in the short term in an aggressive push for market share, with the aim of making more money later when the company's cars are fully autonomous and can earn extra fees by operating as "robotaxis". The Tesla chief executive's unconventional justification for why shareholders should stomach lower profits came as the US electric-car maker reported that price cuts this year had driven its profits margins in the first quarter below already-reduced forecasts. Musk's comments on an earnings call on Wednesday pushed Tesla shares lower in after-market trading, adding another 6 per cent to the 10 per cent decline they had suffered since the start of the month on worries about falling demand.	Elon Musk signals willingness to sacrifice Tesla margins for market share
			Tesla was the first carmaker to venture down this path at its landmark Battery Day in 2020, with founder Elon Musk saying the company would intervene directly, where necessary, to supplement. Public evidence of Tesla moving up the supply chain has so far been relatively muted. But filings last month showed the EV maker has applied for tax breaks to build a potential lithium refinery in Texas or Louisiana. Such a move is seen by many industry observers as necessary to achieve Tesla's ambition of 20mn electric car sales by 2030.	Carmakers take control of supply sourcing as battery costs rise	PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll just tackle whatever set of things are needed to accelerate sustainable energy and doing	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					PC: You've obviously done a number of mining deals trying to secure raw materials. Do you think you could ever go a step further and actually buy a mining company in the future? EM: It's not out of the question. We will address whatever the limitations are on accelerating the world's transition to sustainable energy. It's not that we wish to buy mining companies but if that's the only way to accelerate the transition, then we will do that. There are no arbitrary limitations on what's needed to accelerate sustainable energy. We'll just tackle whatever set of things are needed to accelerate sustainable energy and doing mining and refining or buying a mining company provided we think we can change that mining company's trajectory significantly are possibilities. Yeah.'"	Transcript: FT interview with Elon Musk - Financia Times May, 2022
					PC: Thank you. Of all the other EV start-ups, which one has impressed you the most? EM: I think the company making the most progress besides Tesla is actually VW which is not a start-up, but could be viewed in some ways as a start-up from an electric vehicle standpoint. So VW is doing the most on the electric vehicle front. I think there will be some very strong companies coming out of China. There's just a lot of super talented and hardworking people in China that strongly believe in manufacturing. And they won't just be burning the midnight oil. They'll be burning the 3am oil. So they won't even leave the factory type of thing. Whereas in America, people are trying to avoid going to work at all.	Transcript: FT interview with Elon Musk - Financia Times May, 2022

					"We were frankly not expecting a multi billion-dollar investment under the current administration. Thus, this is proof that despite some of the bottlenecks and restrictions, companies are still finding Mexico attractive," Rodolfo Ramos, an economist at Banco Bradesco, wrote in a research note. "This will have an appealing inward-drawing effect for other companies including auto suppliers to consider Mexico for their production needs." Of course, geography and geopolitics play a massive role in this boom. With China in a new Cold War against the US, and with Russia likely isolated for years to come, many companies are relocating from Asia and Europe to Mexico to tap the benefits of the US-Mexico-Canada trade agreement and export to the US market tariff-free, a process known as nearshoring. By some measure, Mexico's industrial parks are already almost fully occupied and the challenge is to find free space with reliable electricity supply.	New Tesla Gigafactory Marks Mexico's Manufacturing Golden Moment - March 2023
					Tesla Inc.'s Mexican plant will probably require $10 billion in investments in several phases, a game changer for the Nuevo Leon state where it will be based, as global companies rush to relocate to the country's north, Governor Samuel Garcia said. Tesla picked Nuevo Leon, Mexico's industrial cluster hub close to the Texan border, because of its lower costs, availability of workforce and presence of key parts suppliers.	Tesla Mexico Plant Means $10 Billion Investment, Garcia Says - Bloomberg March 2023
					Tesla fired the first shots in the skirmish about three weeks ago. It cut prices by up to a fifth in the US and Europe after first reducing prices in China a second time. The price for models sold in the US fell by $13,000. Tesla dominates EV sales in the US, but more competitors are entering the market. Elon Musk's company accounted for 72 per cent of the 487,000 new EVs sold in 2021, according to research from Kelley Blue Book. A year later the manufacturer's market share fell to 65 per cent of 810,000 electric vehicles, even as its	Electric vehicles defy price war after Ford and Tesla discounts - February 2023
	COMMODITY PRICE TRENDS Geopolitical and economic uncertainty in different forms caused the prices for many raw and input materials to vary in 2019. For example, average prices for raw materials such as crude oil, aluminum, lead, copper and coking coal fell, while prices for iron ore, rare earths, natural rubber and the precious metals palladium and rhodium, among others, rose. Prices for the raw materials that are relevant for e-mobility also developed unevenly: average prices for lithium and cobalt fell, while nickel prices were up on the prior-year level. Based on analyses of factors of influence and trends in the commodity markets, we expect the prices of most commodities to rise in 2020. For the years 2021 to 2024, we continue to expect volatility in the commodity markets with prices trending upwards. We preventively analyze and limit these risks using system-based procurement methods. Long-term, stable supply agreements ensure that the Group's needs are satisfied and guarantee a high degree of supply reliability.	Volkswagen annual report 2019 - page 160	There is a risk of bottlenecks or disruption in supply, as is currently being seen in the case of semiconductor components. Here, the rapid recovery in demand starting in the fourth quarter of 2020, following the pandemic-induced drop in production and sales volumes in the first half of 2020, and the insufficient market capacity of the semiconductor industry combined with high demand from the consumer, IT and telecommunications industries have led to bottlenecks in supply. We intend to safeguard supplies for our production plants by implementing short-term measures and intensifying relationship management and monitoring across the entire supply chain.	Volkswagen annual report 2020 - page 183	In 2022, Volkswagen founded the battery company PowerCo SE that will be responsible for the Group's global battery activities. From the new European battery hub in Salzgitter, this company will manage the development of international factory operations, continuous development of cell technology, vertical integration of the value chain and supplies of machinery and equipment to factories. Other products such as large-scale storage systems for the energy grid are planned for further down the line.	Volkswagen annual report 2022 - page 187
	Operational risks and opportunities The most significant risks from the regular GRC process and QRP lie particularly in the area of cyber security and new regulatory requirements for IT, in quality problems as well as in volatile commodity markets.	Volkswagen annual report 2019 - page	Risks in battery cell production arise particularly from the rising demand for battery cells and the resulting reliance on suppliers, from technological change and from the service life of battery cells. To counter these risks, the Group maintains multiple strategic supplier relationships in order to ensure its supply of batteries in every region.	Volkswagen annual report 2020 - page 183	Vertical integration of value creation is one of the main components of the battery strategy. By building up its own cell production, Volkswagen will progressively take charge of further stages of the value chain so that it can exercise greater influence over the availability, cost and sustainability of key raw materials and other items. Examples include a long-term supply agreement with Vulcan Energy Resources for carbonneutral lithium from the Rhine Rift Valley and a memorandum of understanding with the Canadian government for accelerating the development of sustainable, regional raw material supply chains in North America. Cathode materials have a key role to play in the transformation to e-mobility as a major cost factor and one of the main components in batteries. PowerCo and the Belgian materials technology group Umicore have formed a joint venture that aims to supply cathode and primary materials to the European cell factories starting in 2025. The partners aim to be producing materials for 160 GWh of cell capacity per year by the end of the decade.	Volkswagen annual report 2022 - page 187
	The number of crises and insolvencies among suppliers worldwide increased in 2019. Specialists in restructuring and supply reliability in procurement continuously monitor the financial situation of our suppliers all over the world and take targeted measures to avoid supply bottlenecks. Potential resource shortages, possible speculations on the market as well as current trends in the automotive industry, such as the growing share of electrified vehicles, may also affect the availability and prices of certain raw materials. The raw material and demand trend was continuously analyzed and assessed on an interdisciplinary basis over the reporting year to enable steps to be taken at an early stage in the event of potential bottlenecks.	Volkswagen annual report 2019 - page	The spread of the SARS-CoV-2 virus had a negative impact on business development in fiscal year 2020. Any infectious diseases occurring in the future may also pose a risk of high infection rates among the workforce, resulting in process disruptions in production and non-production areas, for example production stoppages. In the event of the future spread of such diseases, emergency plans to tackle this risk for the purpose of business continuity management will be developed for critical processes, based on the experience of 2020, and incorporated into the risk management systems.	Volkswagen annual report 2020 - page 186	Volkswagen AG sold a total of 1,882,535 (1,775,556) vehicles in fiscal year 2022. During the reporting period, demand recovered from the declines in sales in the prior-year period precipitated by the Covid-19 pandemic. However, the limited vehicle availability due to bottlenecks in the supply of parts caused by the shortage of semiconductors and the Russia-Ukraine conflict had a detrimental impact. In addition, disruptions in the supply chain resulted in delays. Vehicles sold abroad accounted for a share of 64.1 (66.3) %.	Volkswagen annual report 2022 - page 165

	In addition to financial difficulties, supply risks may arise, for example, as a result of fires or accidents at suppliers. Epidemics such as the current spread of the coronavirus may also cause bottlenecks. Supply risks are identified without delay in procurement through early warning systems and mitigated immediately by applying derived measures. Additional measures were taken to safeguard supply and avert future assembly line stoppages caused by suspensions of deliveries. Specialists in procurement systematically investigate risks resulting from antitrust violations by suppliers and file claims for any damages that arise	Volkswagen annual report 2019 - page 173	The Volkswagen Group's planning is based on the assumption that global economic output will recover overall in 2021, provided successful, lasting containment of the Covid-19 pandemic is achieved. Estimates and assumptions by management were based in particular on assumptions relating to the development of the general economic environment, the automotive markets and the legal environment. These and further assumptions are explained in detail in the Report on Expected Developments, which is part of the group management report.	Volkswagen annual report 2020 - page 244	Supply chain management activities at Procurement are focused on safeguarding supplies during start-up phases and for series production. This entails providing support in our suppliers' industrialization processes, monitoring series production and managing supply crises, for example energy and raw material shortages related to the Covid-19 pandemic and the Russia-Ukraine conflict. Even in the early stages of new projects, we conduct audits to ensure that our suppliers will be able to deliver. Furthermore, we provide support for purchased parts along the individual project milestones up to the start of production. Complex components in particular frequently require onsite support from our supplier management team. Finally, an acceptance test of production capacities is carried out to facilitate the timely start of series production of the vehicles at our plants.	Volkswagen annual report 2022 - page 185
	Short-term changes in customer demand for specific equipment features in our products, and the decreasing predictability of demand, may lead to supply bottlenecks. We minimize this risk, for example, by continuously comparing our available resources against future demand scenarios. If bottlenecks in the supply of materials are indicated, we can introduce countermeasures far enough in advance.	Volkswagen annual report 2019 - page 174	At the same time, we were able to ensure safe working conditions in production with a 100-point plan, maintain global supply chains, and safeguard our liquidity, primarily through targeted warehouse management. Volkswagen showed itself to be robust and capable of excellent performance in a year that saw the biggest crisis in decades. As of the close of the year, the Group recorded around 15% fewer deliveries year-on-year, but saw its global market share increase slightly. Operating profit before special items came to €10.6 billion in 2020. Net liquidity of €26.8 billion – an increase of 25.9% year-on-year – underscores the Group's outstanding solidity.	Volkswagen annual report 2020 - page 9	Thanks to our established crisis management structure and global supplier network, we are able to overcome complex challenges along the supply chain and have access to a wide range of locations and technologies. This structure has been instrumental in helping us cope in particular with the impact of the Russia-Ukraine conflict, which has necessitated the construction of backup sites. Cross-divisional work among Procurement, Quality Assurance, Development, Production and Logistics reduced short-term losses and successfully industrialized the backup sites. The measures pursued as a consequence of the Russia-Ukraine conflict demonstrate that global supplier management is working effectively. However, the precarious supply situation, especially for semiconductors, resulted in limited vehicle availability for customers.	Volkswagen annual report 2022 - page 185
	Battery technology is to become a core competency of the Volkswagen Group. The battery accounts for 20% to 30% of the cost of materials in electric vehicles; in future, it will be one of the most important components when differentiating between products. We have already pooled our in-house expertise in battery cells in a Center of Excellence and at the same time intend to accelerate technological change and the development of expertise through intelligent partnerships. We anticipate that we will need a battery capacity of more than 150 GWh a year in the period to 2025 just to equip our own electric fleet with lithium-ion batteries. To cover this enormous demand, we have defined strategic battery cell suppliers for our most important markets and the first MEB models, and we aim to initiate further long-term strategic partnerships in China, Europe	Volkswagen annual report 2019 - page 139	Vertical integration, which is a strategic component of the newly created Board position, targets key success criteria of the electrification strategy, such as maximizing customer benefit, ensuring competitive cost structures and achieving transparency in the supply chain to safeguard channels critical for supply and crucial to sustainability. In the current business model, overall responsibility for all input materials in the battery cell lies with the battery cell manufacturers. Volkswagen's involvement in the supply chain gives it access to costs and capacity for the materials and raw materials needed for battery production, particularly for lithium, nickel, manganese and cobalt (vertical integration). The objective of intervening in the supply chain is to influence costs and capacity so as to maximize the	Volkswagen annual report 2021 - page 151	Volkswagen will build its first North American battery plant in Canada, as US president Joe Biden's multibillion-dollar package of green incentives speeds up its plans for the rollout of electric vehicles on the continent. Thomas Schmall, head of VW's components unit, said during a visit to the carmaker's factory in Salzgitter, Germany that the "IRA is a big tailwind for us, as it decreases the cost of cells and makes possible a faster ramp-up of EV cars in the US". Batteries produced at the Canadian factory will supply VW's $2bn electric vehicle plant in South Carolina, which it announced two weeks ago.	Financial Times - volkswagen picks Canada for battery plant after beinglured by US green incentives
	With the FAST (Future Automotive Supply Tracks) initiative, Group Procurement is instrumental in advancing the Volkswagen Group and its supply network with a view to partnerships and future-viability. FAST facilitates the regular exchange of information so that both sides are strongly positioned to cope with the future challenges facing the automotive industry. Based on a set of criteria, a comprehensive assessment of the previous year is disclosed to the suppliers so that improvements can be made together. Alongside the existing supply relationships, strategic agreements on globalization and innovation are still core issues of this exchange. To this end, we take steps to ensure diversification and localization of the supplier portfolio in an effort to reduce economic and geopolitical risks.	Volkswagen annual report 2019 - page 141	As part of our new strategy NEW AUTO, we are stepping up our efforts to forge partnerships, both for the transformation of our core business and for the establishment of the new mobility solutions business. In the field of battery cells, possible risks could arise from potential disagreement with our partners, possible delays in battery cell development or delayed battery cell production. Close interaction with partners in the field of e-mobility in the form of partnerships and joint ventures supports technological change. Examples include the development of a comprehensive charging infrastructure. This cooperation involves risks such as an increased coordination workload, more complex decision-making processes and the loss of expertise. At the same time, opportunities are presented by the	Volkswagen annual report 2021 - page 212	"Our North America strategy is a key priority in our 10-point-plan that we've laid out last year," said VW chief executive Oliver Blume, referring to the plan he announced when taking over as the head of Europe's largest carmaker. VW has gone further than most rival carmakers to secure resources for batteries by deciding to manufacture cells itself, rather than just assemble batteries.	Financial Times - volkswagen picks Canada for battery plant after beinglured by US green incentives
	Today's market environment is characterized by persistent segmentation, diversification and globalization. We face these challenges with our purchased parts and supplier management, which supports and supervises the supplier processes. From development to series production, we focus on safeguarding the industrialization processes of the purchased parts at the individual supplier locations.	Volkswagen annual report 2019 - page 142	There is a risk of bottlenecks or disruption in supply, as is currently being seen in the case of semiconductor components. Here, the rapid recovery in demand starting in the fourth quarter of 2020, following the pandemic-induced drop in production and sales volumes in the first half of 2020, and the insufficient market capacity of the semiconductor industry combined with high demand from the consumer, IT and telecommunications industries, led to bottlenecks in supply. We intend to safeguard supplies for our production plants by implementing short-term measures along with the use of our relationship management and monitoring across the entire	Volkswagen annual report 2021 - page 194	VW, which has gone beyond most other carmakers to secure increasingly volatile supply chains by announcing plans to not only assemble batteries but also manufacture cells, said two years ago that it would build six gigafactories. Arno Antlitz, VW's chief financial officer, last week said the carmaker "would have done [a North American battery plant] anyway", but that the new subsidies accelerated its plans.	Financial Times - VW puts European battery plant on hold as it seeks €10bn from US
	Our global, cross-brand production network safeguards the processes from the supplier to the factory and assembly line, and from the factory to dealers and customers. Enduring efficiency is a prerequisite for our competitiveness. We meet challenges of the future with holistic optimizations, forwardlooking innovations, flexible supply streams and structures, and an agile team.	Volkswagen annual report 2019 - page 143	There is also the risk that the latest developments in the Russia-Ukraine conflict will have a negative impact on the supply chain and lead to supply bottlenecks. A global economic slowdown exacerbated by trade disputes and especially the consequences of the Covid-19 pandemic, including sharply increased commodity prices, is impacting the financial situation of many suppliers. This is also giving rise to risks of bottlenecks and disruption in supply.	Volkswagen annual report 2021 - page 194	Volkswagen is ramping up its investments in electric vehicles, committing €180bn over the next five years to manufacture its own batteries and expand in the world's biggest markets in the US and China.	Financial Times - VW ramps up investments in electric car transition with €180bn injection

	Volkswagen is creating its industrial cloud as an open platform with the goal of incorporating companies from the entire value chain. In the long term, the Volkswagen Group aims to integrate its global supply chain with over 30,000 sites of more than 1,500 suppliers and partner companies into the cloud, creating a constantly growing, worldwide ecosystem	Volkswagen annual report 2019 - page 145	Government support measures have stabilized the position of suppliers experiencing financial difficulties as a result of the pandemic. In Germany, for example, new rules on short-time working (Kurzarbeit) and loan support schemes, but also the suspension of the obligation to file for insolvency, have prevented companies from becoming insolvent.	Volkswagen annual report 2021 - page 195	Despite pressure to diversify both supply chains and sales away from China following rising geopolitical tensions, VW aims to use investments to strengthen its position in the country, where it makes half its profits. It has taken the view that China is unlikely to invade Taiwan in the short term because of the shock this would cause to its own economy, according to one person who has been part of internal discussions. Blume said that VW had to "listen to the Chinese customer more strongly", adding that in-car karaoke machines and the ability to craft avatars were among trends its China-based software division Cariad was developing.	Financial Times - VW ramps up investments in electric car transition with €180bn injection
			Risks in battery cell production arise particularly from the rising demand for battery cells and the resulting reliance on suppliers, from technological change and from the service life of battery cells. Additional risks may arise from the long-term relation to cell manufacturers and the direct responsibility of Volkswagen in the supply chain. To counter these risks, the Volkswagen Group maintains multiple strategic supplier relationships while also increasing its own battery production within the value chain (raw material extraction, cell production).	Volkswagen annual report 2021 - page 195	"Challenges to our supply chains will become the rule, not the exception," said chief executive Oliver Blume in his first earnings call since taking over nearly two months ago.	Financial Times - VW says supply chain problems are becoming the norm
			Commodity risks can be partially mitigated through backward integration of the supply chain. For example, partnerships and long-term supply agreements with commodity suppliers can be used to ensure supply of the relevant material while also achieving competitive prices. Demand for resources, possible speculations on the market and current trends in the automotive industry, such as the growing share of electrified vehicles, may affect the availability and prices of certain raw materials. Trends in raw materials and demand are continuously analyzed and assessed on an	Volkswagen annual report 2021 - page 195	VW also logged a €1.9bn non-cash impairment charge related to Argo AI, a USbased driverless car venture that it had backed jointly with Ford, which abruptly shut this week. Blume said VW would continue research and development in the field of autonomous driving with Bosch in Europe and cited its recent €2.4bn investment in Chinese AI chip specialist Horizon Robotics. He added that VW was currently in talks with a further partner in the race to develop self-driving cars	Financial Times - VW says supply chain problems are becoming the norm
			We minimize this risk, for example, by continuously comparing our available resources against future demand scenarios. If bottlenecks in the supply of materials are indicated, we can introduce countermeasures far enough in advance. Production capacity is planned several years in advance based on long-term sales planning for all vehicle projects. This involves a degree of risk as it is subject to market momentum and changes in demand. If forecasts are too optimistic, there is a risk that capacity will not be fully utilized. However, forecasts that are too pessimistic pose a risk of undercapacity, as a result of which, it may not be possible to meet customer demand.	Volkswagen annual report 2021 - page 196	Volkswagen will form joint ventures with Huayou Cobalt and Tsingshan Group to secure nickel and cobalt supplies for electric vehicles in China, the world's No. 1 car market, and to slash costs at a time of surging raw material prices. The move is part of a 30 billion euro ($33 billion) push by the world's second-largest carmaker to build a network of battery cell factories and secure more direct access to vital raw materials that are needed to supply them.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply
			With our NEW AUTO strategy, we have set the course to make our Group fit for the future. We are transforming ourselves from an automobile manufacturer with fascinating brands and excellent engineering to a vertically integrated mobility company. Battery and charging will become our core competence and source of revenue. By founding our own company under European law, we are bundling our battery activities and occupying all the stages of the value chain that are critical to success. In future, third parties will also be able to become involved in the company – we are not ruling out an IPO.	Volkswagen annual report 2021 - page 5	Volkswagen (VOWG_p.DE) , Huayou Cobalt (603799.SS) and Tsingshan have signed a memorandum of understanding for a joint venture in Indonesia, where more than 10% of the world's laterite nickel ore reserves are located, to focus on nickel and cobalt raw material production. At the final expansion stage of the venture, it will be able to supply raw materials for 160 gigawatt hours worth of electric vehicle batteries, Volkswagen China Group said in a statement.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply
			In the reporting period the Volkswagen Group produced 8,282,954 vehicles (including the Chinese joint ventures), 6.9% less than in the same period of the previous year. The prior year had been marked by the impact of national measures to contain the pandemic, which had led to the disruption of supply chains with production subsequently being halted in the Volkswagen Group. In fiscal year 2021 as well, supply shortages, especially for semiconductors, resulted in production cutbacks so that the total annual production volumes dropped even further.	Volkswagen annual report 2021 - page 112	"The cooperation aims to achieve significant cost advantages, secure the raw material supply and achieve a transparent and sustainable supply chain," it said. "The two partnerships target to contribute to the Group's long term target of a 30-50% cost reduction on each battery." Global nickel prices have surged almost 400% this year due to the Ukraine crisis, as Russia is a major supplier and its invasion of Ukraine and the subsequent imposition of sanctions on Moscow by the West lit a fire under an already hot market.	Reuters- Volkswagen unveils Asian ventures to secure e-battery materials supply
			Whether the higher inflation rates currently being seen in many countries are judged to be temporary or lasting will be crucial here. Base effects resulting from the Covid-19 pandemic and disruption to supply chains could be seen as grounds to assume that they are a temporary phenomenon. We expect interest rates to increase slightly for the years 2023 to 2026.	Volkswagen annual report 2021 - page 113	In a press statement, Volkswagen said: "The cooperation aims to achieve significant cost advantages, secure the raw material supply and achieve a transparent and sustainable supply chain. "The two partnerships target to contribute to the Group's long-term target of a 30%-50% cost reduction on each battery." Volkswagen signed a memorandum of understanding with Huayou Cobalt and Tsingshan to form a JV in Indonesia to focus on the production of nickel and cobalt raw materials. Indonesia is said to hold more than 10% of the laterite nickel ore reserves in the world. Volkswagen expects the JV, at the final expansion stage, to supply raw materials for 160GWh worth of EV batteries. In the second JV with Huayou in China, Volkswagen will focus on refining nickel and cobalt sulfates, precursor and cathode material production. In a press statement, Volkswagen said: "Huayou will utilize its integrated production process to support Volkswagen to further optimize the battery cost and to further reduce CO_2 emissions in the company's Chinese supply chain of new energy vehicles (NEVs)."	Volkswagen plans JVs in Indonesia and China
			The global spread of the SARS-CoV-2 virus has also affected commodity markets. As a result of the imbalance between supply and demand both during the pandemic and during economic recovery the increase in the price of many raw and input materials was very high in relative terms during 2021. Compared with the previous year, there was a rise in the average prices of the commodities coking coal, lithium, crude oil, cobalt, copper, iron ore, natural rubber, aluminum, nickel and lead. The price of the precious metals platinum and palladium, and especially of rhodium, also rose on average over the year. Based on analyses of factors of influence and of trends in the commodity markets, we expect the prices of most commodities to continue to increase in 2022. There is a risk that this will be exacerbated as a result of the RussiaUkraine conflict. For the years 2023 to 2026, we anticipate continued volatility in the commodity markets with prices trending both upwards and downwards.	Volkswagen annual report 2021 - page 180	Upstream Joint Venture with Huayou and Tsingshan in Indonesia Volkswagen, together with Huayou and Tsingshan, intends to form a JV in Indonesia, where more than 10% of the world's laterite nickel ore reserves are located. The partners agreed to jointly invest their respective advantages and resources for battery raw materials production. At the final expansion stage, the total production capacity of raw materials is equal to the supply of 160 GWh battery's demand for nickel and cobalt raw materials.	Volkswagen Group China intends strategic partnerships for battery raw material supply chain
			Volkswagen presented its plan for transforming the Group into a software-driven mobility company with a strong focus on its powerful brands and global technology platforms, providing synergies and scale as well as opening up new profit pools. "We set ourselves a strategic target to become global market leader in electric vehicles – and we are well on track. Now we are setting new parameters," said CEO Herbert Diess during the presentation of NEW AUTO, the Group's strategy through 2030.	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	Downstream Joint Venture with Huayou in Guangxi, China Volkswagen also plans to establish a JV with Huayou for the refining of nickel and cobalt sulfates, precursor and cathode material production. Huayou will utilize its integrated production process to support Volkswagen to further optimize the battery cost and to further reduce CO2 emissions in the company's Chinese supply chain of new energy vehicles (NEVs).	Volkswagen Group China intends strategic partnerships for battery raw material supply chain
			Proprietary battery tech, charging infrastructure and energy services are key success factors in the new mobility world. Therefore, power will be a Volkswagen Group core competency by 2030, with the two pillars "battery cell and system" and "charging and energy" under the roof of the new Group division Technology.Volkswagen Group plans to establish a controlled battery supply chain by setting up new partnerships and tackling all aspects from raw material to recycling. The goal is to create a closed loop in the battery value chain as the most sustainable and cost-	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	"We never used to talk to mining operators -- now we know their business model," VW's Murat Aksel told the ***Automobilwoche* Kongress in Berlin.**	VW tackles the worst supply chain shortages it has seen, purchasing chief says
			Thomas Schmall, CEO Group Components, said: "A Volkswagen-controlled battery supply chain will enable us to have authority over the biggest cost block, offer the best and most sustainable batteries to our customers and secure BEV success. BEVs will become mobile power banks that can be fully integrated in the energy grid through bi-directional charging. This will enable us to generate additional profits from participation in the energy market by 2030."	NEW AUTO: Volkswagen Group set to unleash value in battery-electric autonomous mobility world - July, 2021	Volkswagen Group is entering into direct purchase agreements in unprecedented areas to tackle the worst supply chain shortages the automaker has seen, its purchasing chief Murat Askel said. VW is also building a database to help predict geopolitical, natural and supply chain risks ahead of time, as it did for financial risks after the 2008 financial crisis, Aksel said. "We never used to talk to mining operators -- now we know their business model," Aksel said. "It is no longer enough to rely on Tier 1 suppliers - we need to look behind the	VW tackles the worst supply chain shortages it has seen, purchasing chief says
			The Volkswagen Group will be a founding member of the Catena-X Automotive Network. The union, which currently consists of 25 partners from the fields of business and science, is pursuing the goal of creating uniform standards for the flow of data and information in the automotive value chain. This should serve as the basis for a digital ecosystem in which automobile manufacturers and suppliers, dealer associations as well as technology suppliers can take part. Volkswagen expects the cross-company, secure and antitrust law compliant data exchange to result in new opportunities for increased efficiency and transparency for production and	Volkswagen builds supply chain efficiency through industry-wide data exchange - April, 2021		
Volkswagen			The Volkswagen Group has entered into three more strategic partnerships, further strengthening its position in the field of batteries. The new partners are the leading materials technology group Umicore, the battery specialist 24M Technologies, and cleantech company Vulcan Energy Resources Ltd. Although these three partnerships are independent from each other, they share a common goal: The industrialization of battery technology and the volume production of even more sustainable, cutting-edge batteries. The Volkswagen Group is consistently implementing its technology roadmap for the in-house development and production of battery cells, as presented at its Power Day earlier this year. In Europe alone, the Group plans to build	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Joint venture with Umicore Volkswagen AG and Umicore, a leader in clean mobility materials, plan to establish a joint venture designed to supply Volkswagen AG's European cell factories with cathode materials. For Volkswagen AG, this is the next logical step towards vertical integration of the supply chain, having already decided to set-up large-scale, in-house production of the unified cell. One key pillar is establishing a long-term partnership that includes the sharing of investments and having a framework to develop next generation technologies, among other things. Moreover, the joint venture aims at jointly building up precursor and cathode material production capacities in	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			In order to develop cutting-edge production technology for its cell plants, Volkswagen AG is investing into Cambridge-based battery start-up 24M, a spin-off from the Massachusetts Institute of Technology (MIT). The goal is to industrialize the 24M technology, a semi-solid process that is an improvement over the dry coating process, in the automotive battery area.	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Volkswagen AG and Vulcan Energy Resources Ltd have signed an agreement regarding the supply of CO2-neutral lithium from the Upper Rhine Valley in Germany. The binding contract focuses on providing lithium hydroxide over a period of five years starting 2026. The product will contribute to securing Volkswagen demand for future in-house cell production both in Germany and Europe. Further aspects of a possible strategic partnership are under negotiation.	Volkswagen enters into strategic partnerships for the industrialization of battery technology - Volkswagen 2021		
			Volkswagen is planning to establish six gigafactories in Europe to cover the growing demand for battery cells within the Group. Battery cell production in Salzgitter is set to start in 2025. The gigafactory in Lower Saxony will produce unified battery cells for the Volkswagen Group's volume segment. In its initial phase, the factory is set to have an annual capacity of 20 gigawatt hours; this is planned to double to 40 gigawatt hours at a later stage. On the basis of the current planning round, the Volkswagen Group is investing heavily in developing battery cell	Volkswagen Group creates European company for its battery business - December, 2021		

			Parallel to the development of these five gigafactories by the newly formed European company, the Swedish start-up Northvolt AB – in which Volkswagen has a stake of around 20 percent – will be building a further factory in Skellefteå in northern Sweden. This will produce battery cells for the premium automotive segment starting in 2023. Northvolt already has an established partnership with the Volkswagen Group in the area of premium battery cells.Volkswagen is forging ahead with the industrialisation of battery technology at all levels of the value chain. This week, the company agreed two strategic partnerships with Umicore and 24M as well as a long-term supply agreement with Vulcan Energy Resources.The goal of the partnerships is to aid the manufacture and procurement of primary materials as well as to optimise battery cell manufacture at the planned gigafactories. The partnerships are designed to build know-how in battery technology and optimize cost management.	Volkswagen Group creates European company for its battery business - December, 2021		
			The Volkswagen Group is pursuing what probably ranks as the most comprehensive electric strategy in the global automotive industry. Over the next five years, the Group will be investing around €52 billion in the development and production of new electric vehicles. The NEW AUTO strategy also covers the development of the new business fields batteries, charging and energy. In addition, the Group is creating dedicated technology platforms that enable cross-brand synergies, including the	Volkswagen Group creates European company for its battery business - December, 2021		
			Dr. Stefan Sommer, Group Board Member for Components and Procurement at Volkswagen Aktiengesellschaft, said: “Over the next ten years the Volkswagen Group will be launching 70-plus new pure electric vehicles. That means approximately a quarter of the vehicles we deliver in 2025 will be powered by electricity. Consequently, there will be a rapid increase in our raw material demand for cell production in the coming years. We must make sure we cover this demand at an early stage. Long-term agreements like the one for lithium, a key raw material, that we have just concluded with Ganfeng are therefore of crucial strategic significance for implementing our electric offensive.”	Volkswagen Group secures lithium supplies - April, 2019		
			Michael Bäcker, Head of Corporate Purchasing e-Mobility at Volkswagen Aktiengesellschaft, explained: “With Ganfeng as a strategic partner we are creating a secure basis for planning capacities and costs. The strategic collaboration is the result of an extensive market analysis executed by Volkswagen’s e-Raw Material Team. This specialized team is focusing on building close relationships with the raw material industry. Together with	Volkswagen Group secures lithium supplies - April, 2019		
			Several companies have initiated a “Responsible Lithium Partnership” aiming to work towards responsible natural resource management, including lithium, in Chile’s Salar de Atacama. This cross-industry partnership is funded at its inception by Volkswagen Group, BASF, Daimler AG, and Fairphone. The partnership intends to foster a dialogue among local stakeholders, generating and synthesizing scientific facts and seeking solutions in a participatory manner.	Volkswagen Group, BASF, Daimler AG and Fairphone start partnership for sustainable Lithium mining in Chile - June 2021		
			Safeguarding supplies of raw materials is a success factor One key success factor is safeguarding supplies of raw materials. The Group is well positioned in this regard. As things currently stand, Volkswagen is confident that it will have sufficient quantities of all the raw materials required to ensure ramp-up of the e-fleet. The Group recently signed a Memorandum of Understanding with Ganfeng on a 10-year agreement relating to Lithium, the main component of a battery. This agreement alone will secure a major part of our lithium needs. Further negotiations with other providers are ongoing. In the meantime, the Group is working systematically to reduce the share of cobalt in batteries – which would also successively reduce the volume of this raw material that would need to be procured. That share is to be cut from the current level of 12 to 14 percent (weight proportion in the cathode) to five percent in the next three to five years. Volkswagen is working to develop cobalt-free battery cells.	Volkswagen - Background: Volkswagen Group’s battery strategy - 2021		

			Volkswagen erwartet eine schrittweise Verschiebung der Umsatz- und Profit-Pools: Zunächst von Autos mit Verbrennungsmotor (ICEs) hin zu batterieelektrischen Fahrzeugen (BEVs) und später stärker in Richtung Software und Dienstleistungen. Dieser Trend wird durch das autonome Fahren beschleunigt. Der ICE-Markt dürfte in den nächsten zehn Jahren um über 20 Prozent zurückgehen. Gleichzeitig wird der Absatz von Elektrofahrzeugen schnell wachsen und Verbrennerfahrzeuge als führende Technologie überholen. Mit einem geschätzten Umsatz von 1,2 Billionen Euro könnte Software bis 2030 zusätzlich zum erwarteten Geschäft mit BEVs und ICEs rund ein Drittel des gesamten Mobilitätsmarktes ausmachen. Dieser könnte sich von heute rund zwei auf dann voraussichtlich fünf Billionen Euro mehr als verdoppeln. Individuelle Mobilität wird auch in 2030 voraussichtlich rund 85 Prozent dieses Marktes sowie des Geschäfts von Volkswagen ausmachen.	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität		
			Eigene Batterietechnologie, Ladeinfrastruktur und Energiedienstleistungen sind zentrale Erfolgsfaktoren in der neuen Mobilitätswelt. Deshalb wird Energie bis 2030 eine Kernkompetenz des Volkswagen Konzerns sein, mit den beiden Säulen „Batteriezelle und System“ sowie „Laden und Energie“ unter dem Dach des neuen Konzernbereichs „Technologie“.	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität	The Volkswagen Group and its battery company PowerCo SE founded in July 2022 intend to accelerate the build-up of their global battery business through rapid expansion to North America. Volkswagen CEO Oliver Blume and the Canadian Minister for Innovation, Science and Industry, François-Philippe Champagne, signed in Wolfsburg today an Addendum to the non-binding Memorandum of Understanding (MoU) of August this year to identify suitable sites for a cell factory in Canada. The two parties will continue their cooperation in the areas of battery value creation, raw material supply chains and cathode material production which had been established in August. Furthermore, PowerCo and materials technology group Umicore have agreed to investigate a strategic supply agreement on cathode material for North America. In September, the two companies had announced that they would cooperate in Europe by forming a joint venture for precursor and cathode material production	Volkswagen - Volkswagen Group and PowerCo SE launch site search for first gigafactory in North America - December, 2022
			Der Volkswagen Konzern plant, durch den Aufbau neuer Partnerschaften und die Abdeckung aller Teilbereiche von den Rohstoffen bis zum Recycling eine selbst kontrollierte Batterielieferkette aufzubauen. Das Ziel: Ein geschlossener Kreislauf in der Wertschöpfungskette als nachhaltigster und kostengünstigster Weg zur Herstellung von Batterien. Um dieses Ziel zu erreichen, baut der Volkswagen Konzern seine Batteriekompetenz aus und reduziert die Komplexität. Dazu führt das Unternehmen eine Einheitszelle ein, mit einem Kostensenkungspotenzial von bis zu 50	Volkswagen - New auto: Volkswagen Konzern erschließt neue Werttreiber für emissionsfreie und autonome Zukunft der Mobilität	Additional cathode material agreement between PowerCo and Umicore For the development of the cell production supply chains required in North America, PowerCo SE and Belgian materials technology group Umicore are intensifying their existing cooperation on the development of regional supply chains for sustainable battery materials. The partners today signed an MoU concerning a long-term strategic partnership to secure cathode materials for future cell production in North America.	Volkswagen - Volkswagen Group and PowerCo SE launch site search for first gigafactory in North America - December, 2022
			Volkswagen hatte sich im Juni 2019 mit rund 900 Millionen Euro an Northvolt beteiligt und im Gegenzug rund 20 Prozent der Anteile sowie einen Sitz im Aufsichtsrat erhalten. Die Produktion von Volkswagen Premium-Zellen wird in Zusammenarbeit mit Northvolt in Skellefteå konzentriert. Die Fertigung dieser Zellen soll 2023 starten und das für Volkswagen vorgesehene Volumen schrittweise auf bis zu 40 GWh Jahreskapazität ausgebaut werden. Die zweite Volkswagen Gigafabrik wird in Salzgitter ab 2025 die Einheitszelle für das Volumensegment produzieren und perspektivisch ebenfalls bis zu 40 GWh pro Jahr fertigen. Beide Gigafabriken sollen mit Strom aus erneuerbaren Energien betrieben werden.	Volkswagen investiert weitere 500		
			Nur gut drei Monate später folgte die Kehrtwende. Grund dafür ist Konzerninsidern zufolge das hohe Tempo, das VW von seinem schwedischen Partner verlangte. Volkswagen sei zunehmend frustriert gewesen über die zähen Fortschritte beim Aufbau der Fabrik. Sie sollte den ursprüngliche Planungen zufolge ab 2024 Batteriezellen im großen Umfang produzieren. Volkswagen sei zu der Überzeugung gelangt, dass das junge schwedische Unternehmen mit dem gleichzeitigen Bau einer Fabrik in Schweden überfordert sei und sich besser auf dieses konzentrieren solle. Genau das sieht die neue Strategie nun vor: Northvolt soll für den VW-Konzern in einer neuen Fabrik in Schweden „Premium-Batteriezellen“ herstellen, die etwa in Porsche-Modellen Verwendung finden. VW erklärte: Die Produktion der Premium-Zellen werde „in Zusammenarbeit mit Northvolt in der schwedischen Gigafabrik“ konzentriert. Die Produktion	Volkswagen in salzgitter		

			Volkswagen has now completed the increase in its stake in Chinese battery cell partner Gotion High-Tech announced last year. Volkswagen is now the largest shareholder in the Chinese battery specialist. The number of Gotion shares held by Volkswagen China rose to 441 million and the shareholding to 26.47 per cent as of 15 December. VW had previously held only a minority stake, as the private placement now completed means VW China has acquired 384 million shares. Since the announcement of the VW investment, Gotion has made enormous progress in expanding its business activities. In September, it announced that it would reach a production capacity of 300 GWh by 2025 – three times as much as previously planned. The company also demonstrated an LFP cell with an energy density of 210 Wh/kg and also started series production of a cell with high nickel content. This is to achieve an energy density of 302 Wh/kg at cell level. While the relationship with Volkswagen has become increasingly close – Gotion has replaced Northvolt as its partner for battery cell production in Salzgitter and is possibly to build VW’s unified cell in China – the company has also entered into collaborations with other carmakers. In November, a battery deal was signed with Great Wall, and there has also been a partnership with VinFast since August 2021.	VW is now majority owner of Gotion High-Tech		
			Volkswagen's (VOWG_p.DE) planned European battery cell plants and securing vital raw materials will cost as much as 30 billion euros ($34 billion), board member Thomas Schmall said, putting a price tag on the expansion for the first time. Schmall, who is in charge of technology at Europe's largest carmaker, said in an interview at the Reuters Next conference that Volkswagen would seek outside partners to fund it."We are talking about 25 to 30 billion (euros) ... including the vertical chain of raw materials, not only the factories," the 57-year old said, adding VW would not have to take the lead on funding and was not aiming for a 50/50 investment split. "It depends on the partnership model we will establish in the next months. We're open to discuss it. For us it's necessary that we can control ... the technology roadmap, the timing, the costs and the availability to enable our rollout." Schmall is overseeing Volkswagen's ambitious plan to build six large battery cell plants in Europe by the end of the decade, a strategic pillar in its bid to overtake Tesla (TSLA.O) and become the world's top electric vehicles seller.	VW expects battery, raw material drive to cost up to $34 bln		
			But production capacity is only one part of the equation, Schmall said, adding that Volkswagen also had to make sure it gets enough raw materials, such as lithium and nickel. This requires a more proactive approach and Schmall said that Volkswagen was looking to strike partnerships, with cooperation announcements due "in some weeks". Volkswagen, which plans to submit its next five-year investment plan to the supervisory board on Dec. 9, is pursuing a mix of strategies, which might even include becoming a shareholder in a mining firm. "You will see the full range," Schmall said, also referring to fixed and mixed price contracts with suppliers. "You have to tailor-fit solutions, necessarily, to specific raw materials."	VW expects battery, raw material drive to cost up to $34 bln		

	We are exposed to a variety of market and other risks, including the effects of changes in foreign currency exchange rates, commodity prices, and interest rates, as well as risks to availability of funding sources, hazard events, and specific asset risks. These risks affect our Automotive and Ford Credit segments differently. We monitor and manage these exposures as an integral part of our overall risk management program, which includes regular reports to a central management committee, the Global Risk Management Committee ("GRMC"). The GRMC is chaired by our Chief Financial Officer, and the committee includes our Controller and Chief Financial Officer, Automotive, our Treasurer, and other members of senior management.	Ford annual report - 2019 page 78	Accordingly, any significant future disruption to our production schedule, whether as a result of our own or a supplier's suspension of operations, could have a substantial adverse effect on our financial condition, liquidity, and results of operations. Further, government-sponsored liquidity or stimulus programs in response to COVID-19 may not be available to our customers, suppliers, dealers, or us, and if available, may nevertheless be insufficient to address the impacts of COVID-19. Moreover, our supply and distribution chains may be disrupted by supplier or dealer bankruptcies or their permanent discontinuation of operations.	Ford annual report - 2020 page 16	Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule and specifications, and a shortage of or inability to acquire key components, such as semiconductors, or raw materials, such as lithium, cobalt, nickel, graphite, and manganese, can disrupt Ford's production of vehicles; • To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material suppliers that subject Ford to risks associated with lower future demand for such materials as well as costs that fluctuate and are difficult to accurately forecast	Ford annual report - 2022 page 74
	A work stoppage or other limitation on production could occur at Ford's or its suppliers' facilities for any number of reasons, including as a result of labor issues, including disputes under existing collective bargaining agreements with labor unions or in connection with negotiation of new collective bargaining agreements, absenteeism, public health issues, or in response to potential restructuring actions (e.g., plant closures); as a result of supplier financial distress or other production constraints, quality issues, or other difficulties; as a result of a natural disaster (including climate-related physical risk); or for other reasons.	Ford annual report - 2019 page 13	Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule, and a shortage of key components, such as semiconductors, can disrupt Ford's production of vehicles. Our products contain components that we source globally from suppliers who, in turn, source components from their suppliers. If there is a shortage of a key component in our supply chain, and the component cannot be easily sourced from a different supplier, the shortage may disrupt our production. For example, the automotive industry is facing a significant shortage of semiconductors. With up to fifty modules on a vehicle, we and our competitors who need integrated circuits are experiencing various levels of semiconductor impact. The semiconductor	Ford annual report - 2020 page 16	COVID-19 and Supplier Disruptions. The impact of COVID-19, including changes in consumer behavior, pandemic fears and market downturns, and restrictions on business and individual activities, has created significant volatility in the global economy. Outbreaks in certain regions continue to cause intermittent COVID-19-related disruptions in our supply chain and local manufacturing operations. We also continue to face supplier disruptions due to labor shortages and other production issues, in addition to the continuing semiconductor shortage. Our inconsistent production schedule has been disruptive to our suppliers' operations, which, in turn, has led to higher costs and production shortfalls. Further, actions taken by Russia in Ukraine have impacted and could further impact our suppliers, particularly our lower tier	Ford annual report - 2022 page 35
	Many components used in our vehicles are available only from a single supplier and, therefore, cannot be resourced quickly or inexpensively to another supplier (due to long lead times, new contractual commitments that may be required by another supplier before ramping up to provide the components or materials, etc.). Such single-source suppliers also could threaten to disrupt our production as leverage in negotiations. In addition, when we undertake a model changeover, significant downtime at one or more of our production facilities may be required, and our ability to return to full production may be delayed if we experience production difficulties at one of our facilities or a supplier's facility. Moreover, as vehicles, components, and their integration become more complex, we may face an increased risk of a delay in production of new vehicles. A significant disruption to our production schedule could have a substantial adverse effect on our financial condition or results of operations	Ford annual report - 2019 page 13	Ford's long-term competitiveness depends on the successful execution of its Plan. We previously announced our plan for the global redesign of our business, pursuant to which we are working to turn around automotive operations, compete like a challenger, and capitalize on our strengths by allocating more capital, more resources, and more talent to our strongest business and vehicle franchises. We plan to do so by becoming more customer centric, embracing technology, and adopting processes that emphasize simplicity, speed and agility, efficiency, and accountability.	Ford annual report - 2020 page 16	Commodity and Energy Prices. Prices for commodities remain volatile. In some cases, spot prices for various commodities have recently diverged somewhat, as anticipated weakening in global industrial activity mitigates price increases for base metals such as steel and aluminum, while precious metals (e.g., palladium), and raw materials that are used in batteries for electric vehicles (e.g., lithium, cobalt, nickel, graphite, and manganese, among other materials, for batteries) remain high. The net impact on us and our suppliers has been higher material costs overall. To help ensure supply of raw materials for critical components (e.g., batteries), we, like others in the industry, have entered into multi-year sourcing agreements and may enter into additional agreements.	Ford annual report - 2022 page 35
	Raw Materials. We purchase a wide variety of raw materials from numerous suppliers around the world for use in production of our vehicles. These materials include base metals (e.g., steel and aluminum), precious metals (e.g., palladium), energy (e.g., natural gas), and plastics/resins (e.g., polypropylene). We believe we have adequate supplies or sources of availability of raw materials necessary to meet our needs; however, there always are risks and uncertainties with respect to the supply of raw materials that could impact availability in sufficient quantities and at cost effective prices to meet our needs. See the "Overview" section of Item 7 for a discussion of commodity and energy price trends, and "Item 7A. Quantitative and Qualitative Disclosures about Market Risk" ("Item 7A") for a discussion of commodity price risks.	Ford annual report - 2019 page 3	With the increasing interconnectedness of the global economy, a financial crisis, economic downturn or recession, natural disaster, geopolitical crisis, or other significant event in one area of the world can have an immediate and material adverse impact on markets around the world. Changes in international trade policy can also have a substantial adverse effect on our financial condition or results of operations. For example, steps taken by the U.S. government to apply or consider applying tariffs on automobiles, parts, and other products and materials have the potential to disrupt existing supply chains, impose additional costs on our business, affect the demand for our products, and make us less competitive.	Ford annual report - 2020 page 19	In response to, or in anticipation of, supplier disruptions, we may stockpile certain components or raw materials to help prevent disruption in our production of vehicles. Such actions could have a short-term adverse impact on our cash and increase our inventory. Moreover, in order to secure critical materials for production of electric vehicles, we have entered into and plan to continue to enter into offtake agreements with raw material suppliers and make investments in certain raw material and battery suppliers, including contributing up to $6.6 billion in capital to BlueOval SK, LLC over a five-year period ending in 2026. Such investments, which are part of our plan to invest over $50 billion in electric vehicles through 2026, could have an additional adverse impact on our cash in the near-term.	Ford annual report - 2022 page 63
			The full impact of COVID-19 on future results depends on future developments, such as the ultimate duration and scope of the outbreak (including any potential future waves and the success of vaccination programs) and its impact on our customers, dealers, and suppliers. Despite the successful restart of our manufacturing operations in 2020, we continue to experience higher than normal levels of absenteeism at our manufacturing facilities and intermittent COVID-19-related disruptions in our supply chain. Moreover, new restrictions could have an adverse effect on production, supply chains, distribution, and demand for vehicles.	Ford annual report - 2020 page 32	For the production of our electric vehicles, we are dependent on the supply of batteries and the raw materials (e.g., lithium, cobalt, nickel, graphite, and manganese) used by our suppliers to produce those batteries. As we increase our production of electric vehicles, we expect our need for such materials to increase significantly. At the same time, other companies are increasing their production of electric vehicles, which will further increase the demand for such raw materials. As a result, we may be unable to acquire raw materials needed for electric vehicle production in sufficient amounts that are responsibly sourced or at reasonable prices. As described below under "To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material	Ford annual report - 2022 page 17
			The shortage is due in large part to strong cross-industry demand, which has presented challenges and production disruptions globally, including at our assembly plants. In addition, Renesas Electronics Corporation, a key supplier of semiconductors for the automotive industry and for us in particular, experienced a significant fire at its Naka Factory in March 2021, and COVID-related work restrictions in Southeast Asia have further impacted semiconductor production.	Ford annual report - 2021 page 18	To facilitate access to the raw materials necessary for the production of electric vehicles, Ford has entered into, and expects to continue to enter into, multi-year commitments to raw material suppliers that subject Ford to risks associated with lower future demand for such materials as well as costs that fluctuate and are difficult to accurately forecast. We have announced plans to significantly increase our electric vehicle production volumes; however, our ability to produce higher volumes of electric vehicles is dependent upon the availability of raw materials necessary for the production of batteries, e.g., lithium, cobalt, nickel, graphite, and manganese, among others. As described above under "Ford is highly dependent on its suppliers to deliver components in accordance with Ford's production schedule and specifications, and a shortage of or inability to acquire key components, such as semiconductors, or raw materials, such as lithium, cobalt, nickel, graphite, and manganese, can disrupt Ford's production of vehicles," to facilitate our access to such raw materials, we have entered into, and expect to continue to enter into, offtake agreements and other long-term purchase contracts. Such agreements obligate us, subject to certain conditions such as quality or minimum output, to purchase a certain percentage or minimum amount of output from raw material suppliers over an agreed upon period of time pursuant to an agreed upon purchase price mechanism that is typically based upon the market price of the material at the time of delivery. Unlike our historical arrangements with suppliers, which are typically annual commitments, under multi-year offtake agreements and other long-term purchase contracts, the risks associated with lower-than-expected electric vehicle production volumes or changes in battery technology that reduce the need for certain raw materials are borne by Ford rather than our suppliers. In the event we do not purchase the materials pursuant to the terms of these agreements, even if	Ford annual report - 2022 page 18
			We previously announced our plan for growth and value creation – Ford+. Ford+ is focused on delivering distinctive and increasingly electric products plus "Always-On" customer relationships and user experiences. Our Ford+ plan is designed to leverage our foundational strengths to build new capabilities – enriching customer experiences and deepening loyalty. As we undertake this transformation of our business, we must integrate our strategic initiatives into a cohesive business model, and balance competing priorities, or we will not be successful. To facilitate this transformation, we are making substantial investments, recruiting new talent, and optimizing our business model, management system, and organization.	Ford annual report - 2021 page 18	In order to secure critical materials for production of electric vehicles, we have entered into and plan to continue to enter into offtake agreements and other long-term purchase contracts with raw materials suppliers and make investments in certain raw material and battery suppliers; however, we may not realize the anticipated benefits of these actions and our efforts to have such suppliers, particularly those in less developed markets, adopt Ford's sustainability and other standards may be unsuccessful, which could have an adverse impact on our reputation. In addition, a restructuring or the implementation of a new or different business strategy may lead to the disruption of our existing business operations, including distracting management from current operations.	Ford annual report - 2022 page 19
			Supplier Disruptions. The automotive industry has a complex supply network with each manufacturers' products containing components sourced from suppliers who, in turn, source components from their suppliers. When there is a shortage of a key component in our supply chain, and the component cannot be easily sourced from a different supplier, the shortage can disrupt production. Since early 2021, we and others in the automotive industry have faced a significant shortage of semiconductors. The global semiconductor shortage is due in large part to makers of semiconductors having allocated their capacity to meet surging demand for consumer electronics during the COVID-19 pandemic while automotive OEMs experienced industry-wide plant closures. At the same time, wafer foundries	Ford annual report - 2021 page 33	The terms of the offtake agreements we have entered into, and those we may enter into in the future, vary by transaction, though they generally obligate us to purchase a certain percentage or minimum amount of output produced by the counterparty over an agreed upon period of time. The purchase price mechanism included in the offtake agreement is typically based on the market price of the material at the time of delivery. The terms also may include conditions to our obligation to purchase the materials, such as quality or minimum output. Subject to satisfaction of those conditions, we will be obligated to purchase the materials at the cost determined by the purchase price mechanism. Based on the offtake agreements we have entered into thus far, the earliest date by which we could be obligated to purchase any output, subject to satisfaction of the	Ford annual report - 2022 page 63
			Pricing Pressure. Over the last year, prices of both new and used vehicles have increased substantially due to both rising demand and supply shortages. It is likely that the rate of price increases will slow down as auto production slowly recovers from the semiconductor shortage, but it is unclear whether prices will decline fully to pre-COVID-19 pandemic levels. Over the long term, intense competition and excess capacity are likely to put downward pressure on inflationadjusted prices for similarly-contented vehicles and contribute to a challenging pricing environment for the automotive industry in most major markets.	Ford annual report - 2021 page 35	June 29 (Reuters) - Liontown Resources Ltd (LTR.AX) signed a lithium supply agreement with Ford Motor Co (F.N), the Australian miner's latest after similar deals earlier this year with Tesla (TSLA.O) and electric vehicle (EV) battery maker LG Energy (373220.KS). Liontown said on Wednesday it will supply Ford with 150,000 dry metric tonnes (DMT) of lithium spodumene concentrate each year for five years from its flagship Kathleen Valley project in Western Australia. The concentrate is a source of lithium essential for making EVs.	Australia's Liontown inks lithium deal with Ford after Tesla, LG agreements
			Our outlook for 2022 assumes the following operating environment: • Supply constraints will remain fluid reflecting a variety of factors, including semiconductor availability and COVID-19 impacts • Wholesales are expected to be up about 10% - 15% year over year • Pricing environment is expected to remain strong, although the interplay between volume and pricing will be dynamic • Inflationary pressures will impact a broad range of costs • Commodity costs will be $1.5 - $2.0 billion higher year over year	Ford annual report - 2021 page 73	At the same time, Ford is transforming its global supply chain management capability to support efficient and reliable sourcing of components, internal development of key technologies and capabilities, and world-class cost and quality execution. John Lawler, Ford's chief financial officer, will lead Ford's global supply chain organization on an interim basis until a chief supply chain officer is selected. Jonathan Jennings, vice president, supply chain, will also take additional responsibility for supplier technical assistance and quality. He will report to Lawler.	Ford Announces Leadership Changes to Strengthen Product Creation and Transform Global Supply Chain Management
Ford					Ford is poised to cut its dependence on Volkswagen technology for its next generation of electric cars in Europe, unravelling a core part of the alliance formed between the rival carmakers two years ago.But from the middle of the decade Ford expects to launch vehicles that use its own in-house system, which is being engineered by Ford in the US, said Martin Sander, the head of electric vehicles in Europe.The two global carmakers formed an alliance in 2020 in order to join forces on electric cars, self-driving technology and commercial vehicles, one of several partnerships across the industry as auto groups team up in the face of rising development bills.	Ford to cut dependence
			GlobalFoundries Inc. (Nasdaq: GFS) (GF), a global leader in feature-rich semiconductor manufacturing, and Ford Motor Company (NYSE: F) today announced a strategic collaboration to advance semiconductor manufacturing and technology development within the United States, aiming to boost chip supplies for Ford and the U.S. automotive industry. The companies have signed a non-binding agreement that opens the door for GF to create further semiconductor supply for Ford's current vehicle lineup and joint research and development to address the growing demand for feature-rich chips to support the automotive industry.	Ford Global foundries - News release - November, 2021	Ford discounted the price on its plug-in Mustang Mach-E car last Monday, weeks after Tesla slashed prices by up to 20 per cent across models. The motor industry seemed on the brink of further reductions for electric vehicles. Headlines declared a price war was on. Then other carmakers stayed on the sidelines. General Motors chief executive Mary Barra said on Tuesday that the company's EVs were priced correctly. Volkswagen declined to cut prices, as did Hyundai and Kia.	Electric vehicles defy price war after Ford and Tesla discounts - February 2023
			"It's critical that we create new ways of working with suppliers to give Ford – and America – greater independence in delivering the technologies and features our customers will most value in the future," said Jim Farley, Ford president and CEO. "This agreement is just the beginning, and a key part of our plan to vertically integrate key technologies and capabilities that will differentiate Ford far into the future."	Ford Global foundries - News release - November, 2021	The three-way nickel processing project – together with a separate supply agreement under development with Ford and Huayou for a precursor cathode active material critical to manufacturing lithium-ion batteries – collectively will combine with Ford's other sourced nickel, significantly contributing to support its EV production targets by the end of 2026.	PT val Indonesia and Huayou sign nickel, March 2023
					"This framework gives Ford direct control to source the nickel we need – in one of the industry's lowest-cost ways – and allows us to ensure the nickel is mined in line with our company's sustainability targets, setting the right ESG standards as we scale," said Lisa Drake, vice president for Ford Model e EV industrialization. "Working this way puts Ford in a position to help make EVs more accessible for millions *and* to do it in a way that helps better protect people and the planet."	PT val Indonesia and Huayou sign nickel, March 2023