NPS-AM-26-032

ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

The Impact of the CHIPS Act on Intel's Manufacturing Capacity and National Security Implications for the Department of Defense

June 2025

Christina M. Day., CIV
Allison N. McCowan, CIV
Michelle L. Ruane, CIV

Thesis Advisors: Jeffrey R. Dunlap, Lecturer
Brett M. Schwartz, Lecturer

Department of Defense Management

Naval Postgraduate School

The research presented in this report was supported by the Acquisition Research Program of the Department of Defense Management at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact the Acquisition Research Program (ARP) via email, arp@nps.edu or at 831-656-3793.

ABSTRACT

The United States remains heavily dependent on foreign sources for advanced semiconductors (SCs), posing national security risks. This thesis examines how the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act addresses vulnerabilities by promoting domestic production, focusing on Intel's strategic response. It analyzes Intel's integrated device manufacturing (IDM) 2.0 strategy, its efforts to expand U.S.-based fabrication, and challenges in achieving high-volume, leading-edge manufacturing for external customers. The study uses policy analysis, industry reports, and case comparisons to assess Intel's role in reducing foreign reliance. Findings show that Intel's expansion—supported by federal incentives—improves resilience, but U.S. capacity remains insufficient to meet domestic demand. Complete independence is unrealistic due to reliance on global supply chains for rare earth elements, back-end processing, and critical minerals. The research highlights China's influence on the global value chain and risks from geopolitical tensions. It recommends sustained government investment, workforce development, and international cooperation to strengthen security and competitiveness. This thesis informs U.S. SC policy by mapping vulnerabilities and offering policy paths to reinforce defense-related technology supply chains.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

We are deeply grateful to Professor Howard Pace and Professor Frank Kragh, who guided us at the outset of this project and helped us establish its foundation before their well-earned retirements. Their early support was pivotal in shaping our direction.

We would also like to sincerely thank Professors Brett Schwartz and Jeff Dunlap, who stepped in during the latter stages to provide exceptional guidance and support, helping us complete this thesis. Their efforts during a critical time were invaluable.

Allison McCowan would like to express her heartfelt gratitude to her husband, Sean, whose unwavering patience, support, and love sustained her throughout this two-year journey at NPS. She is also deeply thankful to the leadership and colleagues at the Air Force Test Center and the Air Force Research Laboratory at Eglin AFB for their encouragement and support in pursuing this opportunity. Special thanks go to her supervisors—Ms. Tracey Anderson, Mr. Eric Washburn, Ms. Misty DeShields, and Ms. Jane Ellison—for their understanding, flexibility, and steady support throughout this process. Finally, she sincerely thanks Mr. James "Jim" Massey, Dr. Monica Allen, and Dr. Jeffery Allen for generously sharing their time, expertise, and insights, which meaningfully contributed to the development of this research.

Christina Day would like to express her deepest gratitude to her husband, Travis, and her son, Blaine, for their sacrifices and unwavering support throughout this journey. She also extends her appreciation to her coworkers, her supervisor, Wendell Brown, and the leadership at AFTC Edwards for allowing her to further her education at NPS and supporting her in her pursuit of excellence.

Michelle Ruane wishes to convey her profound gratitude to her husband, Ted, whose steadfast support, patience, and encouragement have been instrumental throughout this academic pursuit. His confidence in her determination and success has been a guiding force, and she deeply appreciates his unwavering presence and belief in her pursuit.

She also wishes to sincerely thank Todd Graves, Ed Lunney, John Lysher, and Doug Ochsenknecht for sharing their valuable insights on the impact of semiconductor

industry challenges on the Department of Defense. Their perspectives helped this group better understand the complexities and vulnerabilities associated with these issues, ultimately guiding the refinement of this research. Their generosity in sharing their expertise was instrumental in shaping the direction of this thesis, and their contributions are deeply appreciated.

NPS-AM-26-032

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

The Impact of the CHIPS Act on Intel's Manufacturing Capacity and National Security Implications for the Department of Defense

June 2025

Christina M. Day., CIV
Allison N. McCowan, CIV
Michelle L. Ruane, CIV

Thesis Advisors: Jeffrey R. Dunlap, Lecturer
Brett M. Schwartz, Lecturer

Department of Defense Management

Naval Postgraduate School

Prepared for the Naval Postgraduate School, Monterey, CA 93943.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
5G	fifth generation
5N4Y	five nodes in four years
AI	artificial intelligence
ALD	atomic layer deposition
ARRA	American Recovery and Reinvestment Act
ASE	Advanced Semiconductor Engineering
ASML	Advanced Semiconductor Materials Lithography
ATP	assembly, testing, and packaging
CEO	chief executive officer
CHIPS	Creating Helpful Incentives to Produce Semiconductors
CM	critical minerals
CPU	computer processing unit
CSIS	Center for Strategic and International Studies
DoD	Department of Defense
DRAM	dynamic random-access memory
EDA	electronic design automation
EISA	Energy Independence and Security Act
EMIB	Embedded Multi-die Interconnect Bridge
EUV	extreme ultraviolet
fab	fabrication facility
FAST	Fixing America's Surface Transportation
FinFET	fin field-effect transistor
Gen	generation
GF	GlobalFoundries
GPU	graphics processing unit
GVC	global value chain
High-NA	high numerical aperture
IC	integrated circuits

IDM	integrated device manufacturing
IP	intellectual property
JV	joint venture
LED	light-emitting diode
MOSFET	metal–oxide–semiconductor field-effect transistor
NAND	Not AND
NDAA	National Defense Authorization Act
Next-Gen	next generation
nm	nanometer
PC	personal computer
R&D	research and development
RAND	the Research and Development Corporation
REE	rare earth elements
SC	semiconductor
SIA	Semiconductor Industry Association
SMIC	Semiconductor Manufacturing International Corporation
STEM	science, technology, engineering, and mathematics
TSMC	Taiwan Semiconductor Manufacturing Company
YoY	year-over-year

I. INTRODUCTION

Recent advancements and policy measures, such as the Creating Helpful Incentives to Produce Semiconductors (CHIPS) Act, highlight the United States' strategic effort to strengthen its semiconductor (SC) industry amidst increasing global competition and supply chain vulnerabilities. This chapter explores the role of SCs in national security, the challenges facing the industry's supply chain, and the potential impact of Intel's expansion initiatives, supported by the CHIPS Act.

A. OVERVIEW OF THE SEMICONDUCTOR INDUSTRY AND ITS STRATEGIC IMPORTANCE

The SC industry is a cornerstone of modern technology, powering everything from consumer electronics to advanced military systems. As a previous leading player in this industry, Intel was once at the forefront of SC innovation and manufacturing (Miller, 2022, p. 266). However, the complexities of the global supply chain and recent geopolitical events have posed significant challenges to Intel's—and the entire industry's—stability and growth (Wafer World, 2024).

1. The Role of Semiconductors in National Security

The Department of Defense (DoD) uses SCs in various critical military technologies, including communication systems, surveillance equipment, and weapons systems. A secure and reliable supply of these components is crucial for maintaining technological superiority and national security. Any disruption in the supply chain can have profound implications for defense capabilities.

2. Current Challenges in the Semiconductor Supply Chain

Several factors have contributed to the fragility of the SC supply chain:

- Global shortages: A fire at a Renesas Electronics factory in Japan disrupted the supply of automotive chips, which affected Intel's supply chain and forced the company to adjust its production schedules (Kelion, 2021). Additionally, the

COVID-19 pandemic exacerbated an already strained supply chain, leading to widespread shortages and delays in SC production (Fioramonti, 2021).

- Specialization: The SC supply chain has become increasingly complex due to the high degree of specialization in each manufacturing component, leading to interdependencies that can amplify disruptions if any single link in the chain experiences issues (Ji et al., 2023a, 2023b).
- Dependence on foreign manufacturing: A significant portion of SC manufacturing is concentrated in a few regions, such as East Asia, making the supply chain vulnerable to regional disruptions (Akayama et al., 2024; Miller, 2022).

3. The Creating Helpful Incentives to Produce Semiconductors Act

The U.S. government enacted the CHIPS and Science Act of 2022 to revitalize domestic SC manufacturing in response to these challenges. The act provides substantial funding and incentives to encourage companies like Intel to expand their manufacturing capabilities within the United States. By boosting domestic production, the CHIPS Act seeks to reduce reliance on foreign suppliers and enhance the security and resilience of the U.S. SC supply chain. However, recent reports indicate that the Trump administration has made significant staff cuts at the National Institute of Standards and Technology, which could impact the administration and distribution of CHIPS Act funds (Maruccia, 2025).

4. Intel's Position and Potential Impact

As one of the most established and technologically advanced SC manufacturers, Intel has benefited significantly from the CHIPS Act. The company has begun constructing new manufacturing facilities and upgrading existing ones with CHIPS Act incentives (U.S. Department of Commerce, 2024c). As of March 2025, Intel has received $2.2 billion of its $7.8 billion in CHIPS Act funding (Filby, 2025b). These expansions are expected to increase Intel's production capacity, potentially stabilizing the supply chain and supporting national security objectives (U.S. Department of Commerce, 2024c). However, Intel's Ohio manufacturing facility, which was supposed to open in 2026, is now expected to open by 2030 or later (Subin, 2025; Filby, 2025b). This delay raises questions about the timeline for these expansions and their broader impact on the industry.

5. Assessing the Impact

Understanding how quickly and effectively Intel can achieve production of leading-edge chips with the benefit of the CHIPS Act is crucial for assessing the potential benefits to the DoD and the overall SC market (Donaldson, 2024). Recent developments, including potential changes to the CHIPS Act under the Trump administration and Intel's delayed expansion plans, add complexity to this evaluation (Dumas, 2025). This thesis aims to address these questions by evaluating Intel's current manufacturing capabilities, analyzing the impact of the CHIPS Act on the company's capacity expansion, and assessing the broader implications, including how Intel's growth could enhance the DoD's technological edge and strengthen national security, while also influencing global SC supply chain dynamics.

B. THE NEED TO ASSESS THE IMPACT OF THE CHIPS ACT ON INTEL'S MANUFACTURING CAPACITY AND U.S. RELIANCE ON CHINA

The enactment of the CHIPS Act represents a pivotal moment for the SC industry, particularly for Intel (Sutter, 2023). This thesis aims to assess the immediate and projected impact of the CHIPS Act on Intel's manufacturing capacity, focusing on how it may reduce the U.S.'s reliance on China for SC production. Given the strategic importance of SCs to national security, understanding the implications of this shift is crucial for assessing the potential benefits to DoD and the broader SC market.

C. MAIN OBJECTIVES OF THIS STUDY

The primary objective of this study is to assess the impact of the CHIPS Act on Intel's SC manufacturing capacity and its implications for U.S. national security. First, the study evaluates Intel's existing manufacturing capabilities, focusing on technological advancements and current production strengths, including leading-edge process technologies and innovative material integration.

Second, it analyzes the CHIPS Act's specific incentives and support mechanisms for Intel. This includes identifying financial grants, tax incentives, and regulatory support to enhance Intel's manufacturing capabilities. Additionally, the study determines how these incentives are expected to influence Intel's capacity expansion plans, critically assessing their effectiveness.

Third, the study assesses Intel's planned capacity expansions, including projected increases in production capability. This involves developing a detailed timeline for Intel's expansion efforts, highlighting key milestones, potential challenges, and mitigation strategies. This evaluation will thoroughly analyze the logistical, financial, and regulatory hurdles that might impact the expansion process.

Fourth, the study examines the impact of Intel's increased capacity on the SC industry, including market dynamics, competition, and innovation. It examines the potential impact of Intel's expansion on supply and demand within the global market, the competitive landscape among SC manufacturers, and the pace of technological advancements.

Fifth, the study analyzes the strategic importance of Intel's capacity expansion for U.S. national security. This includes identifying potential risks to national security if Intel's expansion efforts are delayed or disrupted and providing recommendations for mitigating these risks and enhancing supply chain resilience. The study assesses how securing a stable supply of domestically produced SCs can support defense capabilities and reduce vulnerabilities in critical infrastructure.

Lastly, the study develops actionable policy recommendations for the DoD and other stakeholders. These recommendations support Intel's expansion of its manufacturing capacity and ensure a secure, resilient supply chain for critical microelectronics. The study provides insights into how government and industry can collaborate to address the challenges and opportunities presented by the CHIPS Act.

D. RESEARCH QUESTIONS

This study addresses several critical research questions to understand the impact of the CHIPS Act on Intel's manufacturing capacity and its broader implications. The primary research question is, "How does the CHIPS Act impact Intel's manufacturing capacity, and how can increased domestic production reduce U.S. reliance on China in the SC supply chain while enhancing national security?" This question is central to understanding the potential of the CHIPS Act to shift the balance of global SC production and strengthen U.S. technological leadership.

The secondary research question is, "What are the challenges and risks of Intel's capacity expansion under the CHIPS Act?" It identifies these challenges and develops strategies to mitigate them, ensuring a resilient and secure SC supply chain for the U.S. This includes examining potential bottlenecks in the supply chain, workforce development issues, and environmental impacts that could hinder Intel's expansion efforts.

The third research question is, "How does Intel's capacity expansion under the CHIPS Act influence broader SC market dynamics and domestic and global competition?" This involves analyzing how increased domestic production capacity affects market share, pricing, innovation, and the competitive landscape among major global SC manufacturers. Understanding these dynamics is crucial for assessing the long-term impact of the CHIPS Act on the worldwide SC industry and U.S. competitiveness.

Together, these research questions guide the investigation into the effectiveness of the CHIPS Act and its potential to reshape the U.S. SC landscape and national security posture. The answers to these questions provide valuable insights for policymakers, industry leaders, and stakeholders aiming to enhance the resilience and security of the SC supply chain.

E. RELEVANCE OF THE RESEARCH TO NATIONAL SECURITY AND INDUSTRY DYNAMICS

The DoD requires a secure and stable supply of SCs to support its critical operations and maintain technological superiority (Office of the Deputy Secretary of Defense, 2022). However, the current landscape of SC manufacturing presents significant challenges. Two foreign-owned companies dominate the advanced SC manufacturing capability critical to U.S. national security and technological advancement (Blevins et al., 2020, p. 25). This dependency on foreign entities presents considerable supply chain and national security risks. Intel represents a crucial opportunity to onshore these capabilities within the United States, supported by the CHIPS Act incentives. This thesis explores how Intel's expansion can enhance domestic manufacturing capacity and reduce reliance on foreign suppliers.

A 2024 Reuters article highlights Intel's past dominance in the chip manufacturing industry, particularly in the 1990s, with its Pentium microprocessors and partnership with Microsoft (Randewich et al., 2024). The same report notes that Intel missed key opportunities with the iPhone and later failed to adopt extreme ultraviolet (EUV) light technology in the 2010s. As Intel's market position weakened, so did the personal computer (PC) industry, as Randewich et al. explained. By 2017, Samsung, based in South Korea, had overtaken Intel as the world's largest chip maker, while Taiwan Semiconductor Manufacturing Company (TSMC) led in cutting-edge manufacturing technology. Growth in the SC industry was focused increasingly on graphics processing units (GPUs) rather than the computer processing units (CPUs) that Intel specialized in (Randewich et al., 2024). In response to this competitive shift, Intel appointed Pat Gelsinger, chief executive officer (CEO). As reported by Randewich et al., he introduced an ambitious plan called "five nodes in four years" (5N4Y). The plan aimed to restore Intel's leadership in chip manufacturing, requiring significant investment in research and development (R&D) and new production facilities. As the only U.S.-based SC manufacturer, Intel's efforts aligned closely with national security objectives (Biden, 2022).

The CHIPS Act aims to bolster domestic SC manufacturing by incentivizing and supporting domestic SC manufacturers. Despite these efforts, several questions remain unanswered:

- **Timeline uncertainty**: The projected timeline for Intel's capacity expansion under the CHIPS Act is unclear, making it difficult to predict when the benefits of the Act will fully materialize (Donaldson, 2024).

- **Industry impact**: Intel's ability to ramp up production has significant implications for the broader SC industry, including market dynamics and competition (Priyadarshi, 2024).
- **National security concerns**: Given the strategic significance of SCs, any reliance on foreign packaging or interruptions in Intel's capacity expansion could pose an immediate threat to national security (Flamm & Bonvillian, 2025).

F. STRUCTURE OF THE THESIS

This thesis is organized into five comprehensive chapters that systematically address the critical aspects of SC manufacturing. It focuses on Intel's expansion and the impact of the CHIPS Act on national security and industry dynamics.

Chapter I provides a comprehensive overview of the study's context and purpose.

- Section A. Overview of the Semiconductor Industry and its Strategic Importance: This section provides an overview of the SC industry and its strategic importance, setting the stage by highlighting SCs' critical role in various high-tech sectors and their impact on technological advancements.
- Section B. Problem Statement: This section discusses the need to assess the impact of the CHIPS Act on Intel's manufacturing capacity and the U.S.'s reliance on China. It outlines the key challenges and risks associated with the current SC manufacturing landscape, emphasizing the strategic importance of reducing foreign dependencies.
- Section C, Main Objectives of this Study: This section clearly defines the research goals, focusing on enhancing domestic manufacturing capacity and evaluating the effectiveness of the CHIPS Act in supporting Intel's expansion.
- Section D, Research Questions: This section presents the primary and secondary research questions that guide the investigation. It identifies the specific queries the study aims to address, including timelines for capacity expansion, industry impact, and national security concerns.

- Section E, Relevance of the Research to National Security and Industry Dynamics: This section explains the research's relevance to national security and industry dynamics, highlighting the study's importance in providing insights into the strategic implications of Intel's expansion and the broader impact on the U.S. SC supply chain. The study's findings could potentially inform policy decisions and industry strategies, significantly contributing to the field.
- Section F, Structure of the Thesis: This section provides an overview of the thesis's structure, guiding readers through the subsequent chapters and the key topics they cover.

Chapter II provides a foundational context for understanding the study.

- Section A. Overview of the Semiconductor Industry: This section covers the history, current trends, and major players in the industry, providing a comprehensive background on the evolution of the SC industry.
- Section B. Intel: This section offers a detailed company profile, including Intel's existing manufacturing capacity and strategic initiatives, setting the stage for understanding the company's potential for expansion under the CHIPS Act.
- Section C. The CHIPS Act: This section describes the CHIPS Act, its objectives, and the incentives it offers SC manufacturers like Intel, explaining the legislative framework designed to bolster domestic SC production.
- Section D. U.S.-China Semiconductor Dynamics: The section analyzes U.S. dependence on China for SCs and the associated risks, emphasizing the strategic importance of reducing reliance on foreign SC suppliers to enhance national security.

Chapter III comprehensively analyzes existing research relevant to the study.

- Section A, Previous Studies on Semiconductor Manufacturing: This section reviews past research on manufacturing capabilities and challenges, providing a detailed understanding of the advancements and obstacles faced in SC manufacturing.

- Section B, Impact of Legislation on Industry: This section examines how previous legislative actions have influenced the SC industry, analyzing policies and regulations that have shaped the industry's development.
- Section C, National Security Implications: This section studies the strategic importance of SC supply chains, exploring their critical role in national security and the potential risks associated with supply chain disruptions.
- Section D, Gaps in the Literature: This section identifies research gaps this thesis aims to address, highlighting areas where existing research is lacking and emphasizing the contributions the current study intends to make.

Chapter IV comprehensively evaluates Intel's capabilities, the impact of the CHIPS Act, and broader implications for the SC industry and national security.

- Section A, Methodology: This section outlines the data collection processes employed to ensure a comprehensive analysis of Intel's manufacturing capabilities, financial performance, strategic initiatives, and broader implications within the SC industry.
- Section A.1, Data Collection Methods: This subsection explains the processes used to collect data, including both quantitative and qualitative methods.
- Section A.2, Quantitative Analysis: This subsection summarizes the use of quantitative data, including industry reports and statistical figures, to evaluate Intel's financial performance, production metrics, expansion efforts, and its position within the global SC industry.
- Section A.3, Qualitative Analysis: This subsection highlights the use of qualitative analysis through academic studies, think tank evaluations, and industry commentaries to provide contextual depth and interpret Intel's strategies and their broader implications for the SC industry and Global Value Chain (GVC).
- Section A.4, Case Study Comparison: This subsection outlines the methodology for analyzing Intel's operations through a comparative study, focusing on its

expansion plans, technological advancements, financial performance, and operational strategies to establish its unique position within the SC industry.

- Section A.5, Ethical Consideration: This subsection outlines the integration of ethical research practices, including the exclusion of human subjects and primary interviews, while leveraging expert discussions and secondary data to guide the study.
- Section B, Case Study Analysis of Intel: This section analyzes Intel Corporation's strategic initiatives, operational evolution, and its broader role in reshaping the global SC landscape.
- Section B 1, Overview of Intel's Manufacturing Capabilities: This subsection explores Intel's evolution, analyzing its manufacturing expertise, operational performance, and adaptation to challenges across economic, geopolitical, and policy landscapes.
- Section B 2, Impact of the CHIPS Act on Intel: This section assesses the incentives and support mechanisms provided by the CHIPS Act.
- Section B 3, Comparative Analysis: This subsection compares Intel with other SC manufacturers benefiting from the CHIPS Act, highlighting differences in strategies and outcomes.
- Section B 4, Reduction of U.S. Dependence on China: This section evaluates how Intel's capacity expansion affects U.S. reliance on China for SCs.
- Section B 5, National Security Implications: This section analyzes the strategic importance of increased domestic SC production.

Chapter V comprehensively overviews the study's outcomes and broader significance.

- Section A, Summary of Findings: This section summarizes the study's key insights, highlighting Intel's role in the U.S. SC industry under the CHIPS Act. It examines Intel's efforts to reduce reliance on foreign suppliers, its contributions to national security, and the impact of its Integrated Device Manufacturing (IDM) 2.0 strategy on reclaiming U.S. leadership in advanced chip manufacturing.

- Section B, Implications for the Semiconductor Industry: This section discusses the broader implications for industry and market dynamics, exploring how Intel's expansion and the CHIPS Act incentives affect the competitive landscape, innovation, and industry growth.
- Section C, Implications for National Security: This section evaluates the strategic importance of the findings for U.S. national security. This section delves into how reducing dependency on foreign SC suppliers and enhancing domestic production capabilities strengthen national security.
- Section D, Policy Recommendations: This section proposes targeted policies to enhance Intel's competitiveness and U.S. SC resilience, focusing on investments in production, supply chain diversification, R&D, export controls, and workforce development.
- Section E, Future Research Directions: This section presents suggestions for future research that build on this study's findings, identifying areas where further investigation is needed to deepen understanding and address any remaining gaps in the literature.
- Section E, Final Thoughts: This section provides concluding remarks on the impact of the CHIPS Act and Intel's role in the SC supply chain, reflecting on the study's significance, the challenges ahead, and the potential for future advancements in the industry.

This structured approach ensures a logical progression, guiding the reader from a foundational context to an in-depth analysis of Intel's expansion under the CHIPS Act and its broader implications for the SC industry and national security. By systematically addressing the research objectives and questions, this thesis aims to provide valuable insights into the challenges, opportunities, and strategic importance of domestic SC manufacturing in the United States. The chapters' comprehensive organization highlights the study’s interconnected aspects, offering a cohesive framework for understanding the impact of legislation and industry advancements on national and global scales.

II. BACKGROUND

The interplay between government policy, technological innovations, and global competition has placed the SC industry at the forefront of strategic national interest. Central to this dynamic is the CHIPS Act, a landmark initiative to bolster the domestic SC industry. This chapter offers an in-depth exploration of the CHIPS Act, shedding light on its objectives, incentives, and legislative framework, which collectively aim to secure the U.S. leadership in this critical technology sector.

A. OVERVIEW OF THE SEMICONDUCTOR INDUSTRY AND ITS STRATEGIC IMPORTANCE

The SC industry is a cornerstone of modern technology, powering everything from consumer electronics to advanced military systems (Richard, 2023). Initially, Intel was at the forefront of SC innovation and manufacturing (Miller, 2022, pp. 116–117). However, Intel's transition from a young, growing company to a mature market leader has come with some major changes. The company has transitioned from having founding engineers as CEOs to having business executives at the helm (Intel, n.d.-g). Simultaneously, Intel lost ground in the manufacturing marketplace to latecomers TSMC and Samsung (Miller, 2022, p. 307). In the early days of the SC industry, nearly every company executed the entire manufacturing process for their SCs (Berger et al., 2023; Miller, 2022, pp. 290–291; Richard, 2023). However, as technology improved and became exponentially more complex, specialization started to move into the industry. The manufacturing of chips became a specialization in itself (Arasasingham et al., 2022; Berger et al., 2023; Grimes & Du, 2022). The Semiconductor Industry Association (SIA) estimates that the U.S. SC industry has lost 50% of the global market share since the 1980s (Semiconductor Industry Association, 2022a).

B. OVERVIEW OF THE SEMICONDUCTOR INDUSTRY: HISTORY, CURRENT TRENDS, AND MAJOR PLAYERS

SCs, sometimes known as "chips" or "integrated circuits" (ICs), were co-invented by Robert Noyce, a founder of Fairchild Semiconductor, and Jack Kilby of Texas

Instruments (Miller, 2022, pp. 44–47). Each of these men were working independently of each other (Miller, 2022, p. 47). SCs initially consisted of transistors connected by thin metal wires to transmit electronic signals (Miller, 2022, p. 47). The silicon used for chips is derived from sand, the basis for the name "Silicon Valley" (Miller, 2022, p. 15).

In the early days of the industry, most companies manufactured their own chips while technology evolved rapidly (Akayama et al., 2024; Miller, 2022). Eventually, Robert Noyce and Gordon Moore of Fairchild Semiconductor left the firm to create what is now known as Intel (Miller, 2022, p. 112). Intel became dominant in the SC industry and was famous for developing computing processors (Miller, 2022).

As Intel matured in the industry and its founding CEOs retired, the company shifted its focus from designing the best chips to pursuing financial performance over technological dominance (Miller, 2022, pp. 302–304). During this period, other SC manufacturing players surpassed Intel in capabilities and market share (Galloway, 2024).

TSMC and Samsung pursued the latest manufacturing technologies, allowing them to develop chips at the leading edge (Akayama et al., 2024; Miller, 2022). It should be noted that the SC industry is dynamic, and what is considered a leading-edge chip changes rapidly in short periods (Akayama et al., 2024; Miller, 2022; A. Shilov, 2025a). Historically, metal-oxide-semiconductor-field-effect transistor (MOSFET) chips that use planar or two-dimensional (2D) architecture to connect transistors are typically described by node size measured in nanometers (nm): 10nm, 7 nm, etc. The MOSFET technology has been pushed to the limits of what is possible in the traditional realm of physics, and the most advanced chips are now produced using fin field-effect transistor (FinFET) three-dimensional (3D) technology, which allows for the expansion of the number of transistors that can be connected via channels rather than fine wires. The transition from 2D MOSFET technology to 3D FinFET has made node size irrelevant, although manufacturers still use the nomenclature for marketing. These chips are less than 7nm and contain tens of billions of transistors (Inquivix Technologies, 2023; Miller, 2022). Manufacturing such complex chips requires highly specialized equipment, primarily an EUV lithography machine capable of producing light at the smallest wavelength possible (Murphy, 2023). EUV light does not exist naturally on Earth; instead, an EUV lithography machine harnesses it by shooting a molten drop of tin with a laser inside a machine that uses a series of ultra-precise mirrors to reflect the light, allowing it to etch patterns in a small silicon wafer. These patterns enable the connection of electric signals between the billions of transistors (Miller, 2022).

Only one company in the world, Advanced Semiconductor Materials Lithography (ASML) in the Netherlands, possesses the technology and knowledge to manufacture an EUV machine, which is required to manufacture advanced chips (Advanced Semiconductor Materials Lithography, n.d.; Miller, 2022, pp. 267–269; Murphy, 2023). Samsung and TSMC were early adopters of EUV lithography. Fearing the technology still needed to be sufficiently developed, Intel chose not to adopt EUV lithography initially. This decision allowed Samsung and TSMC, both relative newcomers to the SC industry, to surpass Intel's technological capabilities, which had long dominated the market (Galloway, 2024).

Intel is currently using EUV machines from ASML to produce its Intel 4 chips, which are comparable to what TSMC and Samsung refer to as 5nm and 4nm processes. Leading-edge chips are required for artificial intelligence (AI), smartphones, military applications, and quantum computing (U.S. Department of Commerce, 2024c). State-of-the-art chips are still challenging to make, but do not require EUV machines and are found in technologies such as CPUs (Galloway, 2024). Simpler varieties of chips are used in appliances and other less complex technologies (Galloway, 2024).

In 2021, Intel appointed former engineer Pat Gelsinger as the corporation's CEO, representing a return to a focus on technological and engineering leadership (R. Goswami & Field, 2024). Gelsinger outlined a strategy called IDM 2.0, aimed at reestablishing Intel's leadership in the manufacturing segment of the industry (Intel, 2021b). This strategy is ambitious, risky, expensive, and complex, with initial cost estimates of $100 billion over five years (Randewich et al., 2024). The company must build new manufacturing facilities, develop a skilled workforce, invest in and learn how to operate EUV machines, and secure customers (Miller, 2022, p. 457).

Intel's existing product segment business specializes in computer processors and other hardware, making it its own built-in customer. While this internal supply capability is a strength, it can also be a weakness. Many technology companies, including Apple, Nvidia, Microsoft, Meta, Google, and Amazon, do not make their chips (Miller, 2022). Instead, they design the chips and outsource production to a fabrication facility, or "fab." When these companies outsource production, they release sensitive intellectual property (IP) to the fab (Miller, 2022, p. 241). Some fabs, known as foundries, only make chips, such as TSMC or Qualcomm (Coleman, 2023). Intel is not a foundry. Instead, Intel operates as an integrated device manufacturer (IDM) that both makes and sells chips (Coleman, 2023).

C. THE CHIPS ACT: DETAILED DESCRIPTION AND ITS OBJECTIVES AND INCENTIVES

The CHIPS Act is a U.S. federal statute enacted by the 117th U.S. Congress and signed into law by President Joe Biden on August 9, 2022 (H.R.4346 – 117th Congress (2021-2022), 2022). The act authorizes roughly $280 billion in new funding to support domestic research and manufacturing of SCs in the U.S. over 5 years (2022–2027). Of this funding, $39 billion is allocated for SC manufacturing incentives through grants, tax credits, and loans (Badlam et al., 2022).

Additionally, the act designates $13.2 billion for research and workforce development and $500 million for SC supply chain activities and international information communications technology security (Mearian, 2024). Furthermore, $174 billion is allocated for the broader ecosystem of public sector research in science and technology, which includes initiatives such as the Moon to Mars Program Office (Badlam et al., 2022).

At the time of writing this thesis, the new Trump administration is considering renegotiating the CHIPS Act awards allocated by the previous administration. President Trump has publicly criticized the CHIPS Act, describing it as an unnecessary subsidization of wealthy corporations and suggesting that funds could be better utilized to reduce the national debt (Moon, 2025; Strom & Schoettler, 2025). This stance has raised concerns about future projects like Intel's Ohio SC plant, which has already faced delays and financial challenges despite being a flagship initiative under the CHIPS Act (Trau, 2025). The administration has also signaled a potential review of contracts and grants issued under the Biden administration, with an emphasis on scrutinizing expenditures and removing provisions related to diversity, equity, and inclusion (Strom & Schoettler, 2025). While no formal changes have been enacted, this uncertainty adds complexity to Intel's expansion plans and the broader objectives of the CHIPS Act.

1. Objectives of the CHIPS Act

The primary objectives of the CHIPS Act are to

- **Strengthen American supply chain resilience:** The act aims to reduce U.S. dependence on foreign SC manufacturing, mainly from East Asia, by boosting domestic SC production (Belvins et al., 2023, p. 16).
- **Counter China's influence:** The act is designed to counter China's growing dominance in the SC industry by incentivizing domestic production (White House, The, 2022).
- **Create jobs and economic growth**: The act aims to create high-skilled jobs in SC manufacturing, construction, and maintenance, catalyzing regional economic development (White House, The, 2022).
- **Advance technological leadership:** By investing in R&D, the act seeks to ensure U.S. leadership in critical technologies such as AI, quantum computing, and autonomous systems (Belvins et al., 2023).

2. Incentives for Semiconductor Manufacturers

The CHIPS Act offers subsidies (like those discussed above) along with several other incentives to SC manufacturers, including Intel:

- **Investment tax credits:** The act offers 25% investment tax credits for manufacturing equipment costs (H.R.4346 – 117th Congress (2021-2022), 2022).
- **R&D funding:** The act allocates $13 billion for SC research and workforce training (Belvins et al., 2023, p. 23).

- **Support for supply chain resilience:** The act includes provisions to support developing and adopting secure and trusted telecommunications technologies and SCs (H.R.4346 – 117th Congress (2021-2022), 2022).

3. Legislative Framework

The legislative framework of the CHIPS Act is designed to bolster domestic SC production through financial incentives, R&D support, and workforce training programs. The act establishes the CHIPS for America Fund, which provides financial incentives for building and equipping domestic fabs and supports SC research activities through partnerships with U.S. industry.

By addressing these objectives and offering these incentives, the CHIPS Act aims to enhance the capabilities of the SC industry and ensure the United States remains a leader in this critical technology sector.

D. U.S.–CHINA SEMICONDUCTOR DYNAMICS: ANALYSIS OF THE U.S. DEPENDENCE ON CHINA FOR SEMICONDUCTORS AND ASSOCIATED RISKS

SCs are a cornerstone of modern technology, critical to the U.S. and China's economic and strategic agendas (Miller, 2022, p. 154; Biden, 2022). The dynamics surrounding the SC industry reveal a complex interplay of dependence, competition, and strategic maneuvering between the two superpowers. China intends to become a global leader on various technological fronts, including AI, quantum computing, and fifth generation (5G) technology. These technologies have dual use for civilian and military applications, and Chinese leadership in these fields would challenge the supremacy of the U.S. military (Biden, 2022). The U.S. maintains control over key inputs in the SC value chain. However, China also has a significant influence, particularly in the packaging and supplying of rare earth elements (REE) and critical minerals (CM). In response to U.S. export controls aimed at curbing Chinese technological progress, China has restricted access to REE and labeled U.S. silicon unsafe (Nguyen, 2024; Office of Congressional and Public Affairs, 2024). These actions have led to accusations and litigation of illegal trade activities on both sides (Lynn, 2021). Despite this tension, the interdependence between the U.S. and China in the SC industry is profound; neither country can achieve complete operational independence in the short to medium term. It should be noted that compared to the U.S., “examination of the semiconductor GVC shows that China’s contribution at present is relatively modest” (Grimes & Du, 2022, p. 12). The U.S.–China dynamic is further complicated by issues such as supply chain integrity, IP theft, economic coercion, and strategic competition, alongside geopolitical concerns like the One China policy concerning Taiwan (Arasasingham et al., 2022; Grimes & Du, 2022; Martin et al., 2023). These factors contribute to the intricate and precarious nature of the global SC supply chain, underscoring the critical need for strategies to mitigate these risks and ensure stability.

THIS PAGE INTENTIONALLY LEFT BLANK

III. LITERATURE REVIEW

This chapter synthesizes existing research to provide a robust foundation for understanding the critical challenges and opportunities facing the SC industry. It reviews past studies on manufacturing capabilities, the influence of legislation, and the national security implications of SC supply chains to identify key patterns and gaps in the current body of knowledge. These gaps, particularly concerning the CHIPS Act's impact on Intel's U.S. supply chain dependencies and broader market dynamics, set the stage for the research questions this thesis aims to address.

Through this comprehensive literature review, the thesis aligns its objectives with the urgent need for innovative policy and industrial strategies to strengthen the U.S.'s leadership in SC technology.

A. REVIEW OF PAST RESEARCH ON MANUFACTURING CAPABILITIES AND CHALLENGES

Section A examines the technological advancements and ongoing challenges in SC manufacturing, offering a foundation for understanding the industry's evolution and current obstacles.

1. Introduction

This literature review section examines previous research on SC manufacturing capabilities and challenges. The review combines findings from various studies to provide an overview of the technological advancements and methodologies that have shaped the industry. Key findings reveal significant progress in areas such as process technology, quality control, and the integration of innovative materials. However, the literature also underscores persistent challenges, including rising costs, supply chain vulnerabilities, labor shortages, and the environmental impact of SC production. By identifying these gaps, the review highlights the need for continued R&D to address these issues and enhance the industry's sustainability and resilience.

2. Background

The SC industry has undergone significant evolution since its inception. Early research focused on developing silicon-based transistors and ICs (Richard, 2023, p. 176). Over the years, advancements in materials science, process technology, and design automation have led to the miniaturization of SC devices and increased manufacturing complexity (Burkacky et al., 2021). These advancements have positioned the SC industry as the cornerstone of technological advancement for decades, driving innovation in various sectors, from computing to telecommunications and the automotive industry (Richard, 2023, p. 178).

3. Manufacturing Capabilities

Advanced manufacturing capabilities are crucial for producing the increasingly complex and miniaturized electronic components the SC industry requires. These capabilities include cutting-edge process technologies, such as EUV lithography, atomic layer deposition (ALD), and advanced etching techniques (Miller, 2022, p. 24).

Recent studies have examined the capabilities required for advanced SC manufacturing. Key areas of focus include:

- **Design and verification:** As ICs have become more complex, designing and verifying them require highly advanced electronic design automation (EDA) tools and methods to ensure the ICs work reliably. The SC industry heavily relies on these sophisticated EDA tools, which assist in the detailed design of ICs and play a crucial role in verifying and optimizing them. EDAs ensure that the final products meet strict quality standards. The development and dependence on EDA tools highlight their importance in modern SC manufacturing (Kahng et al., 2001).
- **Process technology:** Innovations in lithography, etching, and deposition techniques have revolutionized the production of SC devices, allowing for the creation of smaller, more efficient components (EBM Machine, 2024). Advances in these processes enable manufacturers to achieve higher precision and greater

control over the fabrication of intricate SC structures (George, 2009). This progress has been instrumental in the continued miniaturization of electronic devices, contributing to enhanced performance and energy efficiency. As a result, modern SC devices can integrate more functionality into smaller footprints, meeting the demands of various high-tech industries. These technological breakthroughs improve device capabilities while driving new applications and markets in the SC industry (George, 2009).

- **Quality control**: Quality control is a critical aspect of SC manufacturing, ensuring high yield and reliability of the products. According to various textbooks, rigorous metrology and inspection methods are essential to maintaining the integrity of the manufacturing process (Doering, 2008; Geng, 2017; Hnatek, 1993). These methods include advanced techniques for detecting defects and ensuring that each step of the production process meets stringent quality standards. By implementing comprehensive quality control measures, manufacturers can minimize the occurrence of defects, thereby enhancing the overall performance and longevity of SC devices. The emphasis on quality control highlights its significance in achieving optimal manufacturing outcomes and maintaining the competitiveness of the SC industry (Doering, 2008; Geng, 2017; Hnatek, 1993).

4. Challenges in Semiconductor Manufacturing

Despite technological advancements, the SC industry faces several challenges:

- **Rising costs:** The rising costs in SC manufacturing constitute a significant challenge to the industry. The expenses involved in designing and producing advanced SC devices are substantial due to the technology required (Tembey et al., 2023). Costs related to R&D, equipment, and materials have also increased. Building and operating SC fabs has become much more expensive due to the complexity of modern technology and the need for advanced machinery (Richard, 2023). Furthermore, geopolitical tensions, supply chain disruptions, and inflation have added to these costs. These factors have led to higher material, labor, and construction expenses, making it hard for companies to stay profitable and competitive (Tembey et al., 2023).

- **Supply chain issues:** The global SC supply chain is vulnerable to disruptions, as shown by the fire at the Renesas Electronics factory and the COVID-19 pandemic (Fioramonti, 2021; Thomas, 2021). These events exposed how fragile the supply chain is, leading to significant shortages and delays in SC production (Fioramonti, 2021). The pandemic caused interruptions at various stages, from raw material extraction to manufacturing and distribution, which highlighted the industry's reliance on a few key suppliers and specific regions. As a result, industries that depend on SCs, such as automotive and consumer electronics, faced severe production bottlenecks and delays (Burkacky et al., 2021).
- **Labor market gap:** The SC industry faces a significant labor market gap, particularly in the U.S. According to a SIA and Oxford Economics report, the industry will require an additional 115,000 workers by 2030 (Cabello, 2023). However, due to current degree completion rates, approximately 67,000 positions may remain unfilled. This shortage spans various roles, including technicians, computer scientists, and engineers. The report emphasizes the need for strengthened support for regional partnerships, growth in the domestic science, technology, engineering, and mathematics (STEM) pipeline, and retention of international advanced degree students to address this gap (Cabello, 2023).
- **Critical minerals:** The U.S. SC manufacturing industry faces significant challenges due to its reliance on CM. According to a *Massachusetts Institute of Technology Science Policy Review* report, the supply chains for these minerals are very fragile because the U.S. depends heavily on foreign sources (O. Goswami, 2023). Geopolitical tensions and the concentration of mineral supplies in a few countries exacerbate this reliance. Goswami emphasizes the need for targeted investments, such as those encouraged by the CHIPS Act, to develop onshore supply chains and create domestic manufacturing capacity. Recycling and

recovering CM from existing sources can also help reduce this dependency (O. Goswami, 2023).

- **Environmental impact:** SC manufacturing is known for its high resource consumption and notable environmental impact (Brescia, 2024). Recent research has focused on creating sustainable manufacturing practices to address these issues (Burkacky et al., 2021). This includes minimizing energy usage, reducing waste, and implementing eco-friendly materials and processes. The goal is to significantly decrease the industry's carbon footprint significantly, making SC production more environmentally sustainable (Liu et al., 2024).

5. Comparative Analysis

Comparative studies have highlighted significant differences in manufacturing capabilities and challenges across various regions. For example, the U.S. SC industry has long been a leader in advanced process technologies, investing heavily in innovation and precision engineering (Semiconductor Industry Association, 2024). In contrast, East Asian countries, such as Taiwan and South Korea, have excelled in high-volume production, leveraging economies of scale and efficient manufacturing practices to dominate the global market (Burkacky et al., 2021). Recent research has also examined the potential of emerging markets, such as India and Vietnam, to contribute to the global SC supply chain, offering new opportunities for diversification and resilience in production (Wu & Liang, 2024).

B. IMPACT OF LEGISLATION ON INDUSTRY: EXAMINING HOW PREVIOUS LEGISLATIVE ACTIONS HAVE INFLUENCED THE SEMICONDUCTOR INDUSTRY

Section B examines past legislative actions and their impact on the SC industry, laying the groundwork for understanding how policies like the CHIPS Act influence manufacturing capabilities, supply chain resilience, and innovation within the sector.

1. Introduction

The CHIPS Act was introduced to bolster domestic SC manufacturing by incentivizing and supporting SC manufacturers. President Biden announced at the signing ceremony that "the future of the chip industry is going to be made in America" (Gleklen et al., 2023, p. 1).

This thesis examines how the act achieves this goal. However, it is essential to recognize the influence of previous legislative actions on the SC industry, such as the Energy Independence and Security Act (EISA) of 2007, the American Recovery and Reinvestment Act (ARRA) of 2009, and the Fixing America's Surface Transportation (FAST) Act of 2015. Notably, the National Defense Authorization Act (NDAA) for Fiscal Year 2021 set the stage for the passage of the CHIPS Act in 2022 (National Defense Authorization Act for Fiscal Year 2021, 2021).

2. Energy Independence and Security Act of 2007

A review of the EISA of 2007 included provisions to promote energy efficiency and renewable energy, indirectly supporting advancements in SC technology, particularly in the development and mass adoption of light-emitting diode (LED) lighting products (Energy Independence and Security Act of 2007, 2007). This shift created a significant demand for advanced SCs used in LED technology. The act sets new standards for energy efficiency in various appliances and equipment that incorporate SCs. This encouraged innovation and the development of more energy-efficient SC components (Sissine, 2008, p. 7). EISA provided funding and support for advanced vehicle technologies and renewable energy projects, often relying on SC technology (Sissine, 2008, p. 6). This helped drive R&D in the SC industry, promoting federal energy management practices that include using energy-efficient technologies and products, many of which incorporate SCs (Sissine, 2008, pp. 9, 12–14; Srinivasa et al., 2024).

3. The American Recovery and Reinvestment Act of 2009

ARRA (2009) significantly impacted the SC industry by providing funding and incentives for technological advancements and infrastructure improvements (Text – H.R.1

– 111th Congress (2009-2010), 2009; Council of Economic Advisers, 2014, pp. 98–99). It influenced the industry by funding R&D in various sectors, including SCs. This helped drive innovation and technological advancements in SC manufacturing (Congressional Budget Office, 2010, p. 14). The act also included investment in infrastructure projects, indirectly benefiting the SC industry by improving the overall business environment and supply chain logistics (Council of Economic Advisers, 2014, pp. 96–97, 122). Then, by providing financial support to businesses, ARRA (2009) helped create and retain jobs in the SC industry, contributing to economic stability and growth. Lastly, the act promoted clean energy technologies, which increased demand for advanced SCs (Council of Economic Advisers, 2014, pp. 128–129; Congressional Budget Office, 2010, p. 4).

4. The Fixing America's Surface Transportation Act of 2015

The FAST Act of 2015 primarily focused on long-term funding for surface transportation infrastructure (U.S. Department of Transportation, 2015). While its main goal was not directly related to the SC industry, the act indirectly impacted the industry by improving infrastructure through its funding of critical transportation projects. These projects benefited the SC industry by enhancing incentives for building electric vehicles, which automobile manufacturers leveraged (Walsh, 2023). The Act also established new grant programs for essential transportation projects that benefit freight movements, including multimodal projects that can indirectly support the SC industry by improving the efficiency of transporting goods (Srinivasa et al., 2024). Additionally, the act established the National Surface Transportation and Innovative Finance Bureau to provide additional tools and resources to strengthen the coordination across transportation projects, which could benefit industries reliant on efficient transportation, including SCs. By investing in infrastructure, the FAST Act contributed to broader economic growth, thus supporting industries, including SCs, by creating a more stable and prosperous economic environment.

5. The National Defense Authorization Act for Fiscal Year 2021

The NDAA for Fiscal Year 2021 significantly impacted the SC industry through the eventual creation of the CHIPS Act (National Defense Authorization Act for Fiscal Year 2021, 2021; Sutter, 2023). The 2021 NDAA authorized financial incentives to build and equip SC fabs in the U.S. to boost domestic SC production and reduce reliance on foreign manufacturers. The act also funded R&D activities to support U.S. dominance in SC manufacturing technology. This included establishing a National Semiconductor Technology Center and a National Advanced Packaging Manufacturing Program. The 2021 NDAA incorporated measures to fortify the SC supply chain, aiming to enhance U.S. investment in R&D and bolster the development of the nation's science and engineering workforce. By increasing the domestic SC manufacturing capacity, the 2021 NDAA aimed to strengthen national and economic security by reducing dependence on foreign SC production (Gillibrand, 2021).

The CHIPS Act of 2022 is a significant step in revitalizing U.S. SC manufacturing. Previous legislative efforts, such as EISA (2007), ARRA (2009), the FAST Act of 2015, and the 2021 NDAA, underscore the importance of government support in fostering innovation and growth in industry. Moving forward, the success of the CHIPS Act will depend on effective implementation and the industry's ability to adapt. Future research should assess the long-term effects of these policies and investigate strategies to maintain U.S. leadership in SC technology.

C. NATIONAL SECURITY IMPLICATIONS: STUDIES ON THE STRATEGIC IMPORTANCE OF SEMICONDUCTOR SUPPLY CHAINS

The SC industry is critical to national security, as it underpins the technology used in defense systems, communications, and infrastructure (Biden, 2022). In his remarks at the Special Competitive Studies Project Global Emerging Technologies Summit, the U.S. national security advisor emphasized the need to secure supply chains and reduce dependencies on foreign sources, particularly in strategic sectors, including SCs (Sullivan, 2022). The National Security Strategy notes other key industries, such as biodefense and supercomputing, but these different sectors cannot exist without chips. In that sense, the SC industry is vital to national security (Biden, 2022).

SCs are crucial in electronics and computing (Semiconductor Industry Association, 2022b). No single industrial sector exists that does not rely on SCs (Coleman, 2023). In addition to economic importance, SCs are vitally crucial for military applications (Biden, 2022). The literature suggests that the nation cannot eliminate these dependencies. It refers to a concept first coined by Ursula von de Leyen called *de-risking*, which refers to the policy of taking actions to minimize risks where possible (von der Leyen, 2023). According to Grimes & Du,

> Although certain locations play key roles in the semiconductor global value chain (GVC), understanding the evolving GVC is complicated by the fact that the development of a semiconductor product can involve up to 1200 process steps over a six- to eight-week cycle and travel over thousands of miles between different locations and companies involved in the production process. (2022, p. 7)

Reinsch et al. (2022) describe the SC value chain as a "deeply technical and precise six-step process" (2022, p. 4). Within the value chain, represented in Figure 1, each link is concentrated in a specific region of the globe. That global region relies on resources and materials from specialized suppliers that are also geographically dispersed. The linear nature of the graphic in Figure 1 represents a simplification of the "1200 process steps" described by Grimes and Du (2022, p. 7). Within the value chain, Reinsch et al. (2022) suggest that "the semiconductor GVC consists of three main stages: R&D (chip design), fabrication (chip production), and advanced testing and packaging (back-end manufacturing)" (2022, p. 4).

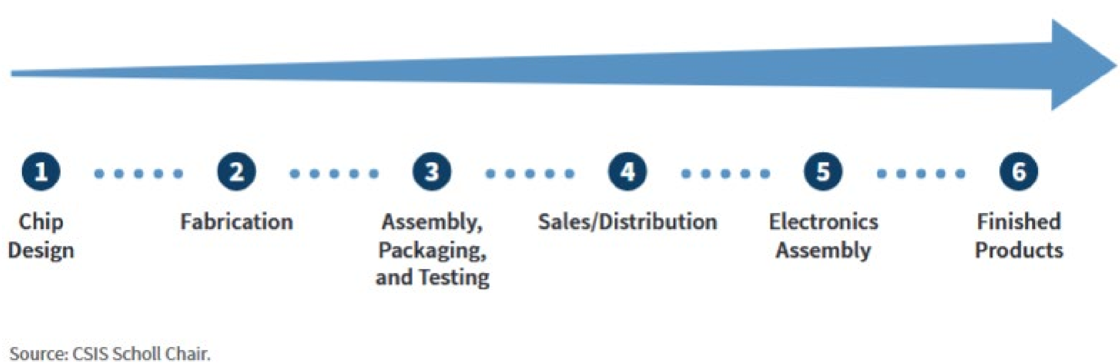


Figure 1. Semiconductor Value Chain. Source: Arasasingham (2022).

China is heavily involved in the process of packaging chips before they are delivered to a customer (Grimes & Du, 2022). China is also responsible for mining some of the key REE and CM required to manufacture chips (Coleman, 2023). China's dominance in the mining and processing of these minerals is attributed to its vast natural reserves and well-established supply chain (Grimes & Du, 2022). Indeed, if there were an adequate supply of these minerals elsewhere, reliance on a foreign supply could be derisked.

China plays a critical role in the SC GVC, particularly in the packaging and testing processes of chips before they are delivered to customers (Grimes & Du, 2022). This specialization has made China an indispensable part of the GVC, as the infrastructure and expertise required for these processes are concentrated within the country. As a result, companies seeking to outsource these crucial steps of SC manufacturing have limited alternatives.

Despite efforts by other nations to diversify their sources of CM, the supply remains insufficient to meet the growing demand (Mitchell, 2023). Geopolitical tensions and the concentration of mineral supplies in a few countries further exacerbate the dependency on China. The lack of alternative sources makes the SC industry vulnerable to supply chain disruptions (O. Goswami, 2023).

Strategic investments and policy initiatives are necessary to address these challenges. For example, the CHIPS and Science Act (2022) encourages the development of onshore supply chains and domestic manufacturing capacity. By creating a more resilient and self-sufficient supply chain, the industry can mitigate the risks of heavy reliance on foreign sources (Grimes & Du, 2022).

Recycling and recovering CM from existing sources, such as electronic waste, can also significantly reduce dependency on foreign supplies. By implementing sustainable practices and promoting circular economic principles, the SC industry can enhance its resource security and contribute to environmental conservation (Liu et al., 2024).

The heavy reliance on China underscores the need for coordinated global efforts to secure the supply of CM and ensure the stability of the SC value chain. Collaborative initiatives among nations, research institutions, and industry stakeholders are essential to developing innovative solutions and reducing vulnerabilities in the supply chain (Mitchell, 2023).

The U.S. also plays a fundamental role in the value chain. The IP and design of chips primarily take place domestically, and the nation is generations ahead of the rest of the world in this portion of the value chain (Blevins et al., 2020). Without the innovation and design work of domestic firms, there would be no SCs to be produced (Martin et al., 2023).

There is very little that the U.S. can do to eliminate untrusted sources from the supply chain. The industry is characterized by "important underlying weaknesses: the limited number and geographic concentration of influential firms, plus a market that is vertically disintegrated, overspecialized, and unable to accommodate substitutions" (Berger et al., 2023, para. 9). Ultimately, the complexity of SCs has driven the industry's two predominant characteristics: oligopolistic firms and specialization.

That is the reality of the SC supply chain as detailed in a Research and Development Corporation (RAND) study, *Supply Chain Interdependence and Geopolitical Vulnerability* (Martin et al., 2023). The lithography machines that manufacturers use to make the chips come from Europe (Miller, 2022, pp. 267–269). The chips are made in East Asia and designed in North America. No single link can supplant another link in the value chain (Berger et al., 2023). Making a SC is an extraordinarily complex process (Coleman, 2023).

The global SC supply chain is highly concentrated in East Asia, with Taiwan and South Korea being key players (Arasasingham et al., 2022). This concentration creates chokepoints that can manifest during periods of geopolitical tension, natural disasters, or other disruptions, posing significant risks to national security.

The national security strategy highlights the importance of investing in domestic manufacturing capabilities to mitigate these risks (Biden, 2022). The CHIPS Act aims to address these vulnerabilities by bolstering U.S. SC production, ensuring a stable and secure supply of critical components for defense and other essential sectors. That may derisk some of the climactic and geopolitical threats that face South Korea's Samsung and Taiwan's

TSMC (Athey, 2023). However, it does not change the fact that packaging and assembly activities are highly specialized and concentrated in East Asia. Nor does it account for the global supply of minerals or other components. In the context of the Great Power Competition, China will be forced to rely on America and vice versa for SCs.

In late 2024, the United States imposed export controls on EUV equipment and IP required for leading-edge chips (American Journal of International Law, The, 2023, p. 145; Office of Congressional and Public Affairs, 2024). Shortly after, China declared U.S. silicon unsafe and placed export restrictions on REE and heavy metals (Nguyen, 2024). It is not understood how well regulations and sanctions can control the supply chain since it is so complex, and no single entity has a complete grasp of its linkages. This makes the idea of decoupling a single nation from the GVC an impossible task in the short term.

1. Integrated Device Manufacturer vs. Foundry Models

In manufacturing advanced SCs, the industry is segmented into two different types of manufacturers, known as fabs. There is the IDM model and the global foundry model (Coleman, 2023). Foundry companies produce SCs for fabless companies that design and sell chips. Nvidia and Apple are examples of fabless companies that rely on the global foundry model to make chips for their products. Intel, TSMC, and Samsung are the only three companies manufacturing advanced SCs, leading the industry in cutting-edge chip fabrication. Intel is historically an IDM company, TSMC is a foundry, and Samsung operates as both an IDM and a foundry.

IDMs are companies that are vertically integrated. They design, produce, and sell their chips. In contrast, most manufacturers, such as TSMC or Semiconductor Manufacturing International Corporation (SMIC), follow the global foundry business model (Berger et al., 2023). There is some advantage to a fabless company working with a foundry rather than an IDM. This is due to the nature of the sensitive IP that must be shared with the manufacturer to facilitate chip production. Fabless companies prefer to work with TSMC rather than Intel or Samsung because TSMC does not sell competing products. On the other hand, IDMs have greater security for their products as the amount of IP sharing is limited. While Intel, Samsung, TSMC, and other chip manufacturers are receiving funding from the CHIPS Act, Intel has received the most significant CHIPS investment of any company, domestic or foreign owned.

2. Intel and the Future of Integrated Device Manufacturing 2.0

In 2021, a report by the SIA stated, "The U.S. has the opportunity to target and capture the next increment of semiconductor investments to help rebalance global production capacity into the U.S. and regions with better political and environmental stability" (2021, p. 3). In that same year, the new CEO of Intel, Pat Gelsinger, announced its $100B IDM 2.0 strategy, which seemed to answer the call from SIA. The plan was ambitious as it pursued 5N4Y, which was progressively more advanced. The plan would take Intel from being an IDM company to having foundry services to make advanced chips for external firms. It included the construction of huge new fabs in Arizona and Ohio, while also making other investments in its other U.S. facilities. Considering that Intel has a position to liaison with the government, it was likely part of a larger strategic plan to support the U.S. national security objective of supply chain security for critical technology. The following year, Congress passed the CHIPS Act, and Intel ultimately became the biggest beneficiary of the legislation with over $8B of investment granted by the federal government. As of the end of the first quarter of 2025, IDM 2.0 has not gone to plan exactly.

Intel is the largest U.S. chip manufacturer in the nation, and realistically, the only company with the capital and knowledge required to manufacture leading-edge chips. The question is, do they have enough capital and knowledge to make the transition? Samsung and TSMC, the only two companies in the world capable of making advanced chips, were early adopters of the EUV technology required to manufacture SCs 7 nm and below. In an industry where the speed of technology is measured in months, not years, Intel was a very latecomer. Still, they had a legacy of innovation and had manufactured SCs for as long as any other company in existence.

As a leading IDM, Intel plays a crucial role in the U.S. SC industry and national security. The Biden administration's strategy emphasizes the importance of companies like Intel in maintaining technological superiority and securing supply chains. Intel's investments in expanding its U.S. manufacturing capabilities, supported by the CHIPS Act, are aligned with the strategy's goals to reduce reliance on foreign suppliers and enhance national security (Biden, 2022).

Intel's ability to produce advanced SCs domestically is vital for the DoD and other critical sectors. By ensuring a secure and reliable supply of SCs, Intel helps mitigate the risks associated with foreign dependencies and supply chain disruptions. This aligns with the broader objectives of the National Security Strategy to strengthen U.S. economic and technological leadership in the face of strategic competition from other countries, including China and Russia.

D. IDENTIFICATION OF RESEARCH GAPS

Despite extensive research on SC manufacturing capabilities, legislative impacts, and national security implications, this thesis aims to address several critical gaps. The research questions guide the identification of these gaps, ensuring a comprehensive exploration of the topic.

- Impact of the CHIPS Act on Intel's manufacturing capacity: While previous studies have examined various legislative actions and their influence on the SC industry, there is a notable gap in understanding the specific impacts of the CHIPS Act on Intel's manufacturing capacity. This shortcoming is addressed in the primary research question: *How does the CHIPS Act impact Intel's manufacturing capacity, and how can increased domestic production reduce U.S. reliance on China in the semiconductor supply chain while enhancing national security*? This thesis fills this gap and assesses how the CHIPS Act incentives translate into actual manufacturing growth by analyzing Intel's current manufacturing capabilities and expansion plans.
- Reduction of U.S. Dependence on China: Existing literature highlights the strategic importance of reducing dependencies on foreign SC sources, particularly given geopolitical tensions and supply chain vulnerabilities. However, empirical research on how much the CHIPS Act can reduce U.S. reliance on China remains limited. This thesis provides an investigation of this issue through the secondary research question: *What are the specific challenges and risks associated with*

Intel's capacity expansion under the CHIPS Act, and how can these be mitigated to ensure a resilient and secure SC supply chain for the United States?

- Comprehensive Evaluation of Supply Chain Security Measures: National security studies emphasized the critical role of secure SC supply chains, but often needed more detailed evaluations of how specific legislative initiatives addressed these concerns. This research focuses on the CHIPS Act's provisions to secure the supply chain and their real-world implications for national security, particularly for DoD. Through examining the national security implications of increased domestic SC production, the thesis provides insights into the effectiveness of the CHIPS Act in enhancing supply chain resilience.
- Influence on Broader Semiconductor Market Dynamics: Existing studies often presented the impact of policy measures on specific companies or sectors, but a detailed analysis of how these measures influenced broader market dynamics was needed. This research aims to fill this gap by exploring the tertiary research question: *How does Intel's capacity expansion under the CHIPS Act influence the broader SC market dynamic and competition domestically and globally*? This thesis will assess the CHIPS Act's incentives and support mechanisms, evaluating their wider impact on market competition and positioning.

By addressing these gaps, this thesis provides a comprehensive and actionable framework for policymakers, industry leaders, and academics to enhance the resilience and security of the U.S. SC industry.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. ANALYSIS

This section examines Intel's operations, strategic decisions, and broader implications within the SC industry. The methodology subsection introduces the data collection method to comprehensively evaluate Intel's manufacturing capabilities, financial performance, and strategic initiatives. The analysis, as a case study, follows the methodology subsection. This analysis integrates operational data, policy frameworks, and industry trends to offer a comprehensive perspective on Intel's role within the global SC landscape.

A. METHODOLOGY

This section outlines the data collection processes employed to ensure a comprehensive analysis of Intel's manufacturing capabilities, financial performance, and strategic initiatives and their broader implications within the SC industry. The methodology combines quantitative and qualitative approaches, leveraging a wide array of resources to synthesize a holistic perspective.

1. Introduction to Data Collection Methods

To conduct the analysis, data was gathered from diverse sources, including academic publications, industry reports, news articles, and case studies. Integrating insights from experts and organizations focused on the SC industry and the GVC ensures a thorough and balanced evaluation.

2. Quantitative Methods

The quantitative data utilized in this research was derived from:

- Industry reports spanning the last four to five years concerning Intel's financial performance, production metrics, and expansion activities.
- Statistical data and figures on global SC markets, technology nodes, and manufacturing capabilities. These sources provide valuable insights into Intel's operations and its relative standing within the industry.

3. Qualitative Methods

Complementing quantitative data, qualitative analysis involved reviewing:

- Academic publications authored by field experts who have conducted studies on various aspects of the SC industry and the GVC.
- Think tank analyses from organizations such as the Center for Strategic and International Studies (CSIS), RAND Corporation, and the SIA provide policy-focused evaluations and strategic frameworks.
- News articles, press releases, and industry commentaries that capture evolving trends, current events, and expert opinions. Together, these resources offer context and interpretive depth to Intel's strategic initiatives and their implications.

4. Case Study Comparison

Intel's operations were analyzed in the form of a detailed case study, incorporating a comparative perspective with other SC manufacturers. This involved evaluating:

- Expansion plans and technological advancements.
- Financial performance and operational strategies.

The case study approach ensures an in-depth understanding of Intel's unique position within the industry.

5. Ethical Considerations

This research does not involve human subjects or primary interviews. While information discussions with industry experts were conducted to inform the direction of the study, their contributions are acknowledged in a non-cited format. Ethical principles, including the proper citation of secondary data and respect for IP rights, were adhered to throughout the research process.

This methodology combines quantitative and qualitative insights to develop well-founded conclusions and recommendations regarding Intel's manufacturing capabilities, strategic initiatives, and the dynamics of the SC industry.

B. CASE STUDY ANALYSIS OF INTEL

This case study examines Intel Corporation's strategic initiatives, operational development, and role in the global SC industry. The study explores the interplay between innovation, policy, and industry dynamics by analyzing Intel's historical trajectory, manufacturing capabilities, and responses to challenges such as regulatory changes, geopolitical pressures, and supply chain issues. The analysis considers how domestic production improvements, supported by the CHIPS Act, contribute to national security and aim to reduce reliance on foreign supply chains. This assessment provides context for Intel's technological advancements and position within the SC GVC.

1. Overview of Intel's Manufacturing Capabilities

Intel serves as a significant case study for examining the complexities of modern SC production. This section analyzes the company's evolution by evaluating its manufacturing capabilities, operational performance, and responses to economic, geopolitical, and policy challenges. By tracing Intel's development in fabrication processes and assessing the impact of the CHIPS Act, the analysis explores broader issues of supply chain resilience and SC industry dynamics. Comparative insights into industry competitors and Intel's contributions to reducing U.S. reliance on Chinese suppliers offer a perspective on national security and global competitiveness tied to domestic SC expansion.

a. Historical Context and Evolution of Intel's Manufacturing Capabilities

Founded in 1968 by Robert Noyce and Gordon Moore, Intel Corporation has played a prominent role in the SC industry for over five decades. Initially focused on memory chip production, Intel introduced the Intel 4004 microprocessor in 1971, marking a significant milestone in computing innovation (Meridian Outpost, n.d.). This innovation marked the beginning of Intel's dominance in the microprocessor market, setting the stage for continuous advancements in SC manufacturing (Intel, n.d.-b).

During the 1970s and 1980s, Intel expanded its manufacturing capabilities, introducing technologies such as the 1103 dynamic random-access memory (DRAM) chip, which became the industry standard for memory (Meridian Outpost, n.d.). The development of the x86 microprocessor architecture further shaped personal computing (Company-Histories.com, n.d.; Meridian Outpost, n.d.). Throughout this period, Intel scaled production to meet increasing demand for microprocessors while maintaining industry standards of quality (Company-Histories.com, n.d.).

In the 1990s, rising competition from international manufacturers, particularly in Japan, pushed Intel to innovate further (Company-Histories.com, n.d.). The launch of the Pentium microprocessor in 1993 set benchmarks for performance and efficiency (Company-Histories.com, n.d.). Investments in advanced manufacturing facilities supported Intel's efforts to sustain technological development and adhere to Moore's Law, which observes that the number of transistors on a microchip roughly doubles every two years (Miller, 2022, p. 8).

In the 21st century, Intel diversified its focus to include emerging areas like data centers, AI, and autonomous vehicles (Intel, n.d.-b). Manufacturing advancements, including the introduction of 14nm and 10nm process technologies, further enhanced transistor density and chip performance (A. Shilov, 2020). These developments reflect Intel's evolving approach to addressing industry needs and technological change within the global SC landscape.

b. Description of Current Manufacturing Facilities and Their Locations

Intel Corporation operates a network of SC manufacturing fabs and assembly/test sites across multiple continents, as seen in Figure 2. These facilities are strategically located to optimize production efficiency and meet the growing demand for SC technologies (Intel, n.d.-d).

Figure 2. Map of Intel Around the World. Source Intel (n.d.-d).

In the United States, Intel's manufacturing sites include the Ocotillo campus in Chandler, Arizona, and the Ronler Acres campus in Hillsboro, Oregon (Intel, n.d.-e). The Ocotillo campus houses several fabs, including Fabs 12, 22, 32, 52, and Fab 62 (Adams, 2024), which focuses on producing advanced chips (A. Shilov, 2024b). The Gordon Moore Park at the Ronler Acres campus is home to fabs like D1X, which focuses on R&D of next-generation (Next-Gen) process technologies (Intel, 2010). Additionally, Intel's Fab 11X in Rio Rancho, New Mexico, contributes to Intel's domestic manufacturing capabilities (Intel, 2024).

Intel also maintains international manufacturing facilities in Ireland, Israel, and Asia (Intel, n.d.-e). In Ireland, the Leixlip campus hosts Fab 24 and Fab 34, which play a significant role in producing leading-edge SCs (Intel, 2023a). In Israel, the Kiryat Gat campus includes Fab 28 and Fab 38, which are known for their high-volume production of Intel's latest chips (Intel, n.d.-a). Intel also operates assembly and test sites in Malaysia, Vietnam, and China, supporting its global production network (Mwaniki, 2024).

Among Intel's recent investments is the development of a $20 billion chip manufacturing mega-site in New Albany, Ohio. This project, known as Ohio One, includes plans for two advanced fabs, aiming to contribute to domestic production capabilities and economic growth in the region (Ethan, n.d.). This initiative aligns with efforts to enhance SC production and address evolving industry demands (Ethan, n.d.).

By strategically distributing its facilities globally, Intel positions itself to address diverse manufacturing needs and support ongoing developments in SC technology.

c. Overview of Intel's Technology Nodes and Fabrication Processes.

Intel Corporation has been a significant contributor to advancements in SC manufacturing.

Over the years, the company's technology nodes and fabrication processes have undergone considerable development, reflecting changes in the industry standards and demands (Meridian Outpost, n.d.).

Intel's process technology roadmap (Figure 3) outlines the progress of its 5N4Y strategy for nodes that have contributed to improvements in performance and efficiency. The Intel 7 process, based on 10nm technology, introduced enhanced transistor density and power efficiency (Conway, 2024). Building on this, Intel 4, a 7nm process, incorporated EUV, a technology that improves production efficiency by increasing chip yields and enabling better scaling of components, leading to enhanced power efficiency (Conway, 2024). This node is also significant because it is the first advanced SC design. Intel 4 is utilized in products such as the Meteor Lake processors, which leverage the capabilities of this node to deliver enhanced performance (see Figure 3) (Conway, 2024).

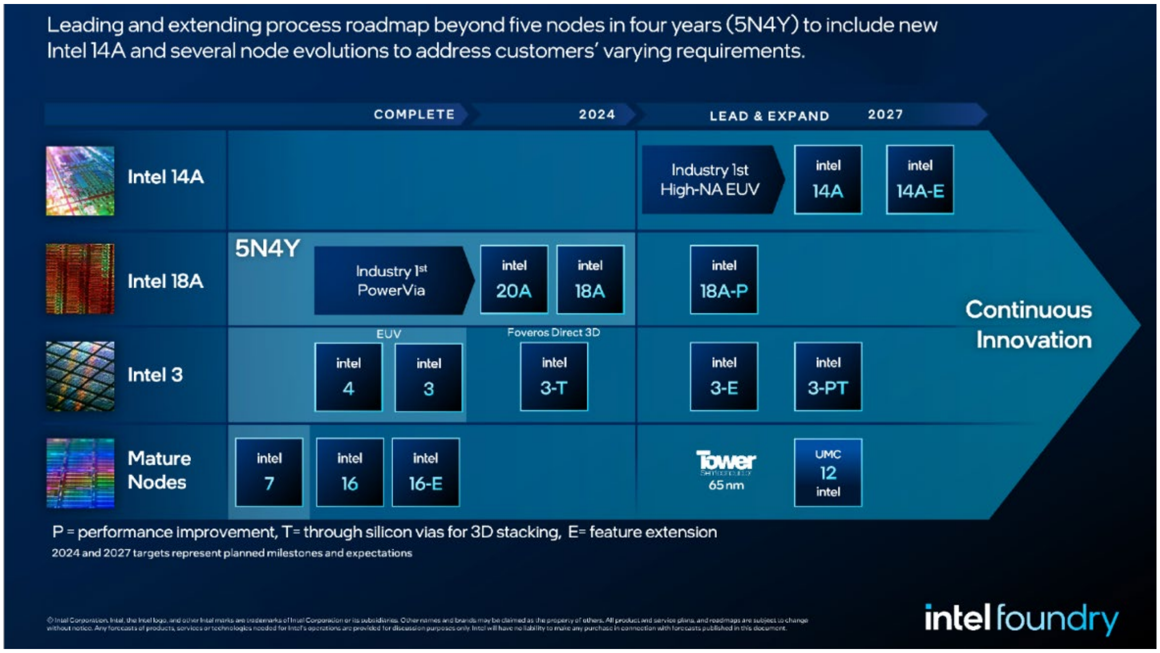


Figure 3. Process Roadmap of Intel Foundries. Source: Conway (2024).

Building on the advancements achieved with Intel 4, Intel 3 was developed as a subsequent node tailored for data center applications. Offering an 18% improvement in performance per watt compared to its predecessor, Intel 3 is optimized for high-performance computing environments (Intel, n.d.-h; Conway, 2024). Intel 20A represents another development in process technology, introducing PowerVia and RibbonFET technologies (Conway, 2024). PowerVia, a backside power delivery method, enhances standard cell utilization and mitigates resistive power delivery issues, contributing to improved efficiency and performance, see Figure 4 (Conway, 2024). RibbonFET, Intel's adaptation of gate-all-around (GAA) transistor technology, supports further component miniaturization while mitigating power leakage (Intel, n.d.-f).

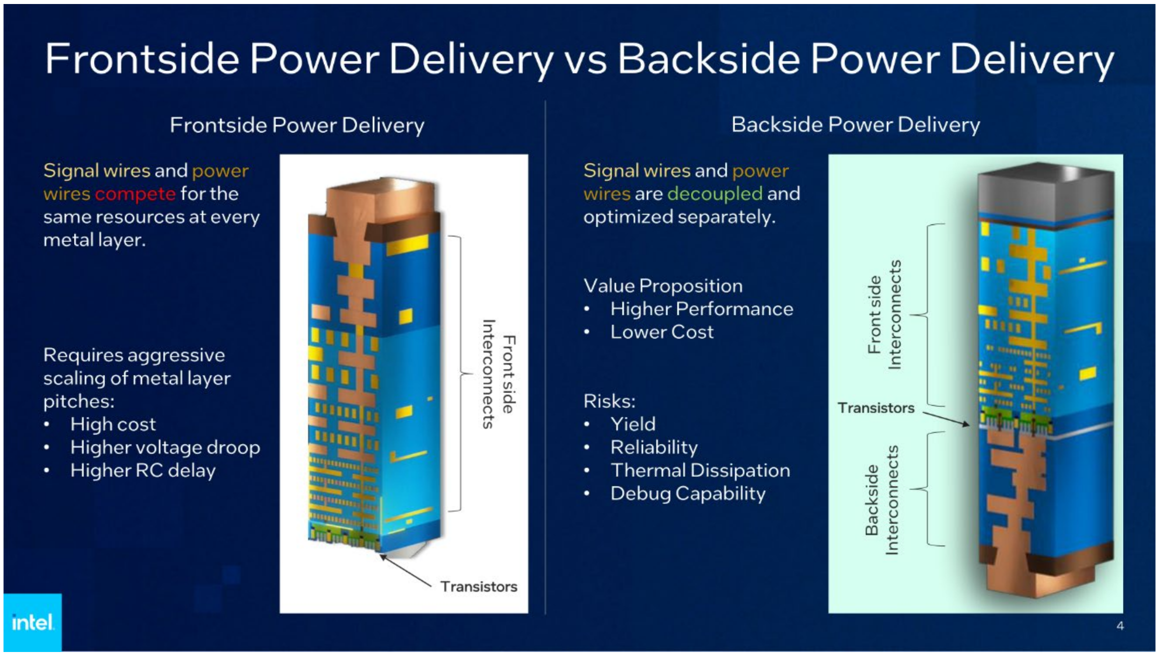


Figure 4. Image of Power Delivery. Source: Conway (2024).

The most advanced node in Intel's current roadmap is Intel 18A, which is projected to begin manufacturing in the latter half of 2024 (Intel, n.d.-f). Intel 18A is expected to deliver "up to 15% improvement in performance per watt and a 30% better chip density vs. the Intel 3 process node" (Intel, n.d.-f). This node incorporates PowerVia and RibbonFET technologies, continuing efforts to enhance manufacturing efficiency and performance (Intel, n.d.-f).

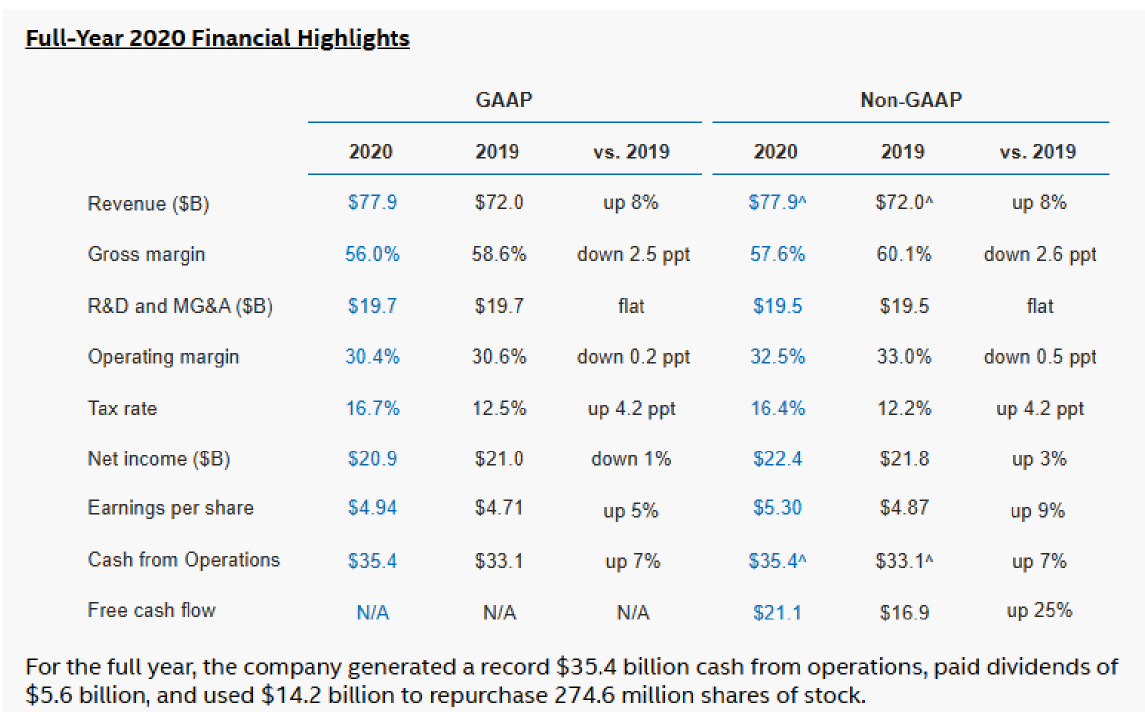
Ongoing advancements in process technology have allowed for significant improvements in transistor density, power efficiency, and overall performance. These developments align with the evolving demands of the SC industry, reflecting efforts to address technological challenges and shifts in the global landscape (Conway, 2024).

d. Pre-CHIPS Act Production Capabilities and Performance: 2020 to Mid-2022

Intel Corporation displayed adaptability and focus on its production capabilities and financial performance from 2020 to mid-2022. Despite obstacles such as the COVID-19 pandemic, supply chain challenges, and heightened competition, the company emphasized innovation, operational efficiency, and investments in advanced manufacturing technologies.

(1) Financial and Operational Performance

In 2020, Intel reported an annual revenue of $77.9 billion, reflecting an 8% year-over-year (YoY) growth (see Figure 5) and marking its fifth consecutive year of record revenue (Intel, 2021a). The company surpassed its fourth-quarter revenue guidance by $2.6 billion, achieving $20 billion in quarterly revenue. This growth was attributed mainly to record PC-centric sales and a 33% YoY increase in PC unit volumes. Intel's leadership emphasized strong demand for its computing capabilities and noted positive outcomes from the company's focus on growth opportunities (Intel, 2021a).


Full-Year 2020 Financial Highlights

	GAAP			Non-GAAP		
	2020	2019	vs. 2019	2020	2019	vs. 2019
Revenue ($B)	$77.9	$72.0	up 8%	$77.9^	$72.0^	up 8%
Gross margin	56.0%	58.6%	down 2.5 ppt	57.6%	60.1%	down 2.6 ppt
R&D and MG&A ($B)	$19.7	$19.7	flat	$19.5	$19.5	flat
Operating margin	30.4%	30.6%	down 0.2 ppt	32.5%	33.0%	down 0.5 ppt
Tax rate	16.7%	12.5%	up 4.2 ppt	16.4%	12.2%	up 4.2 ppt
Net income ($B)	$20.9	$21.0	down 1%	$22.4	$21.8	up 3%
Earnings per share	$4.94	$4.71	up 5%	$5.30	$4.87	up 9%
Cash from Operations	$35.4	$33.1	up 7%	$35.4^	$33.1^	up 7%
Free cash flow	N/A	N/A	N/A	$21.1	$16.9	up 25%

For the full year, the company generated a record $35.4 billion cash from operations, paid dividends of $5.6 billion, and used $14.2 billion to repurchase 274.6 million shares of stock.

Figure 5. Intel 2020 Financial Highlights. Source: Intel (2021a).

The company generated $35.4 billion in operating cash flow, allocated $14.2 billion for share repurchases, and distributed $5.6 billion in dividends, reflecting its financial stability (Intel, 2021a).

In 2021, Intel reported a record annual revenue of $79 billion, representing a 1% YoY increase (see Figure 6). Fourth-quarter revenue amounted to $20.5 billion, driven by strong performance from the Data Center Group and the Internet of Things Group, which reached all-time highs during this period (Intel, 2022a).

Full-Year 2021 Financial Highlights

	GAAP			Non-GAAP		
	2021	2020	vs. 2020	2021	2020	vs. 2020
Revenue ($B)	$79.0	$77.9	up 1%	$74.7	$72.9	up 2%
Gross margin	55.4%	56.0%	down 0.5 ppt	57.7%	59.4%	down 1.7 ppt
R&D and MG&A ($B)	$21.7	$19.7	up 10%	$20.9	$18.9	up 10%
Operating margin	24.6%	30.4%	down 5.8 ppt	29.7%	33.4%	down 3.7 ppt
Tax rate	8.5%	16.7%	down 8.2 ppt	9.1%	16.6%	down 7.5 ppt
Net income ($B)	$19.9	$20.9	down 5%	$22.4	$21.6	up 4%
Earnings per share	$4.86	$4.94	down 2%	$5.47	$5.10	up 7%

For the full year, the company generated $30.0 billion of cash from operations, paid dividends of $5.6 billion, and used $2.4 billion to repurchase 39.5 million shares of stock.

Figure 6. Intel 2021 Financial Highlights. Source: Intel (2022a).

In 2021, Intel generated $30 billion in operating cash flow and announced plans to invest $20 billion in the construction of two SC factories in Ohio, reflecting its focus on expanding domestic manufacturing capabilities (Intel, 2022a). The company attributed its financial results to IDM 2.0 and its strategic efforts across technology development, manufacturing, and its various business sectors (Intel, 2022a).

In contrast, 2022 presented significant challenges for Intel. First-quarter revenue decreased by 7% YoY to $18.4 billion (Intel, 2022b), followed by a sharper decline in the second quarter to $15.3 billion, representing a 22% YoY decrease (Intel, 2022c). These declines were attributed to broader economic slowdowns and internal operational issues (Intel, 2022c). Despite these challenges, Intel reiterated its commitment to its IDM 2.0 strategy, which focuses on improving manufacturing processes to enhance competitiveness (Intel, 2022b).

(2) Strategic Initiatives and Technological Advancements

During this period, Intel implemented various initiatives to enhance production capabilities and advance technological innovation. In 2020, the company began production of its 10nm-based 3rd generation (Gen) Xeon Scalable processors, referred to as "Ice Lake." It also introduced the 11th Gen Intel Core processors, known as "Tiger Lake," as part of its ongoing CPU development efforts (Intel, 2021a). Additionally, Intel entered the discrete graphics market with the launch of Intel Iris Xe MAX GPUs, marking a step toward diversifying its product offerings (Intel, 2021a).

In 2021, Intel expanded its technology portfolio with the introduction of the 12th Gen Intel Core processor family, including the Intel Core i9-12900HK, which was noted as a high-performing mobile processor (Intel, 2022a). The company also began shipping Intel Arc discrete graphics products to original equipment manufacturers and partnered with Amazon Web Services to support Habana Gaudi AI processors (Intel, 2022a).

By mid-2022, Intel had made significant progress in scaling production for its Intel 7 process technology and was advancing the readiness of subsequent nodes, including Intel 4, Intel 3, and the upcoming 20A and 18A nodes (Intel, 2022c). Additionally, a partnership with MediaTek to manufacture chips for smart edge devices highlighted Intel's efforts to expand its foundry business and broaden its revenue sources (Intel, 2022c). These developments reflect Intel's focus on addressing traditional and emerging demands within the SC industry.

2. The Impact of the CHIPS Act on Intel: An Assessment of the Incentives and Support Mechanisms

This section examines the impact of the CHIPS Act on Intel, with a focus on the incentives and support mechanisms driving the company's capacity expansion. By analyzing Intel's strategic goals, expansion plans, and potential challenges, this section explores the immediate and long-term implications for the company's market position and technological leadership. Through a comparative lens, the analysis evaluates how Intel's efforts, supported by the CHIPS Act, compare to those of other global SC manufacturers and how these initiatives influence broader market dynamics and competition.

a. Detailed Analysis of Intel's Expansion Plans and Expected Timeline

Intel has embarked on an ambitious plan to expand its SC manufacturing capabilities in the United States, supported by the CHIPS Act (U.S. Department of Commerce, 2024c). The company aims to invest over $100 billion in the U.S. by the end of the decade, with a significant portion of this investment directed towards building and upgrading SC fabs (Keller, 2024). This expansion is expected to create thousands of jobs and bolster the domestic supply chain for advanced SCs (U.S. Department of Commerce, 2024c).

Some of the key projects and locations that Intel is working on include:

(1) Arizona: Foundry Expansion for Advanced Chips

Intel is investing over $32 billion in Arizona to build two new leading-edge chip factories—Fab 52 and Fab 62—at its Ocotillo campus in Chandler (Intel, 2024). These fabs will support Intel's expansion into the foundry business, providing committed capacity for external customers and producing advanced chips using Intel's 18A process node (A. Shilov, 2025b). This marks a significant step in Intel's strategy to compete with leading foundry businesses like TSMC and Samsung.

(2) New Mexico: Advanced Packaging Facility Expansion

Intel has opened Fab 9 in Rio Rancho, New Mexico, as part of its $3.5 billion investment to expand its advanced packaging capabilities (Intel, 2024). This facility focuses on Foveros, Intel's breakthrough 3D packaging technology, which allows stacking multiple chips for improved performance and efficiency. Additionally, Intel received $500 million in federal funding to further modernize its operations and expand production (Hoops, 2024). The existing production capability being expanded includes Fab 11X, which, along with Fab 9, forms Intel's first co-located high-volume advanced packaging site in the U.S (Intel, 2024).

(3) Ohio: New Plant Construction with Delays

Intel's Ohio One project in New Albany was initially expected to be completed sooner, but has faced significant delays (Millard, 2025). The first phase (Mod 1) is now scheduled for completion in 2030, with operations beginning between 2030 and 2031 (Conn & Millard, 2025). The second phase (Mod 2) is expected to be completed in 2031, with operations starting in 2032. Intel has already spent $3.7 billion on the project and signed contracts worth $3.2 billion, bringing its total commitment to $6.9 billion (Filby, 2025a). Despite financial and political challenges, Intel remains committed to completing the project, citing its importance for domestic SC manufacturing.

(4) Oregon: Strengthening Manufacturing and Technological Leadership

Intel's D1X development factory in Hillsboro, Oregon, is the company's premier hub for SC R&D (Intel, 2023b). The company has invested $3 billion to expand its D1X Mod3 facility, which is crucial in developing Next-Gen chip technologies. Intel's Oregon site is also home to high numerical aperture (High-NA) EUV lithography, a cutting-edge technology that will enable smaller, more efficient transistors (National Institute of Standards and Technology, 2024). While all regional investments contribute to Intel's manufacturing leadership, Oregon specifically focuses on R&D, ensuring Intel remains at the forefront of SC innovation (Intel, 2023b).

The expected outcomes of Intel's expansion plans are projected to support approximately 10,000 manufacturing jobs and 20,000 construction jobs across the selected states (U.S. Department of Commerce, 2024c). The company's investments will also contribute to the production of advanced SCs, which are critical for developing AI technologies and enhancing national security (Keller, 2024).

b. Strategic Goals

Intel's strategic goals under the CHIPS Act revolve around leveraging the incentives and support mechanisms to reclaim its leadership in the SC industry. The company's vision aligns closely with the CHIPS Act's objectives of strengthening domestic SC manufacturing, reducing reliance on foreign suppliers, and enhancing technological capabilities critical to national security. Through significant investments in its U.S. facilities, Intel aims to position itself as a pivotal player in the global SC market. As discussed above, the CHIPS Act has provided Intel with substantial funding to support these ambitions, allowing the company to fast-track its expansion plans and focus on producing leading-edge chips. These chips are essential for AI advancements and advanced computing applications (Keller, 2024; U.S. Department of Commerce, 2024c).

As the only U.S.-headquartered company capable of producing leading-edge SCs, Intel is crucial in addressing vulnerabilities in the U.S. supply chain. Its expansion plans, backed by the CHIPS Act, represent a concerted effort to reduce the country's reliance on foreign manufacturers, particularly in East Asia. By developing advanced packaging technologies and state-of-the-art fabs, Intel is in a position to enhance domestic manufacturing capabilities and mitigate the risks associated with geopolitical tensions and global supply chain disruptions. This strategy aligns with national policy priorities and, if successful, will lead to Intel becoming the third company in the world capable of producing leading-edge chips for the market under its foundry model. (Morales, 2024)

In addition to bolstering domestic manufacturing, Intel's goals are strategically designed to enhance its market position and technological leadership on a global scale (Shivakumar et al., 2024). The company's investments aim to bridge the gap with international competitors by advancing process technologies and scaling production capacity. These efforts are intended to regain customer confidence in Intel's ability to deliver high-performance, reliable SCs, positioning the company as a preferred partner for commercial and government clients. By embracing the CHIPS Act's vision and aligning its strategy with the broader goals of economic resilience and technological superiority, Intel is addressing immediate industry challenges and laying the groundwork for sustained growth and innovation.

c. Challenges and Risks

Intel's ambitious expansion plans under the CHIPS Act are not without significant challenges. These risks span regulatory hurdles, geopolitical tensions, workforce shortages, and supply chain constraints, all of which could impede the company's progress and global competitiveness.

(1) **Legal and Regulatory**

Intel faces potential regulatory challenges, particularly in navigating complicated approval processes for its expansion projects. For example, mergers or partnerships with other companies, such as GlobalFoundries (GF), could face scrutiny from antitrust regulators, delaying or complicating strategic initiatives (Williams, 2025). Additionally, compliance with environmental and zoning regulations for new fabs in states like Arizona and Ohio could slow construction timelines (A. S. Shilov, 2025). To mitigate these risks, Intel must engage proactively with regulators and ensure transparency in its operations.

The U.S. has implemented stringent export controls on advanced SC technologies to curtail access by foreign competitors, particularly China. These measures aim to safeguard sensitive innovations critical to defense and economic resilience. (U.S. Department of Commerce, 2024a) These policies have exacerbated global supply chain vulnerabilities, posing significant challenges. Intel must align its operations with U.S. export policies while diversifying its supply chain and fostering partnerships with trusted allies.

(2) **Workforce Shortages**

The U.S. SC industry faces a severe workforce gap, with an estimated 67,000 positions potentially remaining unfilled by 2030 (Vargas et al., 2021). Intel's expansion plans, particularly in Ohio, depend on a steady pipeline of skilled workers, including technicians and engineers. To address this challenge, Intel has partnered with community colleges to develop specialized training programs, such as the industry's first stackable SC technician certificate (Stadler, 2023). These initiatives are critical to closing the talent gap and ensuring the success of Intel's new fabs.

In addition to these efforts, workforce development has been a central focus of agreements between Intel and state governments and provisions under the CHIPS Act. The state of Ohio provided Intel a $600 million grant to subsidize the construction of two Intel plants in the state, which were supposed to employ 3,000 people (Wickham, 2023). The construction of these facilities has encountered delays. Intel is at risk of the state stopping additional payments to Intel and clawing back the money the state has already provided. However, there does not seem to be a strong political appetite for this move (Pelzer, 2025). The CHIPS Act has allocated substantial resources to workforce development, including funding for the National Semiconductor Technology Center Workforce Center of Excellence and other initiatives to build a robust talent pipeline (U.S. Department of Commerce, 2025).

By aligning its workforce strategies with state-level agreements and federal legislation, Intel addresses immediate talent shortages while contributing to the industry's long-term growth. These collaborative efforts support Intel's expansion plans and strengthen the U.S. SC workforce as a critical component of national security and economic resilience.

d. Expected Impact

Intel's transition under the CHIPS Act marks a pivotal moment in the global SC industry. As only two companies, TSMC and Samsung, currently possess the capability to manufacture advanced chips, Intel's IDM 2.0 strategy represents a fundamental shift, positioning the U.S. as a direct competitor in this critical technology sector (Allen & Goldston, 2025; Flamm & Bonvillian, 2025). The company's decision to introduce a foundry model signifies a shift toward manufacturing chips for external customers, expanding its focus beyond national security, economic competitiveness, and supply chain resilience.

The ability to manufacture advanced chips domestically is a strategic imperative for the United States. Historically, the country has relied on foreign manufacturers for cutting-edge chips, a dependency that poses national security risks in the face of geopolitical uncertainties and trade restrictions (Kusters et al., 2025). Intel's successful expansion will reduce reliance on external suppliers and secure the nation's access to advanced SC technology, mitigating vulnerabilities that could impact critical infrastructure, defense systems, and emerging technologies such as AI. The U.S. government's commitment to Intel's success, evidenced by $7.865 billion in direct funding under the CHIPS Act, reinforces the importance of onshoring advanced chip manufacturing as a long-term safeguard against global supply chain disruptions (Texas Instruments, 2024).

Beyond national security, Intel's investments are expected to reshape competitive dynamics within the SC industry. Success in IDM 2.0 and high-volume advanced chip production would make Intel the third global player, directly challenging TSMC's and Samsung's dominance. The company's push into EUV and High-NA EUV lithography is designed to accelerate technological innovation, further strengthening U.S. leadership in SC development. However, Intel's timeline faces challenges. Intel fully designed the 20A process node but outsourced its production to TSMC while shifting its focus to 18A, the fifth and final node of its 5N4Y strategy. However, in early March 2025, Intel initiated a joint venture (JV) with TSMC to enhance advanced manufacturing capabilities for 18A, reflecting the company's evolving strategy in semiconductor fabrication. The company's JV with TSMC, which includes a 20% stake from TSMC in Intel's chipmaking operations, underscores existing technical and operational hurdles that prevent Intel from meeting its 5N4Y roadmap independently (Singh, 2025). While this collaboration offers short-term expertise and efficiency gains, it raises broader questions about Intel's ability to compete autonomously in the advanced chip market (Fortune Business Insights, 2025; Priyadarshi, 2023).

Economically, Intel's expansion is projected to create thousands of high-skilled jobs across its new fabs. The company's investments in advanced chip technologies will drive domestic SC manufacturing capacity and stimulate local economies in states such as Ohio, Arizona, and New Mexico. The ripple effects extend beyond direct job creation—Intel's initiatives will contribute to broader industry development, fostering innovation in AI, telecommunications, and automotive applications (Keller, 2024; U.S. Department of

Commerce, 2024c). However, Intel must navigate challenges such as workforce shortages, yield optimization, and international competition to capitalize on its investments fully.

From a strategic standpoint, Intel's expansion under the CHIPS Act represents more than an industry evolution—it is a national and economic imperative. The company's ability to successfully execute IDM 2.0 and establish itself as a leader in advanced chip manufacturing will influence U.S. competitiveness, global SC supply chain resilience, and technological independence for decades. While the initiative faces short-term operational challenges, Intel's long-term success would disrupt the duopoly for advanced chip manufacturing held by TSMC and Samsung and allow it to reclaim its status as a global leader in the industry.

3. Comparative Analysis of Intel and Other Semiconductor Companies

The CHIPS Act has marked a transformative period for the U.S. SC industry, creating opportunities and challenges for major players like Intel. While Intel has received substantial incentives to enhance its domestic manufacturing capabilities, it faces fierce competition from international giants TSMC and Samsung. These global leaders, benefiting from their home countries' support and CHIPS Act funding, have significantly expanded their presence in the United States, with advanced fabs and substantial investments in states such as Arizona and Texas. In this context, Intel's efforts to reclaim its leadership in advanced process nodes, driven by innovations such as Intel 18A chips and its IDM 2.0 model, represent a strategic endeavor to bridge the gap with its rivals. This comparative analysis examines Intel's position in the global SC landscape, evaluating its expansion plans, technological advancements, and financial strategies alongside those of TSMC and Samsung, and assessing the broader implications of these developments for the U.S. SC ecosystem.

a. Intel vs. Other Semiconductor Manufacturers

The Chips Act has given Intel significant incentives to bolster its domestic manufacturing capabilities, reinforcing its strategic position as a key player in the U.S. SC industry. However, Intel is competing in two different competitive landscapes because it is trying to operate as an IDM with a new foundry capability, much like Samsung (Sperling, 2024). Now, Intel is trying to compete with other IDMs and pure-play firms operating under the foundry model.

Intel's IDM model, which integrates design and production, allows the company to maintain greater control over its supply chain and technological innovation. This vertical integration contrasts sharply with the pure-play foundry model exemplified by TSMC, where manufacturing is their sole focus. While pure-play foundries benefit from specialization and high-volume production capabilities, Intel's IDM approach enables enhanced collaboration between its design and fabrication teams, potentially driving advancements in energy-efficient transistor technologies and advanced packaging.

IDMs such as STMicroelectronics and GF, headquartered in Switzerland and the U.S., respectively, share Intel's focus on integrating design and manufacturing. These companies have regional production facilities to meet specialized customer demands but lack Intel's scale in leading-edge chip fabrication. For instance, while GF primarily produces mature-node chips, Intel's roadmap includes leading-edge process nodes like Intel 18A (1.8nm) expected by 2025, which aim to reclaim its leadership position in advanced SC technologies (Hutton, 2025).

TSMC and Samsung dominate the industry regarding advanced-node manufacturing and customer acquisitions. TSMC's global operations include fabs in Taiwan, Arizona, and China, focusing on technologies ranging from N5 (5nm) to N2 nodes (A. Shilov, 2022). Similarly, Samsung's U.S. investments, such as its $17 billion facility in Texas, underscore its capabilities in producing high-performance logic chips and advanced process nodes (A. Shilov, 2022). Samsung and TSMC have successfully manufactured advanced chips for the foundry business, mainly due to their governments' substantial financial support and investments. In large part, the success of Samsung and TSMC in the foundry business manufacturing advanced chips is only possible because of government investment (Sperling, 2024).

Moreover, the CHIPS Act has played a pivotal role in fostering U.S investment among these manufacturers, incentivizing domestic and international players to expand their presence in the U.S. market. For instance, TSMC's Arizona fabs and Samsung's

Texas facility have received substantial support under the Act, leveling the playing field while heightening competition for resources and talent. As Intel continues to execute its aggressive expansion plans and IDM 2.0 strategy, it faces the dual challenge of scaling advanced technologies and delivering high yields to match the production capabilities of rival foundries (Intel, 2021b; Morescalchi, 2024a).

b. Comparison of Expansion Plans

Intel's expansion plans under IDM 2.0 include a $100 billion investment in U.S. facilities, with significant projects in Ohio, Arizona, and Oregon (U.S. Department of Commerce, 2024b). These initiatives aim to enhance Intel's capacity to produce leading-edge chips domestically, reducing reliance on foreign suppliers. In comparison, TSMC's Arizona fabs focus on 5nm and 3nm technologies, while Samsung's Texas facility is expected to produce advanced logic chips (A. Shilov, 2024c; Sperling, 2024).

Intel's strategy emphasizes vertical integration and advanced packaging technologies are designed to improve chip performance and efficiency (Morescalchi, 2024b). However, TSMC and Samsung have a proven track record of delivering high yields at advanced nodes, which could challenge Intel's ability to compete effectively in the global market (Shaik, 2023).

c. Technological Advancements

Intel's technological advancements, supported by CHIPS Act funding, include transistor and packaging technology breakthroughs. The company's PowerVia backside power delivery system and RibbonFET architecture are expected to enhance chip performance and energy efficiency, potentially giving Intel a competitive edge (Hutton, 2025; Morescalchi, 2024b).

TSMC and Samsung, however, continue to lead in process technology. TSMC's N3 and N2 nodes, along with Samsung's 3nm GAA technology, are already in production or nearing deployment (Shaik, 2023; A. Shilov, 2024c). While Intel's innovations are promising, its ability to scale these technologies for high-volume manufacturing remains a critical challenge.

d. Financial Analysis

Intel’s financial performance has been bolstered by CHIPS Act incentives, which have offset some of the costs associated with its ambitious expansion plans. However, the company has faced declining revenues in recent years, with a 14% drop in 2023 (Intel, 2024). In contrast, TSMC and Samsung have maintained strong financial positions, driven by robust demand for their advanced nodes and diversified customer bases (Sperling, 2024).

Intel’s IDM 2.0 strategy, which includes offering foundry services to external customers, represents a significant shift aimed at generating new revenue streams. However, this approach requires substantial upfront investment and poses execution risks, particularly in a competitive landscape dominated by established foundries (Intel, n.d.-c).

e. Outcomes and Implications

Intel’s expansion under the CHIPS Act is expected to have far-reaching implications for the U.S. SC industry. By increasing domestic production capacity, Intel will reduce reliance on foreign suppliers and enhance national security (Shivakumar et al., 2024). However, the company’s ability to compete with TSMC and Samsung will depend on its execution of advanced technologies and its success in attracting new customers.

The CHIPS Act has also created a more competitive environment, incentivizing domestic and foreign manufacturers to invest in U.S. facilities. This dynamic could lead to increased innovation and lower costs for consumers, but may also intensify competition for resources and talent (Sperling, 2024; U.S. Department of Commerce, 2024b)

In conclusion, Intel’s comparative position in the SC industry reflects both opportunities and challenges. While the CHIPS Act has significantly boosted the company’s expansion efforts, it must overcome substantial hurdles to compete effectively with global leaders like TSMC and Samsung. By leveraging its IDM model and technological innovations, Intel has the potential to reshape the industry and secure its role as a cornerstone of the U.S. SC ecosystem.

4. Reduction of U.S. Dependence on China: Evaluation of how Intel's Capacity Expansion Affects U.S. Reliance on China

This section examines how Intel's manufacturing capacity expansion, achieved through successfully implementing its IDM 2.0 strategy, will impact the U.S.'s dependence on China. It will begin with an analysis of China's role in the GVC and assess the potential reductions in reliance on China as Intel increases its production capacity.

a. Current Reliance on China: Analysis of the Extent to Which the U.S. Depends on Chinese Semiconductor Manufacturing

At the end of the first quarter of 2025, Intel was nearing the completion of its fourth and final year of implementing its IDM 2.0 strategy, which aimed to achieve 5N4Y (Conway, 2024). Production of Intel's fourth node, the 20A chip, was outsourced to TSMC so that the company could focus entirely on the fifth and final chip of the strategy, the 18A (Alcorn, 2024). At the Intel Vision 2025 conference, they announced that 18A had entered the final stage of risk production (Alcorn, 2024). Risk production begins when the company increases production volumes incrementally to ensure that production yields are viable (Alcorn, 2024). Regardless of the success Intel has in advanced SC manufacturing, the extent of U.S. dependence on Chinese SC manufacturing is relatively limited compared to its reliance on Taiwan and South Korea, according to a 2021 report (Vargas et al., 2021, p. 40).

However, China plays a crucial role in certain areas of the SC supply chain. Intel's capacity expansion will have a minimal, if any, meaningful effect on China. Efforts to diversify supply chains and bolster domestic production aim to reduce this reliance, particularly amid ongoing tensions between the U.S. and China. However, China's role in the GVC will be nearly impossible to eliminate. The global market relies primarily on TSMC and Samsung for the supply of advanced SCs, Chinese firms lag in producing leading-edge chips due to their late entry into the industry as well as U.S. export controls on critical manufacturing equipment (American Journal of International Law, The, 2023, p. 145; Office of Congressional and Public Affairs, 2024). Intel's successful transition into producing advanced chips domestically will partially offset global reliance on TSMC. However, in April 2025, it was announced that TSMC and Intel would form a JV, in which

TSMC would partner with Intel to manufacture 18A, Intel's most advanced chip to date (Singh, 2025). This suggests that Intel is not genuinely ready to execute its 5N4Y strategy alone. This also means that TSMC will continue to play a significant role in the global supply of advanced chips. However, some of that manufacturing will shift to the U.S. According to Reuters, the U.S. Government encouraged this partnership. The fact that Intel, a well-capitalized industry giant, had to partner with a rival company further proves how difficult it is to break into the advanced chip-making market.

While China is not a leader in advanced SC manufacturing, its role in legacy chip production, assembly, testing, and packaging (ATP), as well as its control over REE and CM, makes it a significant player in the GVC (Liu et al., 2024). China's robust legacy chip manufacturing industry does contribute to global supply chains, although alternative suppliers exist in Southeast Asia, the United States, and Europe (Ravi, 2021, pp. 1–2).

China has multiple SC manufacturers specializing in mature-node foundries, memory chips, power SCs, and specialty ICs. Companies like Yangtze Memory Technologies Corporation, which produces Not AND (NAND) flash memory used for data storage; ChangXin Memory Technologies, which focuses on DRAM for temporary data storage; and Hua Hing, which offers foundry services for manufacturing chips designed by other companies, are integral to China's supply chain. The United States and its allies, including Taiwan, South Korea, Japan, and European countries, also have a strong and mature production capacity (Vargas et al., 2021). China's SMIC is a major supplier of mature-node chips, and alternative foundries such as TSMC, United Microelectronics Corporation, GF, and Renesas can help meet global demand, especially as the United States and its partners seek to reduce reliance on Chinese suppliers (Grimes & Du, 2022).

Regardless of Intel's capacity and capability expansions, China will continue to play a significant role in the back-end manufacturing portion of the GVC (Vargas et al., 2021, p. 19). Export controls issued by the Biden and Trump administrations have limited China's access to EUV and other specialized manufacturing equipment, limiting its role in the manufacturing portion of the supply chain. In response to these restrictions, China has invested in advanced packaging and ATP technologies (Xin et al., 2022). U.S. firms, including major chip designers such as Advanced Micro Devices, Intel, and Qualcomm, outsource some of their ATP processes to Chinese firms. China has comparative advantages in labor costs, strong infrastructure, and government investment. Disruptions to China's ATP industry or any firm involved in the GVC could create supply chain bottlenecks.

China also specializes in high-volume packaging for consumer electronics, automotive, and Internet of Things applications (Vargas et al., 2021, p. 39). There is a substantial investment in advanced packaging technologies, such as 2.5D and 3D packaging, to reduce reliance on foreign firms (Vargas et al., 2021, p. 39). Furthermore, the government has implemented initiatives such as Made in China 2025 and established the National Integrated Circuit Industry Investment Fund (Big Fund) to reduce its reliance on other nations.

The Chinese ATP market comprises domestic and foreign companies operating within its borders (Vargas et al., 2021). Taiwan's Advanced Semiconductor Engineering (ASE) Technology is the world's largest SC packaging firm, operating multiple plants in Shanghai and Kunshan. Amkor Technology is a U.S.-owned company that operates a facility in Shanghai, providing advanced packaging services for U.S. firms such as Apple, Qualcomm, and Nvidia. Taiwan's Powertech Technology has a JV with Chinese firm Tsinghua Unigroup and works closely with Micron (U.S.), SK Hynix (South Korea), and Kioxia (Japan).

This is not to state that China is the dominant player in ATP. As of a 2022 report by SIA, Taiwan and China held equal shares of the market at 22% each (Semiconductor Industry Association, 2022a). Chinese firms, such as Jiangsu Changjiang Electronics Technology, Tongfu Microelectronics, and Huatian, have well-developed ATP capabilities. The Chinese government has invested heavily in expanding domestic ATP infrastructure to reduce its reliance on foreign firms (Vargas et al., 2021, p. 32; Yanaizu, 2020, p. 82). China still lacks the most advanced ATP technologies, such as TSMC's Integrated Fan-Out technology, Intel's Embedded Multi-die Interconnect Bridge (EMIB), and Foveros 3D packaging (Business Executives for National Security, 2024, p. 3; A. Shilov, 2024a).

ATP firms are globally dispersed across Taiwan, South Korea, the U.S., and Southeast Asia (including Malaysia, the Philippines, Singapore, and Vietnam) (Business Executives for National Security, 2024, p. 3). The most notable is Taiwanese ASE, the largest ATP firm globally. Taiwan is a leader in high-end ATP, especially for TSMC's advanced nodes (Business Executives for National Security, 2024). In South Korea, Samsung and SK Hynix have ATP capabilities for high-end memory packaging. Amkor is headquartered in the U.S. but primarily operates in Asia. Intel has ATP plants in New Mexico, Oregon, and Arizona that focus on chiplet packaging (A. Shilov, 2024a). Intel's largest ATP facility is in Vietnam, and the company also has facilities in Malaysia, which serve as another ATP hub (Intel, 2024).

Beyond ATP capabilities, China is also a global hub for the assembly of end-use electronics (Vargas et al., 2021, p. 12). As a result, many chips are sold into the Chinese market for use in final goods for sale (Vargas et al., 2021, p. 12) As Vargas et al. explain, a significant portion of these chips are exported back out of China in end-use products such as smartphones or other consumer electronic goods (2021, p. 12). In 2024, the Israeli army detonated the pager devices of Hezbollah operatives inside Lebanon (Lee & Snodgrass, 2024). This was a global wake-up call to the severe risks of supply-chain infiltration by adversarial parties.

Beyond back-end GVC activities, such as ATP and electronics assembly services, the GVC relies heavily on China for raw materials, particularly REE and CM. Vargas et al. describe REE as a "set of 17 metallic elements with electronic and magnetic properties required in electronic products" (2021, p. 43). The authors explain that REEs are electronic products' "building blocks" that should not be ignored when evaluating supply chain risks. The authors also assert China is the global leader in extracting 9 REE. In the refinement of 14 REE (2021, p. 43), Chinese firms control a large portion of the global supply of CM, such as gallium, germanium, and tungsten, which are essential for SC production (Baek et al., 2024, p. 3; Baskaran & Schwartz, 2024a). The U.S. lacks the infrastructure to produce these minerals to meet its domestic demand and lacks refining capabilities (Semiconductor Industry Association, 2021, p. 25). China dwarfs the combined output of the mineral-rich nations of Australia, Canada, and Indonesia (Baskaran, 2024). The U.S. possesses known

REE reserves at the Mountain Pass mine in California and the Stibnite mine in Idaho (Lv et al., 2024). However, these sites cannot meet the domestic demand for CM or REE.

China has imposed export restrictions in 2023 on gallium and germanium, and followed with further CM restrictions in 2024 (Nguyen, 2024). While the U.S. is beginning to evaluate other sources of supply, the lengthy timelines for permitting new mines and developing mineral processing capabilities mean that China's control of CM and REE will endure for the short and medium term (Dwivedi, 2023; Perpetua Resources, 2025).

Even beyond its supply chain dependencies, China exerts influence through its vast domestic demand for SCs, driven by the world's largest population. The domestic purchasing power allows China to shape investment decisions and pricing strategies for global SC firms (Vargas et al., 2021, p. 12). This market leverage adds another dimension to the U.S. reliance on China, as companies looking to maintain access to Chinese consumers may feel pressure to maintain some degree of SC-related operations in China.

While the U.S. does not depend on China for leading-edge manufacturing capabilities, the nation remains an important player in ATP, legacy chip production, and the supply of raw materials (Baskaran & Schwartz, 2024b; Lim, 2025; Muller, 2025). These dependencies are vulnerabilities that the U.S. is actively seeking to address through domestic investments, strategic alliances, and supply chain diversification. However, China's continued and aggressive investment in R&D, ATP advancements, and control over CM and REE ensures that it will remain an essential link in the GVC for the foreseeable future.

b. Projected Changes: Assessment of Potential Reductions in Reliance on China Due to Intel's Increased Capacity

Intel's expansion of its ATP manufacturing capacity reduces the U.S. reliance on China in the GVC. As the only domestic company producing leading-edge chips, its advanced packaging capabilities may enhance Intel's success. In January of 2024, Intel announced the opening of its new Fab 9 advanced packaging facility at the Rio Rancho site in New Mexico (A. Shilov, 2024a). Fab 9 will be home for its Foveros 3D manufacturing. Foveros 3D technology allows chips to stack on chips, including mature node and leading-edge chips, in combination onto a single tile that allows for architecture flexibility (Barrett, 2018). The result is a hybrid processing unit that leverages the best features of CPUs and GPUs (Garreffa, 2022). Furthermore, Intel has EMIB technology, which enables chiplets to be connected, and individual modules are produced using Foveros 3D (A. Shilov, 2024d). Intel's EMIB technology allows for different chips and Foveros hybrid CPUs to be connected, which Intel states will "offer a faster and more cost-efficient path toward achieving 1 trillion transistors on a chip" (Intel, 2024). Intel invested $3.5B into the facility, which will allow Intel to package the advanced SCs that it manufactures for its foundry business as adoption of its Foveros 3D technology increases (A. Shilov, 2024a). Intel's largest ATP facility is in Vietnam and maintains operations in Malaysia.

Intel's investment in new U.S. and European fabs will also reduce reliance on Taiwan and South Korea for leading-edge chips. While TSMC has made significant investments in the U.S., the bulk of its manufacturing capability and knowledge base remains in Taiwan. Strategically, that makes sense for Taiwan as a hedge against potential Chinese aggression, such as a blockade or quarantine.

As Intel successfully expands its domestic chip manufacturing and ATP capabilities, China's dominance in REE and CM will remain a strategic vulnerability. While the United States has made some investments in mining, these efforts have long development timelines. The Stibnite mine only received its permit from the U.S. Forest Service to start operations, "after 8 years of thorough investigation, interagency analysis, consultation, and extensive public feedback on the proposed mine plan of operations" (Perpetua Resources, 2025). For context, the company's own projections estimate that it will be an additional 6 years before the mine starts to meet 35% of the 2022 U.S. demand for the CM antimony (Perpetua Resources, 2025). There are no other significant domestic sources of REE or CM other than the Mountain Pass mine in California.

Intel's increased capacity has the potential to significantly reduce its reliance on China for ATP and advanced packaging; however, achieving complete supply chain independence from China is unlikely to occur for more than a decade, if ever. While Intel's success would abate some national security risks for the United States, additional policy support will be required to address raw material dependencies and ensure supply chain diversification.

5. National Security Implications: An Analysis of the Strategic Importance of Increased Domestic Semiconductor Production

This section assesses the risks and vulnerabilities directly impacting national security concerning China's role in the GVC. The first section will provide a risk assessment, including a discussion of geopolitical risks and the strategic importance of Taiwan, the reliance on China for ATP and CM, export controls, retaliatory actions, and risks to economic and industrial capacity. The second portion will provide policy recommendations to support Intel's efforts and further enhance the supply chain's resilience. This will include recommendations for areas requiring further government investment, strategies to diversify ATP partnerships, securing the supply of CM and REE, export controls, and R&D investment.

a. Risk Assessment: Identification of Potential Risks and Vulnerabilities in the Supply Chain

This section will identify and discuss the potential risks and vulnerabilities related to China's role in the GVC as it relates to U.S. national security. The discussion will focus on risk factors related to China's REE and CM supply, ATP and advanced packaging services, and mature node SC production. In addition, the geopolitical risks associated with policies as they relate to China will also be analyzed.

China's control over REE and CM poses an immediate and substantial risk (Select Committee on the CCP, The, 2023, p. 43). These materials are not merely crucial for SCs but indispensable across the entire electronics manufacturing ecosystem. Their unique properties, including their metallic and electronic characteristics, render REE irreplaceable in various applications, such as smartphones, electric vehicles, and defense systems (Select Committee on the CCP, The, 2023, p. 44). China's restrictions on REE and CM have only begun to impact this supply chain. If manufacturers cannot secure the necessary materials, the output of electronics products will inevitably decline, as will the demand for SCs that power electronic devices. The "Strengthening the Global Semiconductor Value Chain" report underscores the cascading effects of these vulnerabilities to national security and economic stability (Vargas et al., 2021).

China also has a significant role in ATP, particularly in advanced packaging services. This is another risk to the GVC from the U.S. national security perspective. These are essential services required to deliver high-performance chips. The United States has already outsourced a significant portion of its ATP capacity overseas, and China holds a substantial market share in this domain. While China is certainly not the only nation with a considerable market share in the ATP, its contributions to the GVC are nonetheless substantial. Intentional or inadvertent disruption of access to these services would create bottlenecks that delay production, undercutting the ability of U.S. firms to deliver products to the market on time.

Similarly, while China is not the only nation with mature node production capabilities, it does play a significant role in the GVC. Mature node chips are the backbone of everything from vehicles to consumer appliances to military systems, and a significant portion of this production still takes place in China. While these mature node chips are not on the bleeding edge of technology, they remain critical to the global supply chain, and any interruption to their supply would severely impact industries across the globe.

Taiwan is central to the GVC because it is the global leader in the production of advanced chips. The PRC views Taiwan as a "renegade province" and has openly stated that the PRC seeks the reunification of Taiwan with China. The CSIS in a two-part ChinaPower Series identifies China's likely tactics to annex Taiwan (Martin et al., 2023; Tinsley, 2024a, 2024b). Any disruption – whether due to military conflict, economic coercion, or blockade would severely impact U.S. access to leading-edge SCs. Intel's IDM 2.0 strategy aims to reduce reliance on Taiwan, but even in the event of its complete success, Intel's reliance on TSMC will not be eliminated. Advanced chips are highly customized products, and chip designers must utilize the proprietary architecture for the foundry producing their product. It is not a matter of switching from TSMC to Intel or Samsung. A significant expense will be incurred because all the investment in one architecture must be duplicated to transition from one fab to another. Although TSMC has a fab in the United States, it could not handle the additional capacity that may be required if access to its Taiwan facilities is compromised. In 2021, the SIA released a report showing that 92% of advanced chips were produced by TSMC, with Samsung controlling the remaining 8% (Semiconductor Industry Association, 2021). The same report also noted that Taiwan was responsible for 20% of global SC manufacturing capacity. Any restriction of access to Taiwanese firms would devastate U.S. national security and the global economy.

The oligopolistic nature of the GVC is another risk. The *Strengthening the Global Semiconductor Value Chain* report also reminds us that the GVC is fragile in its structure, even without conflict. It is highly segmented, hyper-specialized, and very efficient—until something goes wrong. Natural disasters, infrastructure failures, cyberattacks, tariffs, embargoes, and even minor supplier disruptions can paralyze the system. During the pandemic, a fire at a Japanese factory, one of the missing links in a chain of over 500 suppliers, caused numerous downstream supply chain disruptions in the GVC and the market for finished goods. With capital costs as high as they are in this industry, there is no excess capacity to utilize.

Chris Miller notes in Chip War that integration into the GVC is not just a strength. It is also a vulnerability (Miller, 2022, pp. 353–354). Beijing is just as interested in decoupling as Washington is, and each nation is pursuing this on its terms.

Talent is another underappreciated vulnerability. The U.S. SC workforce is already stretched thin, and the *2024 SIA State of the Industry Report* projects a shortfall of 67,000 skilled workers in chip manufacturing by 2030. More broadly, related U.S. industries could expect a 1.4 million worker shortfall. That is a significant problem because, without talent, even the most advanced fabs will struggle to meet production targets. The report also estimates that 58% of new manufacturing and design jobs in the SC industry could go unfilled by 2030. That is a national security issue hiding in plain sight.

Lastly, there is the unintended consequence of export controls. When the United States restricts SC technologies to China, it risks cutting American firms off profitable overseas markets. According to the *Strengthening the Global Semiconductor Value Chain* report (pp. 42–43), approximately 20% of industry revenue is typically reinvested in R&D.

If revenue drops due to lost market access, innovation could slow. That is a long-term vulnerability that does not make headlines, but it should.

b. Policy Recommendations: Development of Recommendations for Policymakers to Support Intel's Efforts and Enhance Supply Chain Resilience

This section outlines policy recommendations aimed at strengthening U.S. national security by supporting Intel's efforts to become a leading global foundry for advanced chip manufacturing. These recommendations are intended to align with Intel's IDM 2.0 strategy, ensure the company's long-term viability, and enhance the resilience of the SC GVC. Intel's unique position as the only U.S.-based company capable of manufacturing leading-edge chips makes its success inseparable from America's technological sovereignty and security posture. As Chris Miller wrote in Chip War (2022, p. 332) "With out Intel, there won't be a single U.S. company or a single factory outside of Taiwan or South Korea capable of manufacturing cutting-edge processors."

The U.S. government must recognize that Intel is too strategically important to fail. As the only U.S. company currently positioned to manufacture leading-edge chips at scale, Intel is pivotal in mitigating national security risks tied to geopolitical instability, particularly in Taiwan. The reality is that competitors like TSMC and Samsung have achieved their current manufacturing prowess, in large part, due to massive government subsidies. Despite facing financial headwinds and public doubt about its IDM 2.0 strategy, Intel remains essential to U.S. security interests. This paper recommends substantial direct government investment in Intel and other U.S. companies within the GVC. Furthermore, the government should also award long-term production contracts to Intel, ensuring the company is financially positioned to weather economic downturns.

While chip fabrication is a critical component of the GVC, a secure supply chain requires comprehensive capabilities. The United States must invest in manufacturing and the upstream and downstream components of the GVC, focusing on areas where China has considerable market leverage. This includes policies that encourage and support the mining and ATP industries. However, as discussed previously, the need to strengthen the GVC cannot be met by onshoring these capabilities. Policy makers should supplement domestic initiatives with policies encouraging investments and partnerships with foreign producers in allied nations to ensure reliable access to critical inputs. This is especially true for funding REE and CM mining exploration and development.

Finally, the government should invest heavily in R&D of the global SC industry to ensure that policymakers are aware of the state of the GVC. This industry experiences significant changes quickly, and the government must be finely attuned to developments to make informed policy decisions. This knowledge is critical as the government continues implementing and reacting to export controls designed to restrict access to key raw materials and inputs required for a resilient GVC.

By implementing these policies, the United States can improve Intel's position in the SC industry, reduce strategic vulnerabilities, and enhance the resilience of the national SC supply chain.

V. SUMMARY, CONCLUSIONS, RECOMMENDATIONS

A. SUMMARY OF FINDINGS

The findings of this thesis highlight Intel's pivotal role in reshaping the U.S. SC landscape under the CHIPS Act. These key points summarize the study's significant insights:

1. Intel's Strategic Position in the Domestic Semiconductor Industry

Intel emerges as the only domestic player equipped to produce leading-edge chips. Its role under the CHIPS Act solidifies its importance in driving U.S.-based SC manufacturing and fostering technological advancements.

2. Reduction in Reliance on Foreign Suppliers

Intel's expansion into the foundry business in advanced SC manufacturing represents a critical step toward reducing the U.S.'s dependency on foreign suppliers, particularly Taiwan and China. While challenges persist in areas such as back-end manufacturing and reliance on China for raw materials and REE, Intel's progress marks a significant move toward enhanced supply chain resilience and strategic autonomy.

However, the GVC's intricacy inherently limits the extent to which foreign reliance can be eliminated. The CHIPS Act introduces meaningful advancements in domestic capacity by supporting Intel's efforts to manufacture advanced chips—a capability previously exclusive to TSMC in Taiwan and Samsung in South Korea. TSMC and Samsung have also established manufacturing facilities in the United States, contributing to a nascent domestic ecosystem for leading-edge chip production.

Nevertheless, the GVC remains highly specialized and segmented, functioning more as an oligopoly or even a monopoly than a traditional free market. The immense capital and technological barriers to entry make it infeasible for numerous players to replicate similar capabilities profitably. As such, complete decoupling from international suppliers is not a realistic or feasible goal. Instead, the U.S. SC industry must navigate this complex ecosystem by leveraging domestic advancements while strategically engaging with global partners to ensure stability and continued innovation.

3. National Security Implications

This study highlights the critical link between Intel's manufacturing capabilities and U.S. national security. A key achievement of the CHIPS Act is establishing domestic capacity for manufacturing advanced SCs, a capability previously absent in the United States. Intel's JV with TSMC to produce advanced chips for its foundry business, coupled with TSMC's manufacturing operations in the United States, reflects a significant step forward in addressing these gaps. However, as of this study, the extent of the new capacity introduced domestically remains uncertain, and it is anticipated that it will take several years of scaling before these efforts make a meaningful impact on the global market.

Expanding domestic advanced chip manufacturing capacity is pivotal for reducing national security risks. It mitigates vulnerabilities tied to potential geopolitical disruptions, such as a blockade, quarantine of Taiwan, or instability in South Korea, the only other nation capable of producing advanced SCs. Intel's efforts to establish a domestic supply of advanced SCs mark an essential step toward mitigating national security risks. While these capabilities are still developing, they promise to reinforce the resilience of defense systems, communication infrastructure, and critical industries that rely on secure SC access.

4. Intel's IDM 2.0 Strategy and Global Leadership

The CHIPS Act has provided critical support for Intel as it undertakes its IDM 2.0 strategy, a transformative initiative to reshape its role in the global SC landscape. Historically, Intel has operated as an IDM focused on making chips for its products. Intel is now evolving to include foundry services, enabling the production of advanced chips for external customers. This marks a significant strategic pivot, which, if successful, would position Intel as a more versatile competitor in an industry increasingly defined by specialization.

Through IDM 2.0, Intel is making a concerted effort to reestablish its position in advanced SC manufacturing. By integrating EUV lithography into its production processes, Intel is working to close the technological and competitive gap with these global giants. These initiatives reflect Intel's strategic response to evolving market demands and broader goals associated with strengthening U.S. technological capabilities and supply chain resilience.

B. IMPLICATIONS FOR THE SEMICONDUCTOR INDUSTRY

An extraordinary pace of innovation and relentless technological advancement characterizes the SC industry. This constant drive to push boundaries demands substantial and ongoing investment in R&D by firms striving to maintain competitiveness. Adding to this dynamic environment is the GVC's intricacy, a highly specialized, segmented, and interdependent system. Each stage of SC production—spanning design, fabrication, packaging, and distribution—is dispersed across multiple countries, creating a web of complexity that introduces vulnerabilities to disruptions. Compounding these challenges are significant geopolitical uncertainties, which further complicate the GVC's stability and amplify risks in an already fast-moving and competitive industry.

Amid these conditions, the CHIPS Act represents a transformative policy effort designed to reshape the global SC market in favor of the United States. By incentivizing domestic manufacturing and fostering innovation, the Act seeks to mitigate existing vulnerabilities in the GVC and strengthen the U.S.'s position. Together, these factors underscore the rapidly evolving nature of the SC sector and the critical importance of proactive strategies to adapt to its challenges and opportunities.

1. Domestic Production Strengths

Intel's capacity expansion marks a critical step toward bolstering U.S. SC manufacturing and innovation leadership. By enhancing its domestic footprint with investments in state-of-the-art facilities in Ohio, Arizona, and Oregon, Intel addresses supply chain vulnerabilities while positioning itself as a key player in advanced cutting-edge technology. Technologies such as Intel's Foveros 3D and EMIB packaging solutions improve chip performance and underscore Intel's commitment to establishing the United States as a global hub for advanced SC innovation. These advancements reinforce the country's ability to compete in areas such as AI, data centers, and quantum computing, aligning with strategic goals for technological sovereignty and economic resilience.

2. Global Competition

Intel's efforts to regain leadership in the SC industry occur amid fierce competition from international giants TSMC and Samsung. Both companies maintain an edge in high-yield production of advanced nodes and dominate the global market share. While Intel has made significant strides with its IDM 2.0 strategy and developing advanced nodes, it still faces challenges in achieving the same high-volume efficiency as its rivals. The CHIPS Act somewhat levels the playing field by incentivizing domestic and foreign investment in the United States, as demonstrated by TSMC's Arizona facilities and Samsung's Texas plant. However, Intel's success will largely depend on its ability to scale its manufacturing processes effectively, as the company has yet to replicate the production capacities of competitors like TSMC and Samsung. Achieving this will be crucial for Intel's market competitiveness and fostering broader supply chain resilience and stability within the SC industry.

3. Supply Chain Resilience

Despite the gains from Intel's domestic expansions, global SC supply chain vulnerabilities persist. China remains a dominant player in ATP services and the mining and refinement of REE and CM, which are essential for producing SCs. Export restrictions imposed by China have amplified concerns about material shortages, underscoring the necessity for supply chain diversification. Additionally, Taiwan's outsized role in advanced SC manufacturing continues to present geopolitical risks, as any disruption, whether due to conflict, economic pressure, or natural disasters, could significantly impact global production.

While Intel's expanded capabilities contribute to reducing reliance on foreign fabs, critical gaps in ATP, REE, and CM supply chains remain significant U.S. national security risks. The long timelines required to establish domestic production and refining capabilities for raw materials, combined with the specialized nature of ATP, emphasize the need for continued policy intervention and strategic partnerships with allied nations to secure these essential resources.

Intel’s capacity expansion, supported by the CHIPS Act, has the potential to reshape the current U.S. SC industry. However, achieving true supply chain resilience will require a comprehensive approach that addresses persistent vulnerabilities in advanced packaging, back-end manufacturing, raw materials, and geopolitical dependencies. These broader implications underscore the interconnected nature of the SC ecosystem and the ongoing need for innovation, investment, and collaboration.

Importantly, the CHIPS Act must not be viewed as a standalone solution. While it represents a significant step forward, the U.S. government must recognize the need for continued efforts to address high-risk vulnerabilities in the GVC, such as REE, CM, and advanced packaging. Moreover, the interconnected nature of the GVC means that disruptions in any part of the world can trigger cascading effects across the ecosystem. To safeguard U.S. technological and economic stability, policymakers must remain vigilant and prepared to anticipate and respond to these challenges with agility and foresight. Sustained attention and investment are imperative to fortify the SC supply chain against future risks and ensure long-term resilience.

C. IMPLICATIONS FOR NATIONAL SECURITY

The strategic importance of Intel’s capacity expansion under the CHIPS Act extends far beyond economic considerations, encompassing critical national security priorities. This section explores Intel’s role in the GVC, evaluates vulnerabilities tied to China’s dominance and Taiwan’s advanced chip production, and examines the geopolitical impact of export controls.

1. Intel’s Role in Mitigating Supply Chain Risks

As the sole U.S.-headquartered company capable of producing leading-edge chips, Intel is uniquely positioned to address vulnerabilities in the SC GVC. The domestic production of advanced SCs, supported by Intel’s IDM 2.0 strategy, is pivotal in securing critical defense systems, communication infrastructure, and emerging technologies such as

AI. By reducing reliance on foreign suppliers, Intel mitigates risks associated with disruptions from geopolitical conflicts, trade embargoes, or infrastructure vulnerabilities.

While Intel has demonstrated its ability to develop advanced SC technologies, scaling production to meet industry demands remains challenging. Its advanced packaging technologies, including Foveros 3D and EMIB, enhance chip performance and adaptability, ensuring their suitability for complex defense applications. However, achieving high-volume, efficient production of these sensitive and high-performance SCs is essential to secure domestic supply and reduce the risk of supply chain infiltration by adversarial actors. Intel's success will depend on innovation and its ability to manufacture at scale and deliver consistently to meet critical national security needs.

2. Risks Tied to China's Commerce and Taiwan's Advanced Capacity

China's control over the global supply of REE and CM and its significant role in ATP services pose substantial risks to U.S. supply chain resilience. Recently imposed export restrictions on REE and CM have highlighted the vulnerabilities in the relationship between the United States and China. These materials are indispensable for SC manufacturing and broader electronics production, affecting industries ranging from consumer goods to military technologies.

The absence of diversified sources for these critical inputs means the United States remains highly exposed to potential disruptions, with no immediate alternatives for addressing its dependence on China for REE, CM, and back-end manufacturing. While the mutual interdependence between the United States and China provides some stability, it does not eliminate the risks. Given that these vulnerabilities will likely persist in the near term, the United States must account for them thoughtfully when formulating strategic policies and decisions regarding its relationship with China. Acknowledging these supply chain risks is essential for developing long-term solutions that bolster resilience, secure critical resources, and mitigate potential geopolitical and economic fallout.

Taiwan's central role in advanced SC manufacturing presents another strategic vulnerability. With TSMC responsible for over 90% of global leading-edge chip production, the geopolitical risk surrounding Taiwan is a critical concern. Any disruption to Taiwan's manufacturing capabilities – whether through military aggression or economic coercion – would have devastating consequences for the availability of advanced SCs in the global supply. Intel's capacity expansions seek to offset these dependencies, but its reliance on TSMC for specific technologies, such as the 20A node manufacturing, illustrates the difficulty in achieving complete independence from Taiwan.

3. Geopolitical Consequences of Export Controls

The U.S. has implemented export controls to restrict China's access to specific SC manufacturing equipment critical for producing advanced chips. However, these policies have triggered significant repercussions, including retaliation by China against U.S. companies and with their own export controls, reduced market access, and revenue losses that hinder innovation. With approximately 20% of SC industry revenue typically reinvested into R&D, these constraints have slowed the pace of technological advancement, further intensifying the challenges U.S. firms face in maintaining global competitiveness.

Export controls also heighten geopolitical tensions, as target nations often respond with retaliatory measures that further disrupt global trade. In the case of SCs, such retaliation could exacerbate supply chain bottlenecks and intensify competition for essential materials. These dynamics underscore the need for export policies that balance national security and economic resilience, while fostering multilateral agreements with allies to enforce controls effectively.

Intel's capacity expansion and technological advancements bolster U.S. national security by securing critical SC supplies and reducing dependence on foreign manufacturers. While progress has been made in mitigating supply chain risks, challenges tied to China's dominance over REE, CM, back-end manufacturing, and Taiwan's outsourced role in advanced chip production remain significant. Export controls, though essential for safeguarding U.S. technologies, must be carefully managed to avoid unintended consequences that could impact industry innovation and international relations. Addressing these interconnected risks is essential to securing a stable and resilient SC ecosystem for the future.

D. POLICY RECOMMENDATIONS.

To ensure Intel's long-term competitiveness and bolster U.S. resilience in the SC supply chain, this study outlines actionable policy steps aimed at addressing key vulnerabilities and strengthening strategic advances:

1. Strategic Investments

Sustained funding through policy initiatives such as the CHIPS Act is vital for supporting the health of the domestic SC industry. Specific attention should be directed toward:

- Expanding domestic production capacity to include leading-edge nodes and advanced packaging facilities,
- Providing financial incentives for workforce development programs that cultivate a steady pipeline of skilled technicians, engineers, and operators,
- Strengthening public-private partnerships to align federal investments with corporate expansion efforts, ensuring a high return on investment, and
- Building on the U.S.'s chip design and EDA leadership to ensure continued leadership in front-end innovation. The United States remains a global leader in developing chip architectures and designing tools integral to the SC ecosystem. This strength should be supported and integrated into broader manufacturing initiatives to maximize the industry's competitive edge globally

However, it is crucial to recognize that the CHIPS Act must serve as a starting point, not the conclusion, of government support. While the Act introduces transformative incentives, the fast-evolving nature of the SC industry necessitates sustained and adaptive policy efforts. Regular policy evaluations should be conducted to assess the industry's health and competitiveness, ensuring that it effectively meets domestic and global challenges.

Policymakers must also remain prepared to introduce new legislative initiatives or expand existing measures to address emerging technological advancements, supply chain vulnerabilities, and workforce demands. By maintaining a forward-looking approach, the U.S. can safeguard the strategic and economic benefits of a robust and innovative SC ecosystem.

2. Supply Chain Diversification

Broadening the global supply of REE and CM reduces vulnerabilities and ensures resilience in the SC value chain. This entails a multipronged approach:

- Domestic Efforts: Expand manufacturing and refining infrastructure in the United States, including exploring sustainable methods,
- International Partnerships and Diversified Sources: Establish strategic partnerships with allied nations like Australia, Canada, and Indonesia to access their significant reserves while encouraging U.S. private investment in foreign firms to support exploration and production. Collaborate with industry stakeholders to integrate untapped or underutilized reserves globally into the value chain, reducing reliance on a few dominant suppliers; and
- Innovation and Substitution: Provide R&D investment for alternative materials and technologies to replace REE and CM in critical applications, alleviating demand pressure.

By prioritizing these strategies, policymakers and industry leaders can enhance supply chain security while fostering a resilient and interconnected ecosystem for the future.

3. Research and Development

Investing in innovation is crucial for maintaining U.S. leadership in SC technology. Policymakers should

- Prioritize funding for R&D initiatives focused on advancing leading-edge process nodes and packaging technologies,

- Leverage AI to analyze the GVC. Utilize AI to map interdependencies, identify vulnerabilities, and support adaptive policymaking as the industry evolves, and
- Expand collaborations with research universities and national laboratories to accelerate SC fabrication and materials science breakthroughs.

4. Export Controls

While safeguarding IP and preventing adversaries from acquiring critical technologies, export controls must be carefully calibrated to avoid unintended consequences. Policymakers should

- Develop nuanced export policies that balance national security with the need to preserve market access for U.S. SC companies,
- Collaborate with allied nations to enforce multilateral export controls, minimizing the potential for economic retaliation, and
- Regularly review export restrictions to ensure they align with evolving geopolitical and technological conditions.

5. Education and Workforce Training

Addressing the talent gap is imperative for meeting the SC industry's workforce demands. Key recommendations include

- Expanding federal and state support for STEM education programs at both the K-12 and higher education levels,
- Partnering with community colleges to create tailored training programs, such as stackable technician certifications and apprenticeships, to meet industry needs,
- Supporting the expansion of a well-trained, educated workforce across the GVC. The interconnected nature of the SC industry demands a broader talent pool, not just within the United States, but internationally. Investments in education and training programs that enhance skills across the GVC will strengthen

collaboration, increase innovation, and ultimately benefit all stakeholders, including the United States, and

- Establishing partnerships between SC companies, educational institutions, and government agencies to create sustainable workforce pipelines.

By adopting these policy measures, the United States can bolster its capacity to compete globally, reduce strategic dependencies, and enhance the resiliency of the SC supply chain. These steps will secure critical national security technologies and position the United States as a leader in innovation, collaboration, and technological sovereignty.

E. FUTURE RESEARCH DIRECTIONS

The evolving dynamics of the SC industry demand ongoing investigation to address current challenges and capitalize on emerging opportunities. This study's findings highlight several critical areas where future research can build on these insights to inform effective policymaking, industry strategies, and technological innovation.

1. Innovative Materials

Exploring new materials and production processes could significantly enhance SC performance and reduce manufacturing costs. Future research should identify alternatives to critical materials like REE and CM to minimize reliance on nations like China. Investigating advanced materials with improved electronic and thermal properties could pave the way for more efficient and sustainable SC production.

2. Supply Chain Resilience

The SC GVC remains highly vulnerable to disruptions caused by geopolitical tensions, natural disasters, or economic instability. Research aimed at developing strategies to strengthen the supply chain resilience is essential. This could include diversifying supply sources, advancing domestic ATP capabilities, and improving collaborative partnerships with allied nations to mitigate risks tied to single points of failure.

3. Addressing Workforce Shortage

Understanding labor dynamics and developing sustainable solutions are essential for meeting the SC industry's workforce demands. Future research should explore strategies for bridging this gap, including enhancing educational programs, targeted recruitment efforts, and initiatives to retain skilled workers in STEM fields. Studies on the effectiveness of workforce development policies under the CHIPS Act could provide valuable insights.

4. Sustainability

As environmental concerns gain prominence, examining the sustainability of SC manufacturing is crucial. Research should focus on minimizing resource consumption, reducing waste, and implementing eco-friendly technologies and materials. Developing frameworks for sustainable manufacturing practices will reduce the industry's carbon footprint and improve global competitiveness.

5. Cost and Benefits in Policy Outcomes

Future research could analyze the long-term effects of the CHIPS Act on the U.S. SC industry. It will be critical to evaluate how well the incentives drive domestic production and whether they enhance global competitiveness. A detailed assessment of policy outcomes will help refine future legislation to address industry challenges more effectively.

6. International Semiconductor Legislation

Examining SC-related legislation in other countries can uncover best practices and lessons that could guide U.S. policy adjustments. Comparative studies could show how nations like South Korea, Taiwan, and China have effectively supported their SC industries through government initiatives and investments.

7. Global Market Dynamics

The impact of U.S. SC policies on global market dynamics warrants further exploration. Research should assess shifts in trade patterns, competitive positioning, and the evolution of international collaborations in the SC sector. Understanding these dynamics will provide a broader context for evaluating the CHIPS Act and similar initiatives.

8. Technological Advancements

Research should continue investigating emerging technologies and practices that improve SC manufacturing efficiency and reduce dependencies on specific regions or resources. Future studies could focus on breakthroughs in advanced packaging, alternative chip architectures, and innovations extending the capabilities of existing process technologies.

9. Economic and Security Interdependencies

Analyzing the economic and security implications of global SC supply chain interdependencies is essential for understanding the broader geopolitical landscape. Future research could delve into the effects of international collaborations and trade policies on U.S. security and economic stability, offering insights for optimizing partnerships and policies.

By addressing these critical areas, future research can deepen our understanding of the SC industry's strategic importance, enhance its resiliency, and guide policymakers and industry leaders in making informed decisions. These studies will play a vital role in sustaining growth, innovation, and technological leadership in an increasingly interconnected and competitive global landscape.

F. FINAL THOUGHTS

The CHIPS Act represents an important, albeit initial, step in addressing vulnerabilities and bolstering the U.S. SC industry. While it has catalyzed discussions around reshoring and technological leadership, its impact remains difficult to quantify. The Act alone is insufficient to reshape the SC landscape, particularly as key players like TSMC maintain the bulk of their manufacturing capacity abroad. Intel continues to rely on external foundries for critical production processes.

Intel's IDM 2.0 strategy exemplifies the ambition to evolve from a vertically integrated model to one incorporating foundry services, echoing aspects of Samsung's dual model of producing chips for internal and external customers. While Intel has made considerable progress, such as its focus on advanced process nodes like 20A, the reality is that substantial challenges remain. Intel's recent JV with TSMC highlights the difficulty of achieving self-sufficiency in advanced SC manufacturing, as Intel shifts the production of critical chips to external partners. This raises questions about the extent to which Intel, or even the broader U.S. SC ecosystem, is truly expanding domestic capacity and lessening reliance on foreign supply chains

Despite this progress, significant challenges remain. Achieving complete technological independence and supply chain security requires overcoming persistent vulnerabilities, such as workforce shortages, reliance on critical raw materials like REE and CM, and the geopolitical complexities of the global SC ecosystem. Yet, these challenges also present opportunities. Investments in workforce development, strategic partnerships with allied nations, and breakthroughs in advanced technologies offer a path to sustained leadership and resilience.

As Miller (2022) notes,

> Intel…is still America's biggest and most advanced chipmaker. However, its future is more in doubt than at any point since Grove's decision in the 1980s to abandon memory and bet everything on microprocessors. It still has a shot at regaining its leadership position over the next half decade, but it could just as easily end up defunct. What's at stake isn't simply one company, but the future of America's chip fabrication industry. Without Intel, there won't be a single U.S. company—or a single facility outside of Taiwan or South Korea—capable of manufacturing cutting-edge processors. (2022, p. 332)

This underscores Intel's critical role in the U.S. SC landscape, not just as a corporate entity but as a linchpin in the nation's technological and economic security.

The SC GVC remains deeply interconnected, and China continues to hold significant leverage as a supplier of REE and CM. Developing domestic capacity for these resources is essential, but meaningfully reducing dependency will require sustained investment over decades. The narrative of lessening foreign reliance is, at best, aspirational at this stage, as the U.S. supply chain struggles to overcome persistent bottlenecks and achieve resilience.

The CHIPS Act has brought much-needed attention and funding to these challenges, but its success depends on sustained momentum and far more significant investment. A single piece of legislation cannot solve the geopolitical and economic complexities of building a robust and independent SC supply chain. While the Act mirrors initiatives like China's "Big Fund," it pales compared to the scale and continuity of investment needed to achieve parity.

In summary, while the CHIPS Act signals progress, expectations must remain grounded in the understanding that meaningful change is neither quick nor guaranteed. Milestones have already begun slipping, and the challenges faced by major players such as Intel and TSMC illustrate the uphill battle ahead. Securing U.S. leadership in the SC industry will require continued commitment, substantial funding, and a strategic focus on fostering resilience and innovation in a highly competitive and interdependent global ecosystem.

THIS PAGE INTENTIONALLY LEFT BLANK

DISCLOSURE STATEMENT

This paper was prepared and edited with the assistance of Microsoft Copilot, an AI companion created by Microsoft. Copilot provided support in narrowing our topic sufficiently to focus our research and complete the project plan in the allotted time. Following Professor Alan Nelson's suggestions, we consulted the Generative AI page on the Dudley Knox Library website to ensure we understood the boundaries.

Our team chose Microsoft Copilot. Using the NPS Capstone Project Plan fields as a guide, we asked Copilot to provide a thesis statement based on XYZ (copy/pasted our VERY broad topic) and the research questions QRX (copy/pasted our draft research questions). After reading the output, we requested Copilot narrow the topic to a project that could be completed within four months by three people. We then engaged in a back-and-forth exchange with Copilot regarding the output, asking it to expand some points and remove others until we were satisfied.

We then asked Copilot to refine the following into a Problem Identification section of a project plan for a thesis based on the provided topic. We entered the blurb we had previously written/submitted for assignment one in MN 4045. We refined the output using our own words.

Next, we told Copilot to refine our previously provided research questions based on the provided thesis statement and problem identification. We reviewed the questions provided, selected two, and kept one of our original questions.

We also requested that Copilot refine our project objectives based on the suggested thesis statement provided in our draft objective and suggest a project outline for the recommended thesis. We further refined the output from each request, accepting some suggestions and rejecting others. We then discussed this project plan with our advisors and tweaked it based on their feedback.

We drafted a section of the literature review and combined the draft into a single document. During drafting, if there were confusing areas, we utilized Copilot to offer suggestions for improving the clarity and coherence of the content. The authors made all final decisions regarding the content and structure of the paper. The literature review was initially written for Professor Alan Nelson's course, and he permitted/encouraged the use of AI applications in his course. After completing our initial draft, we used the tool to help refine lengthy/confusing sentences during editing.

First, we entered the following:

Help make this more understandable:

We then entered any run-on sentences or confusing paragraphs. We refined the output with our own words.

Additionally, we used Copilot to assist in organizing our information. For this process, we entered the following:

Help organize this information into a more cohesive thesis section titled "XXX"[inserting the title of the thesis section we were working on]:

We then entered our section of the thesis. We reviewed the output and incorporated some of the suggestions.

For the Analysis section of our paper (chapter four), with the permission/ encouragement of Professor Frank Kragh, we used Copilot to assist in preparing portions of our outline. For this process, we entered the following:

The following is an outline for a *thesis section titled "XXX"[inserting the title of the thesis section we were working on]:*

We then entered our outline section, skipped a space, and entered the following:

Please make suggestions for improvement.

We then exchanged ideas until we were satisfied with the results, keeping some and dismissing others. These sections of the outline were then used as the basis of the analysis.

Sometimes, if the output suggested areas we had not considered for research, we requested additional sources. For this process, we entered the following:

Please provide references for the section titled "XYZ" [inserting the title or subtitle from the outline area suggested]

We then reviewed the resources provided and decided whether to incorporate that area into our research (thus leaving it in the outline) or not (in which case we removed it from the outline).

Throughout the drafting of the remaining sections of the paper, we used Copilot to assist in organizing information and/or refining lengthy/confusing sections using the processes described above.

Once our paper was complete, we used Copilot to edit/proofread. For this process, we entered the following:

Please proofread/edit the following:

We then copied/pasted our entire paper (in sections). We reviewed the output and incorporated some of the suggestions.

After receiving feedback from our co-advisors, we used Copilot to assist with rewriting specific paragraphs to ensure they were neutral, as the resources used for the section were primarily Intel's press releases and annual reports, which resulted in an undertone of less objectivity than desired. For this process, we entered the following:

Make this paragraph sound less like business development for Intel and more neutral:

We then copied/pasted the paragraph. We reviewed the output and incorporated some of the suggestions.

Finally, we used Grammarly to proofread the entire paper, searching for grammatical errors and suggestions. We again reviewed the output and incorporated some of the suggestions.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Adams, M. (2024, October 4). *Where are all the North American semiconductor fabs being built (2024 edition)?* Z2data. https://www.z2data.com/insights/where-are-all-the-North-American-semiconductor-fabs-being-built-2024

Advanced Semiconductor Materials Lithography. (n.d.). *EUV lithography systems*. Retrieved February 15, 2025, from https://www.asml.com/en/products/euv-lithography-systems

Akayama, S., Chow, D., & Gupta, S. (2024). *Localizing the global semiconductor value chain*. Arthur D. Little. https://www.adlittle.com/sites/default/files/reports/ADL_Localizing_global_semiconductor_2024_0.pdf

Alcorn, P. (2024, September 4). *Intel announces cancellation of 20A process node for Arrow Lake, goes with external nodes instead, likely TSMC*. Tom's Hardware. https://www.tomshardware.com/pc-components/cpus/intel-announces-cancellation-of-20a-process-node-for-arrow-lake-goes-with-external-nodes-instead-likely-tsmc

Allen, G. C., & Goldston, I. (2025, March 14). *Understanding U.S. allies' current legal authority to implement AI and semiconductor export controls*. Center for Strategic & International Studies. https://www.csis.org/analysis/understanding-us-allies-current-legal-authority-implement-ai-and-semiconductor-export

American Journal of International Law, The. (2023). The United States announces export controls to restrict China's ability to purchase and manufacture high-end chips. *The American Journal of International Law*, *117*(1), Article 1. https://www.proquest.com/docview/2768962307/citation/2700958F69F4F43PQ/1

American Recovery and Reinvestment Act of 2009, Pub. L. No. 111–5, 123 Stat 115 (2009). https://www.congress.gov/bill/111th-congress/house-bill/1/text

Arasasingham, A., Benson, E., & Reinsch, W. A. (2022). *Securing semiconductor supply chains: An affirmative agenda for international cooperation*. Center for Strategic and International Studies. https://www.jstor.org/stable/resrep42770

Athey, P. (2023, October 19). *Fears of China-Taiwan war amp up high-tech "reshoring" push in U.S.* National Journal Daily A.M.; National Journal Group, LLC. https://www.proquest.com/docview/2878781344/abstract/B2AE6346223E4282PQ/1

Badlam, J., Clark, S., Gajendragadkar, S., Kumar, A., & O'Rourke, S. (2022, October 4). *The CHIPS and Science Act: Here's what's in it*. McKinsey & Company. https://www.mckinsey.com/industries/public-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

Baek, S., Janjeva, A., & Sellars, A. (2024, December 4). *China's quest for semiconductor self-sufficiency*. Centre for Emerging Technology and Security. https://cetas.turing.ac.uk/publications/chinas-quest-semiconductor-self-sufficiency

Barrett, B. (2018, December 12). An Intel breakthrough rethinks how chips are made. *Wired*. https://www.wired.com/story/intel-foveros-chips-breakthrough/

Baskaran, G. (2024, January 8). *What China's ban on rare earths processing technology exports means*. Center for Strategic & International Studies. https://www.csis.org/analysis/what-chinas-ban-rare-earths-processing-technology-exports-means

Baskaran, G., & Schwartz, M. (2024a). *China imposes its most stringent critical minerals export restrictions yet amidst escalating U.S.-China tech war*. https://www.csis.org/analysis/china-imposes-its-most-stringent-critical-minerals-export-restrictions-yet-amidst

Baskaran, G., & Schwartz, M. (2024b). From mine to microchip. *Center for Strategic & International Studies*. https://www.csis.org/analysis/mine-microchip

Belvins, E., Grossman, A., & Sutter, K. (2023). *Frequently asked questions: CHIPS Act of 2022 provisions and implementation* (CRS Report No. R47523). Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R47523?form=MG0AV3

Berger, A., Fuchs, E. R. H., Khan, H., & Schrank, A. (2023). A new policy toolbox for semiconductor supply chains. *Issues in Science and Technology*, *39*, 39–42. https://issues.org/new-policy-toolbox-semiconductor-supply-chains-berger-khan-schrank-fuchs/

Biden, J. (2022, January 1). *National Security Strategy*. President of the United States. https://purl.fdlp.gov/GPO/gpo187710

Blevins, E. G., Platzer, M. D., & Sutter, K. M. (2020). *Semiconductors: U.S. industry, global competition, and federal policy* (Congressional Research Service No. R46581).

Brescia, G. F. (2024, April 26). Sustainability in the semiconductor industry. *Power Electronics News*. https://www.powerelectronicsnews.com/sustainability-in-the-semiconductor-industry/

Burkacky, O., de Jong, M., Mittal, A., & Verma, N. (2021). Sustainability in semiconductor operations: Toward net-zero production. In *McKinsey on Semiconductors No 8*. McKinsey & Company. https://www.mckinsey.com/~/media/mckinsey/industries/semiconductors/our%20insights/mckinsey%20on%20semiconductors%20issue%208/mck_on_semiconductors_08_2021.pdf

Business Executives for National Security. (2024). *The global semiconductor supply chain: Four phases*. Semiconductor Supply Chains Info Series, Pt 2. https://bbnc.bens.org/semiconductors---page-2-supply-chain-phases

Cabello, K. (2023, July 25). *Chipping away: Assessing and addressing the labor market gap facing the U.S. semiconductor industry*. Oxford Economics. https://www.oxfordeconomics.com/resource/chipping-away-assessing-and-addressing-the-labor-market-gap-facing-the-us-semiconductor-industry/

CHIPS and Science Act of 2022, Pub. L. No. 117–167, 1366 (2022). https://www.congress.gov/bill/117th-congress/house-bill/4346/text

Coleman, V. (2023, September 30). *Command interview: AF Chief Scientist Dr. Victoria Coleman* (J. Eddins, Interviewer) [Airman Magazine]. https://www.airmanmagazine.af.mil/Features/Display/Article/3544172/at-altitude-af-chief-scientist-victoria-coleman/

Company-Histories.com. (n.d.). *Intel Corporation*. Retrieved March 6, 2025, from https://www.company-histories.com/Intel-Corporation-Company-History.html

Congressional Budget Office. (2010). *Estimated impact of the American Recovery and Reinvestment Act on employment and economic output from October 2009 through December 2009*. https://www.cbo.gov/sites/default/files/111th-congress-2009-2010/reports/02-23-arra_0.pdf?form=MG0AV3

Conn, A., & Millard, K. (2025, February 28). *Ohio Intel plant construction in New Albany delayed by at least three years*. NBC4 WCMH-TV. https://www.nbc4i.com/intel-in-ohio/ohio-intel-plant-construction-in-new-albany-delayed-by-at-least-three-years/

Conway, A. (2024, October 19). *Intel's process roadmap to 2025: Intel 7, 4, 3, 20A, and 18A explained*. XDA Developers. https://www.xda-developers.com/intel-roadmap-2025-explainer/

Council of Economic Advisers. (2014). *Economic report of The President, 2014*. https://obamawhitehouse.archives.gov/sites/default/files/docs/erp_2014_chapter_3.pdf?form=MG0AV3

Doering, R. (Ed.). (2008). *Handbook of semiconductor manufacturing technology* (2nd ed). CRC Press.

Donaldson, S. (2024, December 5). *Federal CHIPS funds reinvigorate Intel project in Ohio, but timing, scale still murky*. The Statehouse News Bureau. https://www.statenews.org/government-politics/2024-12-05/federal-chips-funds-reinvigorate-intel-project-in-ohio-but-timing-scale-still-murky

Dumas, B. (2025, January 20). *Future of CHIPS Act under Trump admin in question*. Fox Business. https://www.foxbusiness.com/politics/future-chips-act-under-trump-admin?form=MG0AV3

Dwivedi, S. (2023, April 12). *Securing the critical minerals that America and its allies lack*. The Strategist. https://www.aspistrategist.org.au/securing-the-critical-minerals-that-america-and-its-allies-lack/

EBM Machine. (2024, September 4). *Lithography in semiconductor manufacturing: Techniques and innovations*. https://ebeammachine.com/lithography-in-semiconductor-manufacturing-techniques-and-innovations/

Energy Independence and Security Act of 2007, Pub. L. No. 110–140, 120 Stat. 1494 (2007). https://purl.fdlp.gov/GPO/LPS94451

Ethan. (n.d.). *Where are Intel chips made 2024? – All factories revealed*. Madefind. Retrieved March 6, 2025, from https://madefind.com/where-are-intel-chips-made/

Filby, M. (2025a, March 4). *Intel already spent billions on delayed New Albany chip factory, new report reveals*. The Columbus Dispatch. https://www.dispatch.com/story/news/2025/03/04/intel-spent-billions-on-delayed-new-albany-chip-factory-project-new-report-says/81344252007/

Filby, M. (2025b, March 15). *Will Intel survive to 2030? We answer your biggest questions on factory delays, CHIPS Act*. USA TODAY. https://www.usatoday.com/story/news/2025/03/15/whats-happening-with-intel-we-answer-reader-questions-on-troubled-chipmaker/82405518007/

Fioramonti, J. (2021, August 11). *COVID-19's impact on the semiconductor industry*. Kidder Mathews. https://kidder.com/trend-articles/covid-19s-impact-on-the-semiconductor-industry/

Flamm, K., & Bonvillian, W. B. (2025). How Intel's innovation problem became a national security crisis. *American Affairs Journal*, *IX*(1), 40–54. https://americanaffairsjournal.org/2025/02/how-intels-innovation-problem-became-a-national-security-crisis/

Fortune Business Insights. (2025). *Semiconductor market size, share, growth & forecast 2024–2032* (No. FBI102365). https://www.fortunebusinessinsights.com/semiconductor-market-102365

Galloway, S. (Director). (2024, October 24). *Nvidia's rise, Intel's fall, and the chips in between ft. Patrick Moorhead* [Video recording]. https://www.youtube.com/watch?v=xx41hjw4BlU

Garreffa, A. (2022, August 23). *Intel's new 3D Foveros packaging tech: LEGO-like chiplets for CPUs*. TweakTown. https://www.tweaktown.com/news/88105/intels-new-3d-foveros-packaging-tech-lego-like-chiplets-for-cpus/index.html

Geng, H. (2017). *Semiconductor manufacturing handbook* (2nd ed). McGraw-Hill.

George, S. M. (2009). Atomic layer deposition: An overview. *Chemical Reviews*, *110*(1), 111–131. https://doi.org/10.1021/cr900056b

Gillibrand, K. (2021, April 20). *Senators Schumer and Gillibrand, Representatives Tonko and Katko, call on Biden administration to invest in U.S. semiconductor production*. Kirsten Gillibrand U.S. Senator for New York. https://www.gillibrand.senate.gov/news/press/release/senators-schumer-and-gillibrand-representatives-tonko-and-katko-call-on-biden-administration-to-invest-in-us-semiconductor-production/

Gleklen, J., Rhee, S.-M., Marotta, M., & Skillman, D. (2023, February 3). *Semiconductors: Legislative and regulatory spotlight – 2022*. Arnold & Porter. https://www.arnoldporter.com/en/perspectives/advisories/2023/02/semiconductors-legis-and-reg-spotlight-2022

Goswami, O. (2023). Chipping in: Critical minerals for semiconductor manufacturing in the U.S. *MIT Science Policy Review*, *4*, 118–126. https://doi.org/10.38105/spr.tnepby7ntp

Goswami, R., & Field, H. (2024, December 2). *Intel CEO Pat Gelsinger ousted by board after disastrous performance*. CNBC. https://www.cnbc.com/2024/12/02/intel-ceo-pat-gelsinger-is-out.html

Grimes, S., & Du, D. (2022). China's emerging role in the global semiconductor value chain. *Telecommunications Policy*, *46*(2), 101959. https://doi.org/10.1016/j.telpol.2020.101959

Hnatek, E. R. (1993). *Digital integrated circuit testing from a quality perspective*. Van Nostrand Reinhold.

Hoops, B. (2024, November 27). *Intel in Rio Rancho receives $500M to expand facility*. KRGQ News. https://www.krqe.com/news/new-mexico/intel-in-rio-rancho-receives-500m-to-expand-facility/

Hutton, R. (2025, February 19). *Intel races to regain chipmaking crown with 18A: The 2nm battle ahead*. PC Outlet. https://pcoutlet.com/parts/cpus/intel-races-to-regain-chipmaking-crown-with-advanced-nodes

Inquivix Technologies. (2023, November 13). *Why trailing edge semiconductor manufacturing matters*. https://inquivixtech.com/trailing-edge-semiconductor-manufacturing/

Intel. (n.d.-a). *About Intel Israel*. Retrieved March 6, 2025, from https://www.intel.co.il/content/www/il/he/company-overview/intel-in-israel.html

Intel. (n.d.-b). *Explore Intel's history*. Retrieved March 6, 2025, from https://timeline.intel.com/

Intel. (n.d.-c). *Financial results*. Intel Corporation. Retrieved March 21, 2025, from https://www.intc.com/financial-info/financial-results?form=MG0AV3

Intel. (n.d.-d). *Global manufacturing at Intel*. Retrieved March 6, 2025, from https://www.intel.com/content/www/us/en/architecture-and-technology/global-manufacturing.html

Intel. (n.d.-e). *How many manufacturing fabs does Intel have?* Retrieved March 6, 2025, from https://www.intel.com/content/www/us/en/support/articles/000089875.html

Intel. (n.d.-f). *Intel 18A process node*. Retrieved March 6, 2025, from https://www.intel.com/content/www/us/en/foundry/process/18a.html

Intel. (n.d.-g). *Intel's founding*. Retrieved December 6, 2024, from https://www.intel.com/content/www/us/en/history/virtual-vault/articles/intels-founding.html

Intel. (n.d.-h). *Semiconductor manufacturing process technologies*. Retrieved March 6, 2025, from https://www.intel.com/content/www/us/en/foundry/process.html

Intel. (2010, October 19). *Intel announces multi-billion-dollar investment in next-generation manufacturing in U.S.* https://www.intc.com/news-events/press-releases/detail/719/intel-announces-multi-billion-dollar-investment-in

Intel. (2021a, January 21). *Intel reports fourth-quarter and full-year 2020 financial results*. https://www.intc.com/news-events/press-releases/detail/1439/intel-reports-fourth-quarter-and-full-year-2020-financial

Intel. (2021b, March 23). *Intel CEO Pat Gelsinger announces "IDM 2.0" strategy for manufacturing, innovation and product leadership*. https://download.intel.com/newsroom/archive/2025/en-us-2021-03-23-intel-ceo-pat-gelsinger-announces-idm-20-strategy-for-manufacturing-innovation-and-product-leadership.pdf

Intel. (2022a, January 26). *Intel reports fourth-quarter and full-year 2021 financial results*. https://www.intc.com/news-events/press-releases/detail/1522/intel-reports-fourth-quarter-and-full-year-2021-financial

Intel. (2022b, April 28). *Intel reports first-quarter 2022 financial results*. https://www.intc.com/news-events/press-releases/detail/1541/intel-reports-first-quarter-2022-financial-results

Intel. (2022c, July 28). *Intel reports second-quarter 2022 financial results*. https://www.intc.com/news-events/press-releases/detail/1563/intel-reports-second-quarter-2022-financial-results

Intel. (2023a, September 29). *Intel's new fab in Ireland begins high-volume production of Intel 4 technology* [Press Release]. https://www.intc.com/news-events/press-releases/detail/1652/intels-new-fab-in-ireland-begins-high-volume-production

Intel. (2023b, October 23). *Intel's Oregon Investments fuel U.S. silicon innovation leadership*. Newsroom. https://newsroom.intel.com/corporate/oregon-investments-fuel-us-silicon-innovation-leadership

Intel. (2024, January 24). *Intel opens Fab 9 in New Mexico*. https://newsroom.intel.com/intel-foundry/intel-opens-fab-9-in-new-mexico

Ji, K., Nauta, L., & Powell, J. (2023a, June 14). *Mapping global supply chains: The case of semiconductors*. Rabobank. https://www.rabobank.com/knowledge/d011371771-mapping-global-supply-chains-the-case-of-semiconductors

Ji, K., Nauta, L., & Powell, J. (2023b, June 14). *Understanding the semiconductor supply chain*. Rabobank. https://www.rabobank.com/knowledge/s011371708-understanding-the-semiconductor-supply-chain

Kahng, A., Latch, J., Mangione-Smith, W., Mantik, S., Markov, I., Tucker, P., Potkonjak, M., Wang, H., & Wolfe, G. (2001). Constraint-based watermarking techniques for design IP protection. *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, *20*(10), 1236–1252. https://doi.org/10.1109/43.952740

Kelion, L. (2021, March 22). *Factory blaze adds to computer chip supply crisis*. BBC. https://www.bbc.com/news/technology-56486242

Keller, S. (2024, November 26). *Intel and Biden-Harris Administration finalize $7.86 billion funding award under U.S. CHIPS Act* [Press Release]. Intel. https://www.intc.com/news-events/press-releases/detail/1718/intel-and-biden-harris-administration-finalize-7-86?form=MG0AV3

Kusters, J., Bhattacharjee, D., Bish, J., Nicholas, J. T., Stewart, D., & Ramachandran, K. (2025, February 4). *2025 global semiconductor industry outlook*. Deloitte Insights. https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-telecom-outlooks/semiconductor-industry-outlook.html

Lee, L., & Snodgrass, E. (2024, September 18). *The detonation of pagers used by Hezbollah shows the depths of supply-chain infiltration*. Business Insider. https://www.businessinsider.com/israel-hezbollah-pager-walkie-talkies-explosion-supply-chain-infilitration-2024-9

Lim, L. (2025, February 6). *The U.S. reportedly plans to investigate China's dominance of legacy chips*. Yahoo News. https://www.yahoo.com/news/u-reportedly-plans-investigate-china-064637718.html

Liu, Q., Xue, D., & Li, W. (2024). A sustainable production segment of global value chain view on semiconductors in China: Temporal and spatial evolution and investment network. *Sustainability*, *16*(19), 8617. https://doi.org/10.3390/su16198617

Lv, A., Liu, S., Nguyen, M., & Devitt, P. (2024, August 16). Explainer: What is antimony and why is China curbing its exports? *Reuters*. https://www.reuters.com/markets/commodities/what-is-antimony-why-is-china-curbing-its-exports-2024-08-16/

Lynn, B. C. (2021, August). Antimonopoly power. *Foreign Affairs*, *100*(4), Article 4. https://www.proquest.com/docview/2544916177/abstract/F30865D7B4C04DDCPQ/1

Martin, B., Baldwin, L. H., DeLuca, P., Henriquez Sanchez, N., Hvizda, M., Smith, C. D., & Whitehead, N. P. (2023). *Supply chain interdependence and geopolitical vulnerability: The case of Taiwan and high-end semiconductors* (Report No. RR-A2354-1). RAND. https://www.rand.org/pubs/research_reports/RRA2354-1.html

Maruccia, A. (2025, February 26). *Semiconductor industry braces for CHIPS Act fallout after federal job cuts*. TechSpot. https://www.techspot.com/news/106925-chips-act-likely-fizzle-out-wake-federal-employee.html

Mearian, L. (2024, September 30). The CHIPS Act money: A timeline of grants to chipmakers. *Computerworld*. https://www.computerworld.com/article/2099381/the-chips-act-money-a-timeline-of-grants-to-chipmakers.html

Meridian Outpost. (n.d.). *Intel processor evolutionary history: Illustrated timeline*. Retrieved March 6, 2025, from https://www.meridianoutpost.com/resources/articles/timeline-Intel-processor-history.php

Millard, K. (2025, March 31). *Why Intel says it had to delay its Ohio One project in New Albany*. NBC4 WCMH-TV. https://www.nbc4i.com/intel-in-ohio/why-intel-says-it-had-to-delay-its-ohio-one-project-in-new-albany/

Miller, C. (2022). *Chip war: The fight for the world's most critical technology* (1st ed). Scribner.

Mitchell, R. (2023, November 21). *China's semiconductor race: Strategic triumph or potential pitfall?* Electropages. https://www.electropages.com/blog/2023/11/could-chinas-rush-semiconductor-sovereignty-hurt-its-industry

Moon, M. (2025, February 14). *Trump administration reportedly eyes renegotiating CHIPS Act awards*. https://www.msn.com/en-us/money/other/trump-administration-reportedly-eyes-renegotiating-chips-act-awards/ar-AA1z3CXv?form=MG0AV3

Morales, J. (2024, September 13). *U.S. Govt pushes Nvidia and Apple to use Intel's foundries: Department of Commerce Secretary Raimondo makes appeal for US-based chip production*. Tom's Hardware. https://www.tomshardware.com/tech-industry/us-govt-pushes-nvidia-and-apple-to-use-intels-foundries-department-of-commerce-secretary-raimondo-makes-appeal-for-us-based-chip-production

Morescalchi, D. (2024a, November 26). *Intel, Biden-Harris Administration finalize $7.86 billion funding award under U.S. CHIPS Act*. Newsroom. https://newsroom.intel.com/corporate/intel-chips-act

Morescalchi, D. (2024b, December 7). *Intel foundry unveils technology advancements at IEDM 2024*. Intel Newsroom. https://newsroom.intel.com/intel-foundry/intel-foundry-unveils-technology-advancements-iedm-2024

Muller, J. (2025, April 15). 1 big thing: China trade war risks stifling U.S. EV movement. *Axios*. https://www.axios.com/newsletters/axios-generate-6fd73550-1923-11f0-9c29-e3c2d5453208?utm_source=chatgpt.com

Murphy, M. (2023, June 26). Why we need EUV lithography for the future of chips. *IBM Research*. https://research.ibm.com/blog/what-is-euv-lithography?utm_source=chatgpt.com

Mwaniki, P. (2024, January 23). *How is Intel's $20b Ohio One chip plant: On track or derailed?* Construction Review. https://constructionreviewonline.com/commentary/intels-20-billion-ohio-plant-a-look-at-the-latest-updates/

National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116–283, 134 Stat. 3388 (2021). https://www.congress.gov/bill/116th-congress/house-bill/6395/text?form=MG0AV3

National Institute of Standards and Technology. (2024, July 24). *Intel Corporation (Oregon)*. NIST.Gov. https://www.nist.gov/chips/intel-corporation-oregon-hillsboro

Nguyen, B. (2024, December 3). *China is banning exports of rare minerals to the U.S. in a trade war tit-for-tat*. Quartz. https://www.yahoo.com/tech/china-banning-exports-rare-minerals-132158175.html

Office of Congressional and Public Affairs. (2024). *Commerce strengthens export controls to restrict China's capability to produce advanced semiconductors for military applications* [Press Release]. Bureau of Industry and Security. https://www.bis.gov/press-release/commerce-strengthens-export-controls-restrict-chinas-capability-produce-advanced

Office of the Deputy Secretary of Defense. (2022). *Securing defense-critical supply chains: An action plan developed in response to President Biden's Executive Order 14017.* Department of Defense.

Pelzer, J. (2025, March 27). *Ohio AG Dave Yost: State has little power to claw back $600M from Intel*. MSN. https://www.msn.com/en-us/money/economy/ohio-ag-dave-yost-state-has-little-power-to-claw-back-600m-from-intel/ar-AA1BE5l3

Perpetua Resources. (2025, January 6). *Perpetua resources secures approval from U.S. forest service for stibnite gold project*. https://www.investors.perpetuaresources.com/investors/news/perpetua-resources-secures-approval-from-us-forest-service-for-stibnite-gold-project

Priyadarshi, K. (2023, December 31). 5 semiconductor industry predictions for 2024. *Techovedas*. https://techovedas.com/5-semiconductor-industry-predictions-for-2024/

Priyadarshi, K. (2024, August 5). Intel's fab capacity expansion: Projected growth and strategic plans through 2030. *Techovedas*. https://techovedas.com/intels-fab-capacity-expansion-projected-growth-and-strategic-plans-through-2030/

Randewich, N., Cherney, M. A., & Bajwa, A. (2024, October 29). The rise and decline of Intel. *Reuters*. https://www.reuters.com/technology/rise-decline-intel-2024-10-29/

Ravi, S. (2021). *Taking stock of China's semiconductor industry*.

Richard, C. (2023). *Understanding semiconductors*. Apress. https://doi.org/10.1007/978-1-4842-8847-4_9

Select Committee on the CCP, The. (2023, December 12). *Reset, prevent, build: A strategy to win America's economic competition with the Chinese communist party*. House.Gov. http://selectcommitteeontheccp.house.gov/media/policy-recommendations/reset-prevent-build-strategy-win-americas-economic-competition-chinese

Semiconductor Industry Association. (2021, March 15). *Risks in the semiconductor manufacturing and advanced packaging supply chain*. https://www.semiconductors.org/wp-content/uploads/2021/04/4.5.21-SIA-supply-chain-submission.pdf

Semiconductor Industry Association. (2022a). *2022 factbook*. https://www.semiconductors.org/wp-content/uploads/2022/05/SIA-2022-Factbook_May-2022.pdf?form=MG0AV3

Semiconductor Industry Association. (2022b, April 20). *Building America's innovation economy*. https://www.semiconductors.org/wp-content/uploads/2021/05/SIA-Industry-Facts_4-20-2022.pdf

Semiconductor Industry Association. (2024, September 11). *2024 state of the U.S. semiconductor industry*. https://www.semiconductors.org/2024-state-of-the-u-s-semiconductor-industry/

Shaik, A. I. (2023, September 5). *Intel plans to overtake Samsung and TSMC with its 1.8nm chips by 2025*. SamMobile. https://www.sammobile.com/news/intel-plans-overtake-samsung-tsmc-1-8nm-chips-2025/

Shilov, A. (2020). Intel's 10nm node: Past, present, and future. *EE Times*. https://www.eetimes.com/intels-10nm-node-past-present-and-future/

Shilov, A. (2022, December 7). *TSMC unveils major U.S. fab expansion plans: 3nm and $40 billion by 2026*. AnandTech. https://www.anandtech.com/show/18682/tsmc-unveils-major-us-fab-expansion-plans-3nm-and-40-billion

Shilov, A. (2024a, January 24). *Intel opens $3.5 billion advanced Foveros 3D chip packaging facility in New Mexico*. Tom's Hardware. https://www.tomshardware.com/pc-components/cpus/intel-opens-dollar35-billion-advanced-foveros-3d-chip-packaging-facility-in-new-mexico

Shilov, A. (2024b, January 25). *Intel teams up with UMC for 12nm fab node at IFS*. AnandTech. https://www.anandtech.com/show/21247/intel-teams-up-with-umc-for-12nm-production-node

Shilov, A. (2024c, May 22). *TSMC's Roadmap at a glance: N3X, N2P, A16 coming in 2025/2026*. AnandTech. https://www.anandtech.com/show/21408/tsmc-roadmap-at-a-glance-n3x-n2p-a16-2025-2026?form=MG0AV3

Shilov, A. (2024d, June 27). *Intel's EMIB packaging tech is now supported by industry-standard design and test tools*. Tom's Hardware. https://www.tomshardware.com/tech-industry/intels-emib-packaging-tech-is-now-supported-by-industry-standard-design-and-test-tools

Shilov, A. (2025a, February 13). *Intel's 18A and TSMC's N2 process nodes compared: Intel is faster, but TSMC is denser*. Tom's Hardware. https://www.tomshardware.com/tech-industry/intels-18a-and-tsmcs-n2-process-nodes-compared-intel-is-faster-but-tsmc-is-denser

Shilov, A. (2025b, March 14). *Intel reaches "exciting milestone" for 18A 1.8nm-class wafers with first run at Arizona fab*. Tom's Hardware. https://www.tomshardware.com/tech-industry/intel-reaches-exciting-milestone-for-18a-1-8nm-class-wafers-with-first-run-at-arizona-fab

Shilov, A. S. (2025, March 14). *Intel's new CEO warns employees about "tough decisions," but Wall Street cheers*. Tom's Hardware. https://www.tomshardware.com/tech-industry/intels-new-ceo-warns-employees-about-tough-decisions-but-wall-street-cheers

Shivakumar, S., Wessner, C., & Howell, T. (2024). Too good to lose: America's stake in Intel. *Center for Strategic & International Studies*. https://www.csis.org/analysis/too-good-lose-americas-stake-intel

Singh, J. (2025, April 3). *Intel, TSMC tentatively agree to form chipmaking joint venture, the information reports*. MSN. https://www.msn.com/en-ca/money/topstories/intel-tsmc-tentatively-agree-to-form-chipmaking-joint-venture-the-information-reports/ar-AA1CfMY1?ocid=BingNewsSerp

Sissine, F. J. (2008). *Energy Independence and Security Act of 2007: A summary of major provisions* (CRS Report No. RL34294). Congressional Research Service.

Sperling, E. (2024, July 15). *Intel vs. Samsung vs. TSMC*. Semiconductor Engineering. https://semiengineering.com/intel-vs-samsung-vs-tsmc/

Srinivasa, C., O'Keefe, N., & Misic, M. (2024, July 23). *From legislation to innovation: The CHIPS Act and a new era of semiconductor innovation*. Foley & Lardner. https://www.foley.com/insights/publications/2024/07/chips-act-new-era-semiconductor-innovation/

Stadler, L. (2023, September 24). *Intel editorial: Intel addresses semiconductor workforce shortage*. Businesswire. https://www.businesswire.com/news/home/20230924048835/en/Intel-Editorial-Intel-Addresses-Semiconductor-Workforce-Shortage

Strom, J., & Schoettler, K. (2025). Trump administration reshapes semiconductor industry policies. *The National Law Review*, *XV*(78). https://natlawreview.com/article/navigating-trumps-semiconductor-strategy

Subin, S. (2025, February 28). *Intel delays Ohio chip plant opening to next decade, was supposed to start production by 2026*. CNBC. https://www.cnbc.com/2025/02/28/intel-delays-ohio-plant-opening-to-2030-production-was-to-start-2026.html

Sullivan, J. (2022, September 16). *Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit*. Briefing Room, The White House. https://bidenwhitehouse.archives.gov/briefing-room/speeches-remarks/2022/09/16/remarks-by-national-security-advisor-jake-sullivan-at-the-special-competitive-studies-project-global-emerging-technologies-summit/

Sutter, K. M. (2023). *Semiconductors and the CHIPS Act: The global context* (CRS Report No. R47558). Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R47558/5

Tembey, G., Dahik, A., Richard, C., & Rastogi, V. (2023, September 28). Navigating the costly economics of chip making. *BCG Global*. https://www.bcg.com/publications/2023/navigating-the-semiconductor-manufacturing-costs

Texas Instruments. (2024, December 20). *Texas Instruments announces award agreement for CHIPS and Science Act funding*. PR Newswire. https://www.prnewswire.com/news-releases/texas-instruments-announces-award-agreement-for-chips-and-science-act-funding-302337541.html

Thomas, R. (2021, April 6). *Chip maker Renesas shifts production following factory fire*. Supply Chain Digital. https://supplychaindigital.com/supply-chain-risk-management/chip-maker-renesas-shifts-production-following-factory-fire

Tinsley, B. L., Brian Hart, Matthew P. Funaiole, Samantha Lu, Truly. (2024a, June 5). *How China could quarantine Taiwan*. https://features.csis.org/chinapower/china-quarantine-taiwan

Tinsley, B. L., Brian Hart, Matthew P. Funaiole, Samantha Lu, Truly. (2024b, August 22). *How China could blockade Taiwan*. https://features.csis.org/chinapower/china-blockade-taiwan

Trau, M. (2025, March 5). *The CHIPS Act brought Intel to Ohio. Trump wants it gone. Will Ohio's congressional representatives defend it?* News 5 Cleveland. https://www.news5cleveland.com/news/politics/ohio-politics/the-chips-act-brought-intel-to-ohio-heres-what-gop-says-about-trumps-plan-to-repeal?form=MG0AV3&form=MG0AV3

U.S. Department of Commerce. (2024a). *Foreign-produced direct product rule additions and refinements to controls for advanced computing and semiconductor manufacturing items* (Final Rule Nos. 0694-AJ74). https://public-inspection.federalregister.gov/2024-28270.pdf

U.S. Department of Commerce. (2024b, August 9). *Two years later: Funding from CHIPS and Science Act creating quality jobs, growing local economies, and bringing semiconductor manufacturing back to America*. https://www.commerce.gov/news/blog/2024/08/two-years-later-funding-chips-and-science-act-creating-quality-jobs-growing-local

U.S. Department of Commerce. (2024c, November 26). *Biden-Harris Administration announces CHIPS incentives award with Intel to advance U.S. leading-edge chip capacity and create tens of thousands of jobs* [Press Release]. https://www.commerce.gov/news/press-releases/2024/11/biden-harris-administration-announces-chips-incentives-award-intel

U.S. Department of Commerce. (2025, January 15). *Building the U.S. semiconductor workforce: January 2025 update*. National Institute of Standards and Technology. https://www.nist.gov/system/files/documents/2025/01/15/Workforce%20Accomplishments%20Fact%20Sheet_%2001.15.25.pdf

U.S. Department of Transportation. (2015, December 4). *The fixing America's Surface Transportation Act or "FAST Act."* https://www.transportation.gov/fastact?form=MG0AV3

Vargas, A., Varadarajan, R., Goodrich, J., & Yinug, F. (2021, April). *Strengthening the global semiconductor value chain*. Semiconductor Industry Association. https://www.semiconductors.org/wp-content/uploads/2021/05/BCG-x-SIA-Strengthening-the-Global-Semiconductor-Value-Chain-April-2021_1.pdf

von der Leyen, P. (2023, 29). *Speech by the President on EU-China relations to the Mercator Institute for China Studies and the European Policy Centre* [Interview]. https://ec.europa.eu/commission/presscorner/detail/en/speech_23_2063

Wafer World. (2024, March 29). *Silicon wafer supplier strategies for global supply chain*. https://www.waferworld.com/post/silicon-wafer-supplier-strategies-for-global-supply-chain

Walsh, D. (2023, May 28). *Advances in technology are driving popularity of EVs*. Yale School of the Environment. https://environment.yale.edu/news/article/advances-technology-are-driving-popularity-evs

White House, The. (2022, August 9). *CHIPS and Science Act will lower costs, create jobs, strengthen supply chains, and counter China*. https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

Wickham, S. (2023, September 25). *Ohio delivers on commitment, issues onshoring grant to Intel*. Ohio Department of Development. https://development.ohio.gov/home/news-and-events/all-news/2023-0925-ohio-delivers-on-commitment-issues-onshoring-grant-to-intel

Williams, W. (2025, February 17). *Hell freezes, pigs fly: Rumor has it that Intel could merge with AMD's former foundry in potential multi-billion deal*. TechRadar. https://www.techradar.com/pro/hell-freezes-pigs-fly-rumor-has-it-that-intel-could-merge-with-amds-former-foundry-in-potential-multi-billion-deal

Wu, Z., & Liang, C. (2024). A review and prospects of manufacturing process knowledge acquisition, representation, and application. *Machines*, *12*(6), 416. https://doi.org/10.3390/machines12060416

Xin, C., Chen Yun, Xun, C., & Xiaojie, W. (2022). Back-end electronics manufacturing equipment in China and their key components. *Strategic Study of Chinese Academy of Engineering*, *24*(4), 74–84. https://doi.org/10.15302/J-SSCAE-2022.04.008

Yanaizu, S. (2020). Disentangling China's grand strategy: Interview with Yoichi Funabashi. *Harvard International Review*, *41*(2), Article 2. https://www.proquest.com/docview/2570252272/abstract/E2AA1E22DC264D66PQ/1

Acquisition Research Program
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net