

THE CAR CHIP SHORTAGE: A MIRROR TO GLOBAL ECONOMIC VULNERABILITIES

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Abstract

This thesis explores the global semiconductor chip shortage that disrupted the automotive industry and its implications for economic vulnerabilities and supply chain resilience. The semiconductor industry, after enduring challenges in 2023, is projected to recover, with sales expected to increase by 16.6% to nearly \$617 billion by 2024, underscoring its critical role in technology, particularly in automotive and AI sectors (Deloitte, 2024). Originating with the COVID-19 pandemic, the study examines the shortage's widespread effects, highlighting the complex interdependencies and the fragile balance of global supply and demand. The research employs qualitative analysis and reviews literature to investigate several aspects of the shortage. First, it explores the causes of the semiconductor shortage. Next, it examines the direct impact on the automotive industry. Finally, it considers the broader implications for global economic stability and supply chain management.

The findings reveal that the just-in-time manufacturing model, coupled with a heavy reliance on a limited number of semiconductor suppliers, exacerbated the industry's vulnerability to disruptions. In response, the automotive industry's strategic adaptations—ranging from supply chain diversification to increased local production efforts—highlight the pressing need for enhanced resilience against such systemic shocks. Furthermore, the thesis evaluates responses from governments and industries aimed at mitigating effects and fostering long-term resilience.

In addition, this research contributes to research on global supply chain vulnerabilities by offering insights into the necessity of strategic planning, flexibility, and diversification in supply chain management. It advocates for a multifaceted approach to resilience, emphasizing the importance of predictive analytics, strategic stockpiling, and international cooperation to navigate future challenges in an unpredictable global market. By examining the semiconductor chip shortage through the lens of global economic interdependencies, this thesis underscores the imperative for adaptive strategies that ensure economic stability and the robustness of global supply chains in the face of unprecedented disruptions.

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Introduction

In 2020, the automotive industry faced a profound impact due to a severe shortage of semiconductor chips, essential for critical functions ranging from engine management to entertainment systems. This disruption underscored the delicate balance of global supply and demand. It is essential to understand the crucial role of the semiconductor industry, which serves as the economic backbone for various sectors by providing technological advancements. Dominated by major companies like Intel, Samsung, and TSMC, the semiconductor industry is vital not only for consumer electronics but increasingly for automotive applications, emphasizing its wide-reaching impact and strategic significance. (Deloitte, 2024).

The semiconductor industry is characterized by rapid technological advancements and fast-evolving standards, with research and development playing a critical role in maintaining a competitive advantage. The semiconductor industry is projected to grow significantly, with sales expected to reach nearly \$617 billion by 2024, according to Deloitte. This growth underscores the industry's critical role in modern technology, driven by increasing demands from sectors such as automotive and artificial intelligence (Deloitte, 2024).

Understanding the semiconductor industry's structure is crucial for analyzing the economic vulnerabilities and supply chain disruptions highlighted in this thesis. Concentrated mainly in East Asia, the industry's complex geopolitical and logistical dynamics influence global supply chains significantly.

The chip shortage, driven by increased demand for personal electronics during COVID-19 and exacerbated by trade tensions, exposed the misalignment between semiconductor production timelines and the automotive industry's just-in-time manufacturing (“The coronavirus will cut China’s early 2020 car sales” 2020).

Kim and Desrochers (1997) discuss the complexities of semiconductor manufacturing, highlighting the challenges in controlling fabrication cycle times, which are critical for industries dependent on these components. This shortage not only exposed the automotive sector's susceptibility to disruptions but also underscored the interconnected vulnerabilities across global manufacturing and trade, leading to significant financial and operational impacts for car manufacturers globally.

Having detailed the direct impacts of the semiconductor chip shortage on the automotive industry, it is imperative to consider the broader implications of these findings for global supply chain management and economic policy.

The findings illustrate significant vulnerabilities in global supply chains, particularly within the automotive sector, highlighted by the semiconductor chip shortage. This shortage not only disrupted production but also emphasized the delicate balance required in supply chain management. Given the concentrated nature of the semiconductor industry—dominated by a few key suppliers in East Asia—the shortage exemplifies the risks associated with economic concentration and the need for geographical and supplier diversification.

Strategically, the automotive industry’s response to the shortage—ranging from seeking alternative suppliers to redesigning products to use different types of chips—underscores the importance of flexible and responsive supply chain strategies. These measures, while initially reactive, must evolve into proactive strategies that include building more robust and diversified supply networks. Governments, too, have a role to play. The introduction of policies aimed at

encouraging domestic production of critical components, as well as fostering international cooperation on supply chain resilience, are vital steps in mitigating future disruptions.

This thesis advocates for a more integrated approach to supply chain management, one that incorporates the principles of risk management, strategic stockpiling, and predictive analytics. Such measures can enhance the ability of industries to respond to and recover from supply chain disruptions, thereby ensuring economic stability and security in an increasingly interconnected and technologically dependent global economy.

The car chip shortage demonstrated the vulnerabilities in modern economic systems, highlighting the interdependencies and fragility of global supply chains reliant on specialized components. This disruption affected multiple sectors, emphasizing the strategic importance of semiconductor chips not only in automotive but also in consumer electronics. As manufacturers worldwide grappled with the shortage, it underscored the fragility of supply networks that span continents, revealing how localized challenges—be it a pandemic, geopolitical tensions, or natural disasters—can have far-reaching economic consequences. (“Low demand will curb Russian car sector after COVID” 2020).

Moreover, the chip shortage highlighted the competitive dynamics between nations and corporations vying for dominance in key technology sectors, emphasizing the strategic importance of semiconductor manufacturing. It prompted a reevaluation of supply chain strategies, urging businesses and governments alike to reconsider their dependence on a limited number of suppliers and geographies. In this sense, the car chip shortage serves as a microcosm of global economic interdependencies, compelling a deeper understanding and rethinking of how interconnected and yet vulnerable our global economy truly is.

This thesis explores the following research question: How does the car chip shortage illuminate the vulnerabilities—specifically transport disruptions, and market concentration— within

global economic interdependencies, and what are its broader implications for supply chain management and economic policy? To address this question, the objectives of the study are as follows. First, it seeks to dissect the root causes of the car chip shortage, mapping out the interplay between demand dynamics, supply chain constraints, and geopolitical factors. Second, the study aims to analyze the immediate effects of the shortage on the automotive industry, while also identifying the ripple effects on other sectors and the global economy at large. Third, it endeavors to uncover the broader economic vulnerabilities that the shortage has exposed, particularly focusing on the fragility of global supply chains and the risks of economic concentration. Finally, the study proposes to offer insights and recommendations on mitigating these vulnerabilities, with the aim of enhancing supply chain resilience and informing economic policy decisions. Through this comprehensive approach, the thesis aims to contribute to a deeper understanding of global economic interdependencies and the challenges of managing complex supply chains in a highly interconnected world.

To frame this research within a theoretical paradigm, this thesis draws upon the concepts of industrial policy and state-market relations. This perspective allows me to explore how governments and markets interact to shape the conditions under which industries operate, particularly in the context of global supply chains and technological innovation (Cohen, 2009). By examining the car chip shortage through this lens, we can better understand the role of policy in mitigating vulnerabilities and fostering economic resilience.

The thesis is organized into six main sections, following this introduction.

First, the Literature Review section embarks on an exploration of existing research and theories concerning global economic interdependencies, supply chain vulnerabilities, and the specific nuances of the semiconductor industry within the automotive sector. This review establishes a contextual backdrop against which the car chip shortage is examined.

Second, the methodology section, the research design and approach are detailed, elucidating the qualitative analysis methods employed. This includes the criteria for the selection of case studies and data sources, providing clarity on how evidence was gathered and analyzed to support the investigation.

Third, the findings section presents a detailed analysis of the car chip shortage, delving into its immediate impacts on the automotive industry, the broader economic vulnerabilities it unveiled, and the particularities of transportation disruptions and economic concentration.

Fourth, a discussion section interprets the findings, highlighting their practical implications, offering policy recommendations to mitigate similar vulnerabilities in the future, and addressing the limitations of the study. The discussion revealed that the global semiconductor chip shortage significantly disrupted the automotive industry, underscoring the industry's vulnerability to just-in-time manufacturing models and concentrated supply chains. Strategic adaptations, such as supply chain diversification and increased local production, have been pivotal in addressing these challenges, showcasing the critical need for enhanced resilience and flexibility in global supply management.

Finally, the conclusion reiterates the key insights gained, revisiting the research question and objectives, and summarizing the contributions of the thesis to the broader discourse on global economic interdependencies and the resilience of supply chains. This structure ensures a logical flow, guiding the reader through a nuanced understanding of the car chip shortage as a critical case study in global economic vulnerabilities.

Literature Review

The global economy is deeply interconnected, heavily influenced by globalization, technological advancements, and trade liberalization (Essid & Jenkins, 2011). These interdependencies have grown more complex, significantly impacting international relations and national policies (Renfro & Anderson, 2010). Understanding these global economic dynamics is crucial for effectively managing international influences and mitigating associated risks.

Furthermore, globalization links states and regions, facilitating economic growth despite potential shocks and vulnerabilities (Haaland et al., 2002). It also poses risks, necessitating strategic measures such as adopting appropriate currency regimes and regulating banking sectors to enhance stability in developing economies.

The impact of economic globalization on the tropical world provides a case in point for the uneven distribution of globalization's benefits and costs. Yeung and Dicken (2000) argue that economic globalization is a complex process with uneven geographical impacts, posing serious questions of equity between different parts of the world and across social groups. They highlight the intrinsic component of market capitalism, uneven development, as a major global problem, particularly affecting parts of the tropical world.

Having outlined key themes and debates, it is crucial to explain the selection criteria for these sources to ensure their relevance and reliability in addressing global economic complexities. To ensure the research's robustness and relevance, sources were meticulously selected based on several criteria: firstly, assessing each source's validity by examining the publication's reputation and the authors' credentials, and prioritizing peer-reviewed articles and reports from credible institutions. Second, the representativeness of the sources was considered to ensure a

comprehensive understanding of the global semiconductor industry, including both well-established theories and cutting-edge research. Lastly, potential biases of the sources were critically evaluated, focusing on the diversity of geographic and industry perspectives to provide a balanced view. This careful selection process supports the construction of a well-rounded analysis grounded in reliable and relevant information.

In addition, supply chains, the backbone of global economic interdependencies, illustrate the process by which raw materials are transformed into finished goods and then distributed to consumers worldwide. These chains often span multiple countries, with each specializing in different stages of production based on their comparative advantages. This specialization enhances efficiency and cost-effectiveness but also introduces vulnerabilities, as disruptions in one part of the world can ripple through the entire supply chain, affecting global production and distribution. Aylor et al. (2020) emphasize the need for designing resilient systems within these chains to effectively mitigate disruptions, highlighting strategies that multinational corporations can adopt to bolster their operational stability.

Trade networks further exemplify economic interdependencies, as countries import and export goods and services to balance domestic supply and demand. The World Trade Organization (WTO) and various regional trade agreements facilitate this exchange by setting rules and reducing barriers to trade. However, geopolitical tensions and protectionist policies can disrupt these networks, leading to shortages, inflation, and strained international relations.

Financial systems also play a critical role in global economic interdependencies. Capital flows across borders through investments, loans, and currency exchanges, linking economies in a complex financial web. This interconnectedness can be a conduit for economic prosperity, allowing for the diversification of risk and the efficient allocation of resources. Yet, it also

means that financial crises can have far-reaching impacts, as seen during the 2008 global financial crisis.

The car chip shortage, analyzed by Chowdhury et al. (2021), demonstrates the interdependencies within global supply chains, particularly how disruptions in semiconductor production affect automotive manufacturing and beyond. Their review highlights how the increased demand for consumer electronics during the COVID-19 pandemic shifted semiconductor production priorities, causing significant delays and losses in the automotive sector. This scenario underlines the complexity and vulnerability of global economies interconnected by supply chains that not only drive growth but also pose systemic risks, emphasizing the importance of strategic planning to enhance economic resilience.

In summary, the global economic interdependencies outlined here are a testament to the complexity and vulnerability of the world economy. While these connections can foster growth and innovation, they also expose economies to systemic risks. Understanding these dynamics is crucial for developing strategies to mitigate vulnerabilities and enhance economic resilience.

Previous studies on supply chain vulnerabilities have delved into the multifaceted nature of risks and disruptions that supply chains face, offering a rich body of knowledge that informs our understanding of global economic interdependencies. These studies have broadly categorized supply chain vulnerabilities into several key areas: natural disasters, geopolitical tensions, economic fluctuations, and technological disruptions, each contributing uniquely to the fragility of global supply chains.

Research on natural disasters, such as earthquakes, floods, and pandemics, highlights the immediate and often unpredictable impact these events can have on supply chain operations. The 2011 Fukushima earthquake and tsunami in Japan, for example, had a profound effect on the automotive and electronics supply chains, demonstrating how localized events can disrupt

global production networks. These studies advocate for enhanced risk assessment and disaster preparedness as essential components of supply chain management (Gunasekaran et al., 2015).

Geopolitical tensions and trade disputes also pose significant risks to supply chains, as seen in the studies examining the effects of tariffs and trade wars on global trade flows. Bednarski et al. (2024) provide a comprehensive review of geopolitical disruptions in supply chains such as the US-China trade conflict which has been a focal point of research, showcasing how political decisions can lead to increased costs, supply shortages, and the need for supply chain rerouting and diversification.

Economic fluctuations, including recessions and sudden spikes in demand, represent another vulnerability. The car chip shortage, precipitated by a surge in demand for consumer electronics during the COVID-19 pandemic, underscores how economic shifts can lead to supply-demand mismatches, highlighting the importance of agile and flexible supply chain strategies.

Technological disruptions, while often beneficial, can introduce vulnerabilities through reliance on specific technologies or platforms. The cybersecurity risks to supply chain management systems are a growing concern, with studies pointing to the need for robust security measures to protect against data breaches and cyberattacks (Witt et al., 2019).

These previous studies collectively emphasize the importance of resilience and adaptability in supply chain management. By identifying and analyzing these vulnerabilities, researchers and practitioners can develop strategies to mitigate risks and enhance the robustness of global supply chains against a backdrop of increasing uncertainties.

Furthermore, scholarly perspectives on economic concentration and transportation disruptions offer insightful analyses into how these factors contribute to and exacerbate supply chain vulnerabilities. Economic concentration, referring to the dominance of a few firms over a

significant portion of market share within an industry, can lead to increased risks of supply chain disruptions. This is because the reliance on a limited number of suppliers or producers for critical components or raw materials can create choke points in the supply chain. Studies in this domain have explored the ramifications of such concentration, highlighting the potential for significant disruptions in the event of operational failures, labor disputes, or financial instability within these dominant firms.

Transportation disruptions, on the other hand, encompass a broad range of issues affecting the movement of goods across global supply chains. These can include infrastructural inadequacies, logistical bottlenecks, regulatory changes, and unforeseen events like natural disasters or geopolitical conflicts. The scholarly work in this area has extensively documented how transportation disruptions can lead to delayed shipments, increased costs, and inventory shortages, thereby affecting the overall efficiency and reliability of supply chains.

A notable aspect of the literature on economic concentration is its focus on the semiconductor industry, which has become highly concentrated in certain geographical regions and among a few key players. This concentration has implications for industries reliant on semiconductor chips, such as the automotive sector, which faced significant challenges during the chip shortage. Scholars argue that such concentration increases the fragility of supply chains, making them more susceptible to disruptions from localized events, whether they be natural disasters, political unrest, or public health crises.

Similarly, research on transportation disruptions has shed light on the critical role of logistic networks in maintaining the flow of goods and services across borders. The COVID-19 pandemic, for instance, served as a real-world stress test, revealing vulnerabilities in transportation networks as countries-imposed lockdowns and travel restrictions, disrupting global trade. Academic contributions in this area advocate for diversified transportation

strategies and investment in infrastructure resilience as means to mitigate the impacts of such disruptions.

Together, these scholarly perspectives underscore the interconnected challenges posed by economic concentration and transportation disruptions. They highlight the need for strategic planning and policy interventions to address these vulnerabilities, emphasizing the importance of diversification, resilience, and robust risk management practices in safeguarding global supply chains against future disruptions.

The critical evaluation and synthesis of literature on global economic interdependencies, supply chain vulnerabilities, economic concentration, and transportation disruptions reveal a multidimensional understanding of the challenges and risks facing modern supply chains. This synthesis not only highlights the interconnected nature of these challenges but also underscores the complexity of managing and mitigating risks in an increasingly globalized economy.

The literature on global economic interdependencies provides a foundational understanding of how countries, industries, and companies are linked through complex networks of trade, investment, and production. These interdependencies, while driving efficiency and economic growth, also introduce vulnerabilities, as disruptions in one part of the world can quickly cascade through these networks, affecting global supply and demand. The synthesis of these studies emphasizes the dual nature of globalization as both a facilitator of economic prosperity and a potential source of systemic risks.

Studies on supply chain vulnerabilities further delve into the specific risks associated with the operation and management of global supply chains. As already stated, from natural disasters and geopolitical tensions to economic fluctuations and technological disruptions, the literature identifies a range of external factors that can interrupt the flow of goods and services. A critical

evaluation of these studies reveals a consensus on the need for more resilient and flexible supply chain strategies that can adapt to and recover from disruptions.

To reiterate, the examination of economic concentration and transportation disruptions brings to light the structural aspects of supply chain vulnerabilities. Economic concentration, particularly in critical sectors like semiconductor manufacturing, poses significant risks due to the reliance on a limited number of suppliers. Similarly, transportation disruptions highlight the logistical challenges of moving goods across increasingly complex and stretched supply chains. The synthesis of this literature underscores the importance of diversification—both in terms of suppliers and logistics options—as a strategy for reducing risk.

In synthesizing the literature, a critical insight emerges while individual studies offer valuable perspectives on specific aspects of supply chain vulnerabilities, a holistic approach is necessary to fully understand and address these challenges. This entails not only identifying and mitigating risks but also rethinking the structure and management of global supply chains to enhance their resilience. Furthermore, this synthesis suggests the need for collaborative efforts among stakeholders—governments, businesses, and international organizations—to develop policies and practices that strengthen supply chain resilience against a backdrop of increasing uncertainty.

In summary, the critical evaluation and synthesis of the literature paint a complex picture of the vulnerabilities facing global supply chains. It calls for a multifaceted approach that combines risk management with strategic planning and policy interventions, aiming to safeguard the global economy against future disruptions.

Methodology

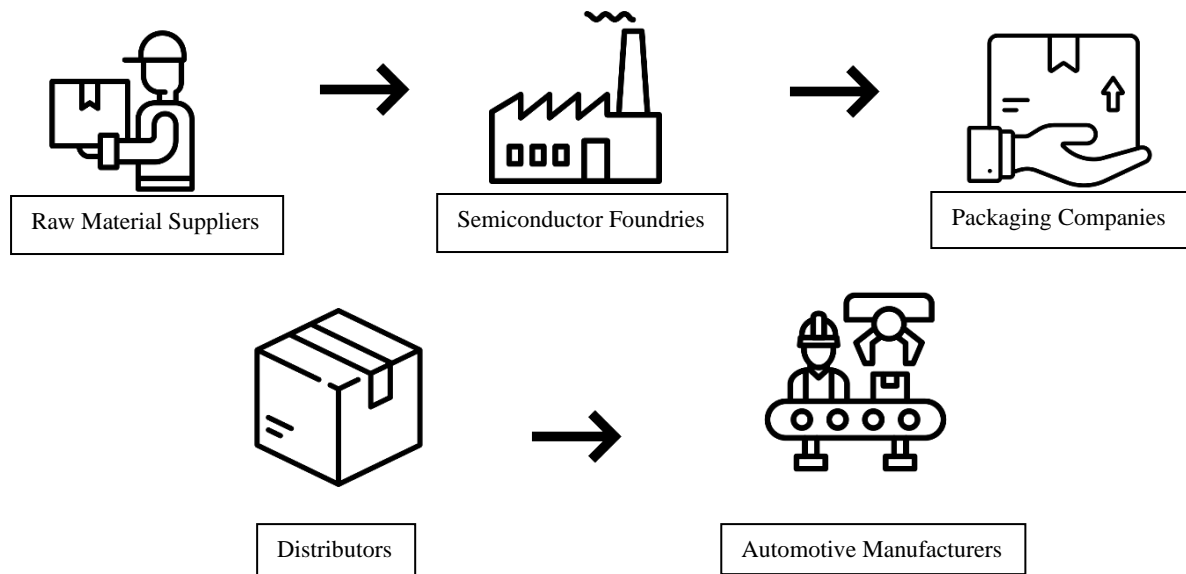
This thesis examines the global impact of the semiconductor chip shortage through qualitative analysis and a thorough review of secondary data. I meticulously selected secondary sources based on their relevance to the semiconductor industry and impact on global supply chains. The data spans industry reports to academic studies, focusing on the most recent publications to reflect current trends. This approach leverages the detailed exploratory power of qualitative research to uncover complex interdependencies more effectively than quantitative methods might.

Central to this qualitative endeavor is the adoption of a study based on the collection of secondary data, which serves as the investigative core, enabling an examination of the car chip shortage's effects not just within the borders of the automotive industry but also its broader ramifications across global economic landscapes. By homing in on distinct episodes where the chip shortage has notably disrupted automotive production and supply chain mechanisms, the intention is to glean more expansive insights into the fragilities and resilience of economic structures and the consequential considerations for policy formulation. This research design offers a comprehensive view of the car chip shortage, treating it as a prism to critically examine the vulnerabilities and adaptabilities of the global economic and supply chain fabric.

To fully understand the scope and impact of the semiconductor shortages on the automotive industry, it is crucial to comprehend the semiconductor supply chain itself. According to Lee (2001), the supply chain model for the semiconductor industry encompasses a range of strategic and operational dynamics that are critical to managing global market demands. The diagram below visually represents the various stages of the semiconductor supply chain, from raw material sourcing to final delivery to automotive manufacturers. Each node and link in this chain is susceptible to disruptions, which can ripple through the entire automotive sector. This

supply chain diagram serves as a foundational element of our analysis, helping to identify key vulnerabilities and the flow of materials that are critical for semiconductor manufacturing. Understanding this flow is essential for analyzing how disruptions at different stages can impact overall production and supply.

Illustration 1



The backbone of this study is an extensive collection of secondary data, encompassing academic literature, industry reports, news articles, and official statistics relevant to the semiconductor industry, the automotive sector, and global supply chain disruptions. The selection of the automotive industry was guided by criteria such as the severity of the chip shortage impact, geographic location, and the company's position within the global supply chain, ensuring a diverse and representative sample.

This approach acknowledges the limitations imposed by the absence of primary data collection through interviews. However, it compensates for this with a robust array of published materials that offer both theoretical insights and up-to-date industry figures and analyses. This approach aligns with the principles outlined in Martins et al. (2018), which discusses the strategic advantages and methodological rigor associated with the use of secondary data in research.

Data analysis in this study follows a structured process, beginning with thematic analysis to sift through the vast amounts of secondary data. This step involves identifying, analyzing, and reporting patterns (themes) within the data that are relevant to understanding the economic and supply chain implications of the car chip shortage. Themes related to supply chain vulnerabilities, economic concentration, and the effects of transportation disruptions are of particular interest, given their prominence in the literature review.

Comparative analysis further enriches the study by examining how different sectors besides automotive—such as consumer electronics and manufacturing—and different geographic regions have been affected by similar supply chain disruptions. This broader view allows for a more comprehensive understanding of the chip shortage's impact, drawing parallels and distinctions that illuminate the global nature of economic vulnerabilities.

Integrating findings from the literature review, this analysis not only seeks to answer the central research question but also to contextualize the car chip shortage within wider economic and supply chain theories. The literature on globalization's effects, the intricacies of supply chain management, and the specific challenges of the semiconductor industry inform the interpretation of data, providing a theoretical framework that enhances the study's empirical findings.

Ethical considerations in this research are paramount, especially given the reliance on secondary data. The study is committed to upholding the highest standards of academic integrity and ethical research practices. This includes ensuring the accurate citation and responsible use of all secondary data sources, respecting the intellectual property rights of authors and publishers, and maintaining the confidentiality and anonymity of any indirect data that could be traced back to individuals or entities. By adhering to these ethical guidelines, the study ensures its findings are both credible and ethically sound.

Acknowledging the limitations of this study is crucial for a balanced interpretation of its findings. The exclusive use of secondary data, while practical and rich in scope, means that the analysis may not capture the most current developments or the nuanced perspectives that primary data collection through interviews could provide. This limitation is particularly relevant in a fast-moving situation like the car chip shortage, where the landscape can shift rapidly due to new technological advancements, policy changes, or shifts in consumer behavior.

Furthermore, the qualitative nature of the study, while offering depth, may limit its generalizability. The insights derived from specific case studies within the automotive industry and the broader economic analysis are deeply contextual and may not apply uniformly across other industries or future disruptions. This specificity, however, is also a strength, providing detailed insights into the complexities of global supply chains and economic interdependencies.

In conclusion, this methodology section outlines a comprehensive approach to exploring the car chip shortage's implications for global economic vulnerabilities. Through a qualitative, case study approach, the study leverages an extensive array of secondary data to delve into the complexities of supply chain disruptions, economic concentration, and the broader economic implications of such crises. While mindful of its limitations—particularly the reliance on secondary data and the exclusion of interviews—the study is poised to offer significant insights into the vulnerabilities and resilience of global supply chains. As it moves into the findings section, the research stands on a solid methodological foundation, ready to contribute to the ongoing discourse on managing and mitigating the risks inherent in our interconnected global economy.

Findings

The semiconductor chip shortage significantly impacted the automotive industry in 2021, causing about 9.5 million units in production losses and an estimated \$210 billion revenue shortfall. General Motors alone reported a \$2 billion loss, exemplifying the major economic strain faced by manufacturers.

Table 2

Manufacturer	Estimated Vehicles Not Produced	Estimated Revenue Loss (USD)	Time Period
Global Industry (SP Global, 2023)	9.5 million units	\$210 billion	2021
Various Global (AlixPartners, 2021)	7.7 million units	\$195 billion	2021
General Motors (SP Global, 2023)	Estimated 200,000 units	\$2 billion	2021

This analysis addresses the research question by examining the shortage's effects on the automotive industry, its ripple effects across sectors, and governmental and business responses. This comprehensive evaluation links theoretical frameworks with empirical data to enhance understanding of economic resilience and supply chain robustness amid such disruptions.

The semiconductor chip shortage presented unprecedented challenges for the automotive industry, a crucial part of the global economy. This scarcity struck at the heart of automotive manufacturing, where chips are crucial for a myriad of applications, from engine control units to advanced driver-assistance systems. The semiconductor demand in the automotive sector has notably increased, influenced by the ongoing trends in vehicle electrification and computerization. Concurrently, artificial intelligence has surged as a pivotal technology, significantly impacting the semiconductor market by expanding its applications across R&D, marketing, and production processes (KPMG, 2024). As the shortage took hold, automotive manufacturers across the globe reported severe disruptions. For instance, major players like General Motors and Toyota were forced to halt production lines, leading to significant financial setbacks. In the first half of 2021 alone, it was estimated that the automotive industry would incur losses exceeding \$110 billion in revenue due to these disruptions (Wu et al., 2021).

The root cause of these challenges lay not only in the increased demand for consumer electronics but also in the just-in-time manufacturing model that left little room for supply chain flexibility. Manufacturers found themselves in a bind, with long lead times for chip production exacerbating the issue. Specific cases highlight the depth of the impact: Ford announced a halt in the production of its F-150 trucks, a bestseller in the U.S. market, while Volkswagen warned of cutting production by several hundred thousand vehicles in the following year. These instances underscored a critical vulnerability in the automotive supply chain: an over-reliance on a handful of semiconductor suppliers.

In response, automotive companies adapted quickly by renegotiating contracts, seeking alternative suppliers, and sometimes redesigning vehicles to accommodate chip scarcity. These strategic shifts towards supply chain diversification and the increased inventory levels of critical components marked a pivotal evolution in supply chain management within the industry. (Kesavan & Marianand, 2022).

Comparing these industry responses to the literature reveals a clear alignment with recommended resilience strategies. Previous research emphasized the importance of diversification and flexibility within supply chains as critical to mitigating the impact of disruptions (Ferdous et al., 2022). The automotive industry's shift towards these strategies not only highlights the practical application of theoretical resilience models but also marks a significant evolution in supply chain management practices (Ye, 2023). This comparative analysis indicates that, while the chip shortage presented a formidable challenge, it also served as a catalyst for innovation and adaptation, driving the automotive industry towards more resilient and robust supply chain configurations (Shcherbakov, 2022).

The semiconductor chip shortage had far-reaching effects beyond the automotive sector, significantly impacting industries like consumer electronics and manufacturing. The global lockdowns caused a surge in demand for personal computing and entertainment systems, leading to competition for semiconductor resources, product delays, and increased costs that affected consumer prices and access. This situation highlighted the critical role of semiconductors and the vulnerabilities of a concentrated industry where a few major players dominate production. Such economic concentration created supply chain choke points, exacerbating the shortage's impact, and exposing the fragility of global supply networks heavily dependent on specialized manufacturers.

This situation also brought to light the strategic importance of semiconductors as a foundational element of contemporary technology and manufacturing. The breadth of the shortage's impact across various sectors underscores the semiconductor's role as a critical, yet vulnerable, linchpin in the global economy. Drawing parallels from the literature, the event further highlighted the need for strategic diversification and resilience-building within supply chains. As industries and governments grapple with the fallout, the chip shortage serves as a stark reminder of the need for more robust, adaptable supply networks capable of withstanding such

systemic shocks. This episode not only informs future strategies for mitigating supply chain vulnerabilities but also prompts a reevaluation of global economic structures and dependencies.

In addition, the semiconductor chip shortage highlighted significant vulnerabilities in global supply chains, particularly the extended lead times for chip deliveries that caused widespread production delays which ballooned from a few weeks to several months or more, causing widespread production delays. This situation revealed the weakest links in the supply chain: an over-reliance on a limited number of chip manufacturers, primarily located in Asia, and the fragility of just-in-time manufacturing practices that left little room for error or delay.

As the semiconductor industry navigates through its growth phase, two major challenges surface prominently—talent acquisition and supply chain vulnerabilities. The industry's focus on diversifying supply chain geographies and enhancing talent development strategies underscores its proactive approach to mitigating potential disruptions and ensuring sustained growth (KPMG, 2024). In response to these disruptions, businesses and governments swiftly initiated a variety of strategies aimed at mitigating the impact and preventing future shortages. One prominent approach was the diversification of supply sources, with companies seeking out new relationships with chip manufacturers outside the traditional supply bases to reduce dependency on any single source. Additionally, there was a marked shift towards increasing local production of semiconductors, with several countries announcing significant investments in building and expanding chip manufacturing capabilities within their borders. Strategic stockpiling of essential components emerged as another key strategy, as companies sought to buffer themselves against future supply chain disruptions by maintaining larger inventories of critical parts, including semiconductor chips.

These pragmatic short-term responses also align with broader supply chain resilience strategies discussed in existing literature. Literature highlights the importance of diversification, local

production, and strategic stockpiling as key to robust supply chain management. However, the scale and speed of these adaptations in the wake of the chip shortage provide new empirical evidence supporting these strategies, while also pointing to the need for ongoing innovation in supply chain management to address the complex challenges posed by globalization and technological dependence. This convergence between practical responses and theoretical frameworks underscores the dynamic nature of supply chain management and the continuous learning process it entails in the face of global disruptions.

Furthermore, the semiconductor chip shortage catalyzed a wave of policy measures and government interventions worldwide, aiming to mitigate the immediate impacts and fortify against future supply chain vulnerabilities. Recognizing the strategic importance of semiconductor manufacturing to national security and economic stability, governments initiated a series of economic policies designed to support affected sectors and accelerate recovery. For example, financial incentives and subsidies were introduced to cushion the automotive industry, among others, ensuring continuity in production despite the chip scarcity.

Moreover, significant investments were made in domestic semiconductor manufacturing capabilities. For example, the United States has proposed billions in funding for semiconductor research and production to regain control over crucial supply chain elements and reduce foreign dependency. Similar initiatives in the European Union and parts of Asia highlight a global recognition of the need for enhanced supply chain resilience.

These policy responses align closely with recommendations from existing literature on supply chain management, which emphasizes the importance of local production capabilities and strategic government intervention in critical sectors. However, the scale and urgency of these responses offer new insights into the potential for rapid policy adaptation in the face of global disruptions. While the literature suggests a gradual approach to building supply chain

resilience, the chip shortage underscored the need for swift, decisive action to protect economic interests and national security. This divergence underscores the evolving role of government policy in managing complex, globalized supply chains in a technologically dependent world.

As already stated, the semiconductor industry's economic concentration significantly exacerbated the chip shortage crisis, revealing how market dominance by a select few companies and countries can amplify global supply chain vulnerabilities. Predominantly centralized in East Asia, the production of semiconductor chips is controlled by a handful of industry giants, leading to a bottleneck when demand surges or production is disrupted. This concentration meant that the pandemic-induced increase in demand for consumer electronics directly impacted the availability of chips for other industries, demonstrating the fragility of a global supply chain dependent on so few.

The literature review highlighted economic concentration as a theoretical concern with practical implications for supply chain resilience, suggesting that such a narrow production base could lead to significant disruptions. The chip shortage brought these discussions into stark reality, underscoring the need for diversification in manufacturing and sourcing strategies to mitigate similar risks in the future. By reflecting on the literature, it becomes evident that while the theoretical risks of economic concentration were known, the chip shortage served as a real-world validation of these theories, emphasizing the urgent need for strategic changes in global supply chain management practices.

Moreover, the chip shortage underscored significant transportation and logistic challenges, further complicating the global supply chain crisis. Key among these were logistic bottlenecks at major shipping ports and infrastructural inadequacies that delayed the delivery of critical components. As demand for semiconductors surged, the existing transportation infrastructure struggled to keep pace, with port congestion and limited cargo capacity leading to significant

delays. These issues were compounded by pandemic-related restrictions, which reduced workforce availability and disrupted traditional logistic operations.

In response to these challenges, companies and governments alike implemented measures aimed at alleviating bottlenecks and enhancing logistic efficiency. Expedited shipping routes, increased investment in logistic infrastructure, and the deployment of digital tracking technologies were among the strategies employed to ensure smoother transit of semiconductor chips. These measures resonate with findings from the literature review, which emphasized the importance of agile and resilient transportation networks in mitigating supply chain disruptions. By adopting a more proactive approach to logistic planning and infrastructure development, stakeholders began addressing some of the systemic weaknesses highlighted by the chip shortage, illustrating a practical application of theoretical solutions to transportation and logistic challenges in the supply chain.

Lastly, this thesis synthesizes key findings to deepen our understanding of the car chip shortage and its broader implications for global economic vulnerabilities. It reveals how the crisis not only disrupted the automotive industry but also had ripple effects across various sectors, underlining the critical role of semiconductors in today's interconnected global economy. The analysis showcases the exacerbating effect of economic concentration within the semiconductor industry and the compounded challenges of transportation and logistic inefficiencies. These findings align with theoretical frameworks discussed in the literature review, particularly the vulnerabilities associated with supply chain centralization and the importance of resilience strategies. However, the unprecedented scale of this shortage and its widespread impact offer new insights, challenging existing theories to accommodate the complexities of modern supply chains. This synthesis underscores the necessity for adaptive strategies that address both the immediate challenges and the structural vulnerabilities

highlighted by the chip shortage, paving the way for more robust and resilient global economic systems.

Additionally, this analysis acknowledges limitations, including reliance on available data and the evolving nature of the chip shortage, which may influence result interpretation and applicability. These constraints highlight the necessity for ongoing research to fully grasp the shortage's long-term effects on global supply chains and economic resilience.

To conclude, the findings of this study illuminate the profound impact of the semiconductor chip shortage on the automotive industry and beyond, revealing critical vulnerabilities in global supply chains and economic systems. These insights respond directly to the research question, underscoring the urgent need for diversified supply chains and enhanced resilience strategies. As we transition to the discussion section, these findings will be further analyzed against existing theories and research, aiming to bridge the gap between theoretical frameworks and practical implications. This next step will delve into how the lessons learned from the chip shortage can inform future policy and strategic planning in supply chain management.

Discussion

In 2021, the semiconductor chip shortage significantly disrupted the automotive sector. This was exacerbated by the just-in-time manufacturing model and a heavy reliance on a few Asian suppliers, leading to considerable industry-wide delays and financial losses.

The situation highlighted the fragility of global supply chains and the risks associated with concentrated sourcing. The crisis not only disrupted production but also exposed the fragility of relying on a few key suppliers, which led to significant production delays and financial losses as discussed in literature such as by Kim and Desrochers (1997). This underscores the urgency of reevaluating supply chain strategies to improve resilience and risk management.

Following the initial disruptions, automotive companies and governments worldwide began implementing adaptive strategies to mitigate the impacts and prevent future shortages. This included diversifying supply sources, investing in local semiconductor production, and revising inventory and procurement strategies to build more resilient supply networks.

The study's findings reveal how the semiconductor chip shortage aligns with and challenges existing theories on global supply chain vulnerabilities. Existing literature, such as Cohen (2009) and Essid & Jenkins (2011), outlines the complexities of modern supply chains, suggesting the necessity of diversification and redundancy. Yet, the severity of disruptions during the chip shortage suggests that current strategies are inadequate for such unforeseen events, highlighting a gap between theoretical frameworks and practical realities.

However, the severity of the automotive industry's disruption diverges starkly from some prior assumptions about supply chain resilience, as highlighted in my findings. While the literature emphasizes the importance of diversification and flexibility (Haaland, et al., 2002), the scale of the shortage's impact suggests that the current levels of preparedness and the existing

strategies for managing supply chain risks were insufficient to mitigate such a disruption. This divergence prompts a reevaluation of traditional supply chain models and calls for an integrated approach that considers not just economic efficiency but also strategic redundancy and resilience.

Furthermore, the industry's response, including increased local production and diversification of suppliers, aligns with theoretical recommendations but underscores the need for rapid adaptability and enhanced foresight in supply chain management. However, literature also indicates that these measures, while critical, must be part of a broader, proactive strategy that includes technological innovation and international cooperation to manage and mitigate risks effectively.

In response, automotive manufacturers and governments worldwide adopted various strategies to mitigate these impacts. Automakers renegotiated contracts and sought new suppliers, while governments invested in local semiconductor production to decrease dependencies. These measures aim to enhance supply chain resilience and echo the literature's call for increased diversification and flexibility.

However, when comparing these responses to best practices highlighted in academic and industry studies, gaps become evident. The literature suggests that beyond immediate reactive measures, long-term strategies focusing on building robust, agile supply chains are essential. This includes fostering relationships with a broader base of suppliers and investing in predictive analytics to foresee and mitigate such disruptions. While the automotive sector and governments have initiated steps towards resilience, the literature implies a more comprehensive approach is necessary—one that incorporates not just diversification, but also technological innovation and collaborative industry-wide efforts to address systemic vulnerabilities.

The effectiveness of these responses, therefore, must be viewed as a spectrum. While some measures have undoubtedly mitigated the immediate impacts of the chip shortage, aligning with the literature's emphasis on agility and redundancy, the crisis also underscores the need for a more profound transformation of supply chain strategies to safeguard against future disruptions. This involves a shift from reactive to proactive measures, ensuring that the automotive industry and its supporting governments not only bounce back from such challenges but also build a more resilient foundation for the future.

In addition, the semiconductor chip shortage has profound implications for supply chain management, underscoring the critical need for resilience and flexibility in modern supply chains. This crisis has vividly illustrated the dangers of over-reliance on just-in-time manufacturing models and the necessity of diversifying supply sources to mitigate risks. Companies must now re-evaluate their supply chain strategies to incorporate more robust risk management practices, a move supported by literature emphasizing the importance of supply chain agility and redundancy (Essid & Jenkins, 2011; Haaland, Midelfart, & Thøgersen, 2002).

To build resilience, companies should consider multi-sourcing strategies, developing relationships with multiple suppliers across different geographic locations to reduce the risk of future disruptions. Additionally, investing in predictive analytics and supply chain visibility tools can enable more proactive management of supply chain risks. These tools can provide early warning signs of potential disruptions, allowing companies to adjust their strategies in real-time.

Moreover, literature suggests that building strategic stockpiles of critical components can serve as a buffer against short-term shocks (Kim & Desrochers, 1997). However, this approach must be balanced with the carrying costs associated with inventory management. Finally, fostering stronger collaboration within the supply chain, including suppliers, manufacturers, and

customers, can enhance collective resilience. Such partnerships can lead to more transparent, flexible supply chains capable of adapting to changes and challenges more effectively.

Incorporating these strategies requires a shift in mindset from cost minimization to value creation through resilience and flexibility. This transition, while challenging, is essential for companies aiming to thrive in an increasingly volatile global market.

Equally significant, the semiconductor chip shortage underscores the need for strategic government intervention to bolster supply chain resilience and secure economic stability. Policymakers should consider incentivizing the domestic production of critical components, such as semiconductor chips, to reduce dependency on concentrated overseas suppliers. This could involve tax incentives, subsidies for research and development, and investment in advanced manufacturing technologies. Additionally, fostering public-private partnerships can encourage innovation and the sharing of best practices in supply chain management. The findings and literature reviewed suggest the importance of developing a national supply chain strategy that emphasizes diversification, agility, and the strategic stockpiling of essential goods. Governments can play a pivotal role in facilitating dialogue between key industry stakeholders to anticipate future challenges and coordinate more resilient responses. These recommendations aim to create a more robust framework for managing global supply chain risks, ensuring industries are better prepared for unforeseen disruptions.

Additionally, this study, while comprehensive, faces limitations, notably in its reliance on secondary data and the scope of industries examined. The evolving nature of the semiconductor chip shortage and its impacts across diverse sectors suggests that my findings represent a snapshot within a broader, shifting landscape. Future research could benefit from incorporating primary data, including interviews with industry insiders and policymakers, to capture real-time insights and the nuances of strategic responses. Additionally, examining the effects of the

chip shortage on emerging technologies and sectors beyond automotive, such as healthcare and renewable energy, could provide a more holistic view of its global implications. Exploring the effectiveness of different supply chain resilience strategies in various industrial contexts would also enrich our understanding, offering tailored recommendations for stakeholders across the global economy.

In conclusion, the semiconductor chip shortage has provided a critical lesson in the fragility of global supply chains, emphasizing the need for enhanced strategic planning and government intervention to foster resilience and secure economic stability. This discussion sets the stage for future research to explore these strategies' efficacy further and develop more robust frameworks for managing global supply chain risks.

Conclusion

This thesis explored the significant disruption caused by the global semiconductor chip shortage, focusing on its profound impacts on the automotive industry and broader economic systems. The core of this investigation addressed how the shortage underscored the fragility of global supply chains and the broader implications for economic resilience.

The research identified key vulnerabilities, notably how the automotive sector, crucial to global manufacturing, was severely impacted by the chip scarcity. This led to widespread production halts and financial losses, illustrating the industry's critical dependency on semiconductor technology and the risks of optimized but fragile supply chains.

Additionally, the ripple effects of the shortage extended beyond the automotive industry, affecting diverse sectors, and highlighting the interconnectivity of modern economies. This situation brought to light the economic concentration in the semiconductor industry and the associated supply chain risks due to limited suppliers and regional focus.

In response, various adaptive strategies were implemented by industries and governments to mitigate impacts and enhance future resilience. These measures showed mixed effectiveness, suggesting the need for a foundational shift towards more resilient supply chain frameworks.

In addition, the study provides empirical insights into the dynamics of supply chain vulnerabilities and informs both industry practitioners and policymakers on the necessity of flexibility and strategic planning. For industry leaders, the crisis highlights the importance of diversifying supply sources, investing in technological innovation, and enhancing predictive capabilities to preempt future disruptions. For policymakers, it is crucial to support domestic manufacturing capabilities and foster international cooperation to enhance supply chain resilience. It also contributes to academic discussions by drawing parallels with existing

literature and proposing future areas of research to further understand and strengthen global supply networks against disruptions.

Theoretically, this research enriches the existing body of knowledge by providing empirical evidence on the dynamics of supply chain vulnerabilities and resilience strategies in the face of a global disruption. By drawing parallels and contrasts with existing literature, it not only reaffirms the significance of supply chain flexibility and diversity but also challenges and extends current understanding, particularly regarding the role of government intervention and public-private collaboration in mitigating supply chain risks. Thus, this study contributes to a deeper comprehension of supply chain management in a globally interconnected economy, offering pathways for both practical application and further academic exploration.

To mitigate future risks and enhance industry preparedness, it is imperative to adopt a multifaceted approach to supply chain management. Firstly, companies should prioritize diversifying their supplier base to reduce dependency on a single source, thereby minimizing risk exposure. Strategic partnerships and alliances across different geographies can further bolster supply chain resilience. Secondly, investing in advanced predictive analytics will enable better anticipation of supply chain disruptions, allowing for more agile responses. For policymakers, creating a conducive environment for domestic manufacturing of critical components, through incentives and support for research and development, is crucial. Additionally, fostering international cooperation to ensure a stable and secure global supply chain is essential. Implementing these recommendations requires a concerted effort from both industry leaders and policymakers, emphasizing the need for a proactive stance towards supply chain vulnerabilities in an ever-evolving global market.

While this study is comprehensive, it acknowledges certain limitations that open avenues for future research. Primarily, the reliance on secondary data sources, though extensive, may not

capture the nuanced, real-time decisions made by companies and governments in response to the chip shortage. Future studies could benefit from primary research, including interviews and case studies, to deepen understanding of strategic responses and their effectiveness. Additionally, the focus on the automotive industry, though critical, leaves room for exploration of the chip shortage's impact across other sectors reliant on semiconductor technology. Investigating these sectors could yield a more holistic understanding of global supply chain vulnerabilities. Moreover, longitudinal studies examining the long-term outcomes of the implemented strategies would offer valuable insights into the sustainability of supply chain adaptations. Addressing these limitations through future research will enrich the dialogue on supply chain management and resilience, contributing to more robust and adaptable global supply networks.

To conclude, this research ventures beyond the immediate crisis of the semiconductor chip shortage to illuminate broader themes of vulnerability and resilience within global supply chains. It stands as a testament to the intricate dance between technological advancement and economic stability, urging a reevaluation of supply chain strategies considering emerging challenges. The semiconductor industry's outlook for 2024 reflects a dynamic market poised for significant expansion, driven by technological advancements in automotive and AI sectors. The strategic emphasis on talent management and supply chain diversification is not only imperative for addressing immediate challenges but also crucial for securing long-term industry stability. These insights not only validate the importance of strategic flexibility in the face of supply chain disruptions but also underscore the necessity for ongoing adaptation to technological advancements and market demands (KPMG, 2024). As we gaze forward, this study beckons a future where supply chains are not just efficient, but also robust and adaptable, capable of withstanding the shocks of an unpredictable global market. It advocates for a

paradigm shift towards resilience, ensuring that the lifelines of the global economy are fortified against the tempests of change.

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