Automotive Semiconductor Market Forecast - Considering Global Variables

Master Thesis

By

Hiren Maheshbhai Dudhat
Matriculation Number: 3347377
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Faculty of Applied Natural and Cultural Science

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Supervisor: Prof. Dr. rer. pole. Alexander Ruddies
Supporting Supervisor: Prof. Dr. -Ing. Rainer Holmer
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Abstract

The automotive industry is undergoing a profound transformation driven by electrification, advanced driver-assistance systems, and the emergence of software-defined vehicles. This evolution has significantly increased the demand and economic importance of semiconductors, while simultaneously exposing the sector to volatility, as demonstrated by the 2020-2023 global chip shortage. Against this backdrop, the present research addresses three central questions: how to design a robust forecasting model for the automotive semiconductor industry, what the expected global market size will be in the next twelve months, and how external global variables influence this trajectory.

To answer these questions, the study developed a quantitative forecasting framework using company-level automotive revenues from five major semiconductor suppliers between Q1 2009 and Q1 2025. A Seasonal Autoregressive Integrated Moving Average (SARIMA) model was established as the baseline due to its ability to capture strong seasonal and autoregressive patterns. This baseline was then extended to a SARIMAX model to integrate exogenous variables including Battery Electric Vehicle (BEV) sales, G20 GDP, the Global Financial Stress Index (FSI), and Polysilicon Prices. The analysis compared forecast accuracy and examined the scenario implications of each variable.

The findings reveal that SARIMA provided the most reliable short-term forecasts, with external variables enriching interpretive scenarios but not consistently improving predictive accuracy. Among them, G20 GDP (Group of Twenty County Gross Domestic Product) exerted the most stable and explanatory influence, while BEV sales, FSI, and polysilicon prices introduced volatility or short-term distortions. The central forecast estimates the global automotive semiconductor market size at approximately USD 62 billion over the next twelve months, indicating a phase of temporary moderation after years of rapid growth, rather than a structural decline.

This research contributes a replicable methodology for integrating financial data with global variables to forecast market dynamics in a sector characterized by high technological convergence and economic uncertainty. By highlighting the balance between endogenous industry momentum and exogenous global forces, it advances the academic and practical understanding of forecasting in the automotive semiconductor domain. The results reaffirm that while short-term volatility is inevitable, the long-term trajectory remains robust, positioning semiconductors as the indispensable backbone of the future of mobility.

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In the end, this thesis represents not only my individual effort but also the collective support of those who inspired, guided, and encouraged me throughout this endeavor.

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List of Abbreviations

Abbreviation	Definition
EV	Electric Vehicle
ADAS	Advanced Driver-Assistance System
AD	Autonomous Driving
PHEV	Plug-in Hybrid Electric Vehicle
AI	Artificial Intelligence
OTA	Over The Air
V2X	Vehicle to Everything
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
LIDAR	Light Detection and Ranging
USD	United State Dollar
ICE	Internal Combustion Engine
SiC	Silicon Carbide
GaN	Gallium Nitride
CAGR	Compound Annual Growth Rate
ECU	Electronic Control Unit
CEO	Chief Executive Officer
OEM	Original Equipment Manufacturer
COVID-19	Coronavirus Disease 2019
ABF	Ajinomoto Build-up Film
IT	Information Technology
JIT	Just-in-Time
G20	Group of Twenty Countries
GDP	Gross Domestic Product
FSI	Financial Stress Index
ARIMA	Autoregressive Integrated Moving Average
SARIMA	Seasonal Autoregressive Integrated Moving Average
SARIMAX	Seasonal Autoregressive Integrated Moving Average with eXogenous Regressors
BEV	Battery Electric Vehicle
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
DC	Direct Current
E/E	Electrical/Electronic
FPD	Flat Panel Display
GPS	Global Positioning System
MCU	Microcontroller Unit
IC	Integrated Circuit
IGBT	Insulated Gate Bipolar Transistors
JPY	Japanese Yen
BMS	Battery Management System
CAN	Controller Area Network
LIN	Local Interconnect Network
NFC	Near Field Communication
UWB	Ultra-Wideband
NXP	Next eXPerience

Abbreviation	**Definition**
IoT	Internet of Things
RF	Radio Frequency
ID	Identifier
R&D	Research and Development
ESMC	European Semiconductor Manufacturing Company
VSMC	Vision-power Semiconductor Manufacturing Company
EMS	Electronics Manufacturing Service
STM	STMicroelectronics
ASIC	Application Specific Integrated Circuit
ASSP	Application Specific Standard Product
CMOS	Complementary Metal Oxide Semiconductor
FD-SOI	Fully Depleted Silicon on Insulator
MEMS	Micro-Electric-Mechanical System
P&D	Power & Discrete
D&RF	Digital & RF
H1	First Half
TI	Texas Instruments
PSG	Power Solutions Group
AMG	Analog and Mixed-Signal Group
ISG	Intelligent Sensing Group
WBG	Wide Band Gap
FSI	Financial Stress Index
OFR	Office of Financial Research
KG	Kilogram
ZEV	Zero Emission Vehicle
SDV	Software Define Vehicle
HPC	High Performance Computing
GPU	Graphics Processing Units
BVAR	Bayesian Vector Autoregression
APG	Automotive Product Group
ADG	Automotive and Discrete Group
MDRF	Microcontrollers, Digital ICs and RF products
SEC	U.S. Securities and Exchange Commission
OECD	Organisations for Economic Co-operation and Development
AR	Autoregressive
MA	Moving Average
SAR	Seasonal Autoregressive
SMA	Seasonal Moving Average
RMSE	Root Mean Squared Error

1. Introduction

1.1. Background of the Automotive Semiconductor Market

This chapter establishes the foundational context for the thesis, tracing the evolution of the automotive industry and highlighting the increasingly pivotal role of semiconductors within it. It also contextualizes the market within broader global economic trends and past disruptions, providing a comprehensive overview necessary for understanding the complexities of market forecasting.

1.1.1. Evolution of the Automotive Industry

The automotive industry is undergoing an unprecedented transformation, moving beyond its traditional mechanical roots to become a highly sophisticated, software-defined ecosystem. This evolution is primarily driven by the rapid adoption and integration of electric vehicles (EVs), advanced driver assistance systems (ADAS), and the burgeoning development of autonomous driving (AD) technologies [1].

The shift towards electric vehicles represents a significant revolution, propelled by zero emission technology and continuous advancements in battery capabilities. Electric cars are gaining substantial popularity due to their environmental benefits and the ongoing evolution of battery technology, supported by a rapidly expanding charging infrastructure [1]. In 2024, nearly half of all new cars sold in China were electric, including Plug-in Hybrid Electric Vehicles (PHEVs), demonstrating accelerated market adoption. Europe also saw the market share of all EVs, including hybrids, exceed 50% in 2024, despite some fluctuations in Battery Electric Vehicle (BEV) market share [2]. Globally, EV sales in Q1 2025 were projected to reach approximately 20 million units, marking a 17% increase over the previous year. This growth is primarily driven by strong adoption in key regions, with Europe seeing a 28% increase, largely propelled by Germany, and China selling over a million EVs in Q1 2025. This expansion is further spurred by government incentives, improvements in battery technology allowing modern EVs to travel 300-500 miles on a single charge and reducing charging times dramatically, expanding charging infrastructure, smart technology integration, and lower long-term ownership costs [3].

Modern vehicles have transformed into sophisticated systems on wheels, featuring advanced connected and autonomous capabilities, largely propelled by Artificial Intelligence (AI) [4]. Connected vehicle technology, powered by 5G advancements, enhances real time communication, significantly boosts traffic safety, and integrates in-vehicle infotainment systems [1]. This includes features like remote diagnostics, Over The Air (OTA) updates, and Vehicle to Everything (V2X) communication, encompassing Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) interactions. These advancements are foundational for a connected road network aimed at improving traffic flow and reducing accidents [5].

ADAS are a cornerstone of enhanced vehicle safety, encompassing functionalities such as adaptive cruise control, lane departure warning, and automatic emergency braking [1]. These systems rely heavily on an array of sensors, cameras, radar, and Light Detection and Ranging (LIDAR) to monitor the vehicle's surroundings and provide real time feedback, thereby reducing human error and enhancing overall road safety. ADAS represents a crucial step towards fully autonomous vehicles, offering a glimpse into a future with even less human intervention [5].

In 2025, industry is witnessing a significant increase in the development and testing of autonomous vehicles, with expectations of more self-driving cars on the roads. Major players like Tesla, Waymo, and Ford are at the forefront of developing and testing autonomous technology [1]. This also includes advanced AI algorithms, to navigate roads and make driving decisions without human intervention [6]. The growth potential for autonomous technology is substantial, promising to redefine the concept of mobility, enhancing convenience and reshaping how people perceive and interact with transportation [1].

The convergence of these technologies signifies that the demand for semiconductors is not merely an additive sum of these individual advancements, rather each technology enhances the capabilities and necessity of the others, leading to a synergistic, rather than linear increase in semiconductor content and complexity per vehicle [4]. For instance, AI as detailed is not just integral to ADAS and autonomous driving but also optimizes EV energy management and revolutionizes the entire design and manufacturing process of vehicles. This profound technological convergence is fundamentally transforming the automotive industry into a "software defined vehicle" paradigm [1]. This transformation profoundly alters traditional vehicle architecture, manufacturing processes and business models. The shift implies a continuous, accelerating demand for higher performance, more integrated and more secure semiconductors. It elevates semiconductors beyond simple components to strategic enablers, necessitating deeper technological partnerships between automakers and chip manufacturers. This underlying theme is critical for understanding the drivers of the automotive semiconductor market.

1.1.2. Increasing Role and Economic

The profound transformation of the automotive industry is inextricably linked to the escalating integration and economic significance of electronics and semiconductors. These components are no longer mere accessories but are now the "heart" and "backbone" of modern vehicles, controlling everything from core operations to advanced safety and entertainment systems [5].

The value and number of semiconductors per vehicle have risen sharply and are projected to continue an exponential increase [7]. In 2023, the average car contained approximately USD 590 worth of semiconductor devices, a figure projected to climb to USD 1,000 by 2029 [7]. Another projection indicates the value rising from USD 540 in 2022 to USD 912 by 2028. The number of semiconductor devices per car is expected to increase from approximately 834 in 2023 to 1,106 by 2029, and from 850 in 2022 to 1,080 in 2028. This growth is primarily fueled by the increasing implementation of ADAS and vehicle electrification [7], [8], [9].

EVs are a major driver of semiconductor demand, requiring significantly more semiconductors than traditional Internal Combustion Engine (ICE) vehicles typically two to three times as many chips [3]. The semiconductor content in an EV can range from USD 1,500 to USD 3,000 per vehicle, compared to USD 400 to USD 600 for traditional ICE vehicles [10]. This increased content is due to their heavy reliance on electronic systems for propulsion, power management, and connectivity [3]. Power semiconductors alone account for 30-40% of total automotive semiconductor demand, driven by EV powertrain needs, with materials like Silicon Carbide (SiC) and Gallium Nitride (GaN) becoming crucial for higher efficiency and lower energy loss [10].

The global automotive semiconductor market, valued at approximately USD 50 billion in 2023, is projected to surpass USD 100 billion by 2030 [10]. Other projections include growth from USD 42.9 billion in 2022 to 70.0 billion USD by 2027, representing a Compound Annual

Growth Rate (CAGR) of 10.1%, and from USD 43 billion in 2022 to USD 84.3 billion in 2028, with a CAGR of 11.9% [8], [11]. This rapid expansion signifies a major opportunity for both automakers and semiconductor companies. Beyond powertrains, semiconductors are integral to infotainment systems, ADAS and various Electronic Control Units (ECUs) [6]. Infotainment and telematics systems, driven by advancements in mobile and internet technologies, accounted for the largest share of the automotive chip market by application. The shift towards software defined vehicles has further increased semiconductor content, making the industry more vulnerable to semiconductor price fluctuations [11]. The Chief Executive Officer CEO of Intel predicted that by 2025, chips will constitute 12% of premium vehicle material costs, rising to 20% by 2030 [12]. This highlights the growing financial significance of semiconductors within the overall vehicle cost structure.

This robust expansion redefines the automotive sector's standing within the broader semiconductor industry. Historically a smaller consumer of chips cars accounted for 15% of global chip consumption, while personal electronics accounted for around 50% in 2021. This exponential growth transforms the automotive segment into a critical, high-value and strategically vital pillar for chip manufacturers [13]. The shift in vehicle architecture means semiconductors are no longer simply commodity components but rather strategic enablers, such as SiC for EVs and advanced technology nodes for ADAS [8]. This necessitates that semiconductor companies move beyond a transactional supplier relationship to become essential long-term partners for Original Equipment Manufacturers (OEMs), as evidenced by the need for dedicated automotive specific production lines and secure, long-term partnerships [10]. The future of automotive innovation encompassing safety, efficiency, environmental sustainability, and autonomy is now directly dependent on continuous innovation and a reliable supply from the semiconductor industry. This creates a deeply interdependent relationship where advancements in one sector directly drive the other. Consequently, the automotive semiconductor market emerges as a distinct and strategically vital segment within the broader semiconductor industry, demanding specialized and sophisticated forecasting approaches.

However, this increasing integration of advanced semiconductor technology also introduces a critical economic dynamic. While there is a clear and strong drive for integrating more semiconductor content due to the demand for advanced features in new vehicles, the rising cost of the overall vehicle and the challenge of maintaining a balance between cost and quality are significant concerns for the automotive semiconductor market. The higher semiconductor content in EVs, for instance, directly translates to them being more expensive to produce [7], [10]. This inherent dynamic presents a critical balancing act for automakers. They must integrate cutting-edge, high-performance semiconductors to remain competitive, meet evolving consumer demands for advanced features, and comply with environmental regulations. Yet, this integration comes with significantly higher production costs, which can impact on vehicle affordability and market accessibility. This implies a strategic imperative for semiconductor manufacturers to focus on developing cost effective designs without compromising quality to enable the mass market adoption of EVs and the broader integration of advanced features across vehicle segments [10]. This inherent interplay between cost, quality, and innovation will likely influence market segmentation, with premium vehicles potentially serving as early adopters for the most expensive and advanced semiconductor solutions, while mass market vehicles will necessitate optimized, lower-cost semiconductor solutions to remain competitive and accessible to a wider consumer base. These dynamic impacts the overall market size and growth trajectory, meaning that forecasting models must implicitly account for these complex economic considerations beyond purely technological advancement.

1.1.3. Impact of Recent Disruptions

The automotive industry's increasing reliance on semiconductors was starkly highlighted by the profound impact of the 2020-2023 global chip shortage, which affected over 169 industries worldwide [13]. This crisis served as a critical lesson in supply chain vulnerabilities and the imperative for robust forecasting and supply chain resilience.

The chip shortage was described as a "perfect storm" of factors, primarily stemming from Coronavirus Disease 2019 (COVID-19) pandemic disruptions, which led to factory closures and logistical challenges, and a sudden surge in demand for consumer electronics due to the shift to a stay-at-home economy [13]. This strained global semiconductor manufacturing capacity, further exacerbated by specific, unforeseen events like the Texas winter storm Uri in February 2021, which caused widespread power outages, and a fire at Japanese manufacturer Nittobo in July 2020, impacting Ajinomoto Build-up Film (ABF) substrate production [14]. ABF is a type of substrate material used in advanced semiconductor packaging.

The automotive industry was among the most severely affected sectors, experiencing disruptions and delays on an unprecedented scale [13]. Automakers, having incorrectly predicted a sales drop at the pandemic's outset, canceled chip orders and were subsequently unprepared to meet the rebound in demand. Chip manufacturers, in turn, prioritized commitments to the higher volume Information Technology (IT) sector, which further reduced the capacity for automotive chips. The global automotive industry was expected to lose USD 210 billion in revenue in 2021 due to the chip shortage [14]. Ford alone lost over USD 1.3 billion in the first three months of 2022. Major automakers were forced to cut production and temporarily halt assembly lines due to the scarcity of semiconductor chips [13]. For example, Toyota planned to cut global vehicle production by 40% in September 2021, and General Motors announced it would halt production of almost all cars at its North American plants for a week or two that same month. During the third quarter of 2021, new car sales in the United States were only two-thirds of what they had been in the same period in 2020, as supply could not meet demand. Opel closed its Eisenach manufacturing plant until 2022 due to the shortage, leading to the temporary layoff of 1,300 workers. By 2023, the automotive industry largely recovered, with global car production increasing by 3% [14].

The average modern car can contain between 1,400 and 1,500 chips, with some vehicles having up to 3,000 [13]. The shortage primarily affected advanced features in vehicles, such as infotainment systems, driver assistance technologies, and engine management systems, all of which heavily rely on semiconductor components. The ripple effects extended to consumers, who faced longer wait times for vehicle deliveries and limited choices in available models. This crisis revealed significant vulnerabilities in global supply chains, particularly the reliance on Just-in-Time (JIT) manufacturing, which proved fragile when the pandemic forced the closure of industries and shipping hubs globally. Businesses were left without strong reserve supplies, leading to disruptions at every stage of the supply chain. The complexity of automotive supply chains meant that disruptions at one stage had cascading effects, impacting suppliers, subcontractors, and ultimately the end consumer. This has led to significant changes in the automotive industry, with companies now signing long-term contracts with semiconductor suppliers to ensure consistent supply [14].

1.2. Problem Statement

The automotive industry's ongoing transformation into a "software-defined vehicle" ecosystem, as evidenced by the rapid adoption of electric vehicles, advanced driver-assistance systems, and autonomous driving, has fundamentally altered its core economics. This technological convergence has created a synergistic, exponential increase in the value and number of semiconductors per vehicle, transforming them from simple components into strategic enablers.

However, this elevated reliance on semiconductors has exposed the automotive sector to unprecedented volatility and supply chain vulnerabilities, a fragility starkly demonstrated by the 2020-2023 global chip shortage. This crisis, described as a "perfect storm," resulted in billions in lost revenue and underscored the critical need for a more proactive and sophisticated understanding of market dynamics. While the strategic importance of semiconductors is now widely recognized, a significant gap remains in providing a comprehensive, forward-looking forecast that accurately quantifies the market's trajectory by accounting for the complex interplay between financial performance and a range of critical external variables.

Current market analyses often provide high-level projections that fail to capture the dynamic influence of macroeconomic indicators and key industry-specific drivers. This lack of a nuanced and comprehensive forecasting model leaves key stakeholders from semiconductor manufacturers and automotive OEMs to financial investors without the actionable intelligence required to manage supply chain resilience, mitigate risks, and inform strategic planning in a rapidly evolving market.

This research, therefore, aims to bridge this critical gap. By developing a robust forecasting model this research will provide forward looking view of Automotive Semiconductor Market Size and Growth not only based on historical financial data but also explicitly accounts external global variables.

1.3. Research Questions

This thesis aims to address the identified problem by answering the following research questions:

"How to create a robust forecasting model particular for automotive semiconductor industry?"

"What will be the global automotive semiconductor market size in the next 12 months based on financial data?"

"How will the global automotive semiconductor market size be affected by external global variables?"

1.4. Objectives

The primary objectives of this thesis are to:

Identify and Analyze Global Variables: Systematically identify and analyze the most influential global macroeconomic variables (e.g., real Gross Domestic Product (GDP), Financial Stress Index (FSI), polysilicon prices) and technological trends (e.g., EV sales, ADAS penetration) that impact the automotive semiconductor market demand.

Quantify Impact of Technological Shifts: Quantify the increasing semiconductor content per vehicle driven by the evolution towards EVs, ADAS, and autonomous driving, and assess its contribution to overall market growth.

Develop a Forecasting Model: Develop and implement a SARIMA & SARIMAX (Seasonal Autoregressive Integrated Moving Average with Exogenous Regressors) model using historical financial data from selected companies (Q1 2009 to Q1 2025) to forecast the automotive semiconductor market.

Evaluate Model Performance and Limitations: Evaluate the performance of the developed SARIMAX model against established metrics, identify its limitations in capturing market volatility and unforeseen disruptions, and propose areas for future refinement.

1.5. Thesis Structure

This thesis is structured into five chapters, each building upon the previous one to provide a comprehensive analysis and forecasting framework for the automotive semiconductor market.

Chapter 1: Introduction provides the background of the automotive industry's evolution and the increasing role of semiconductors. It outlines the problem statement, defines the research questions, and states the objectives of the study. This chapter also contextualizes the market within broader global economic trends and recent disruptions.

Chapter 2: Literature Review will delve into existing academic and industry literature on automotive market trends, semiconductor technology, demand forecasting methodologies, and the impact of global macroeconomic variables and supply chain dynamics. This chapter will identify gaps in current research and establish the theoretical foundation for the chosen forecasting approach.

Chapter 3: Methodology will detail the research design, data collection processes (including the Q1 2009 to Q1 2025 financial data from five companies), and the specific steps involved in developing and implementing the SARIMAX model. It will describe the selection of exogenous variables, and the statistical techniques employed for model validation.

Chapter 4: Results and Discussion will present the findings from the forecasting model, including the forecast of the automotive semiconductor market. This chapter will analyze the impact of the identified global variables and technological trends on the forecast, discuss the model's accuracy, and interpret the implications of the results for stakeholders.

Chapter 5: Conclusion and Future Work will summarize the key findings of the thesis, reiterate the answers to the research questions, and discuss the contributions of the study. It will also acknowledge the limitations of the research and propose directions for future work, including potential enhancements to the forecasting model and areas for further investigation in the automotive semiconductor market.

2. Literature Review

2.1. The Automotive Semiconductor Market Landscape

The global automotive semiconductor market comprises various businesses and organisations involved in the design, development, manufacturing, marketing, and sale of semiconductors specifically for use in automobiles [15]. These semiconductors are fundamental components that enable a wide array of advanced functionalities in modern vehicles. Semiconductors themselves are materials with electrical conductivity between that of a conductor and an insulator, integral to devices such as transistors, solar panels, sensors, and electric circuits, and their application has expanded significantly within contemporary vehicles [16].

2.1.1. Market Size and Growth Drivers

Market Size: The global automotive semiconductor market has demonstrated significant growth, with its size reaching USD 42.9 billion in 2022. Projections indicate a substantial expansion to USD 70.0 billion by 2027, exhibiting a Compound Annual Growth Rate (CAGR) of 10.1% during this period [11]. Another assessment reported the market size as USD 68.4 billion in 2024, which marked a slight decrease of 1.2% from USD 69.2 billion in 2023 [17]. Looking further ahead, the market size was approximately USD 100.48 billion in 2025 and is forecasted to climb to USD 142.87 billion by 2030, reflecting a 7.29% CAGR from 2025 to 2030. Unit shipments are also anticipated to rise from 108.12 billion in 2025 to 160.96 billion by 2030, at a CAGR of 8.28%. Notably, the semiconductor content in an EV is considerably higher, averaging USD 1,500 per vehicle, which is approximately triple the value found in an ICE model [18]. Historically, the automotive semiconductor industry has been identified as one of the fastest growing segments within the broader semiconductor industry, constituting approximately 9% of the total semiconductor market in 2015, representing a market size of around USD 33.40 billion [19].

Growth Drivers: Several key factors are propelling this substantial growth in the global automotive semiconductor market:

- Increasing Vehicle Production in Emerging Economies: vehicle output growth in regions such as Asia-Pacific (particularly China and India) and Mexico is significantly boosting semiconductor demand. Automakers are expanding domestic capacity, forming joint ventures, and localising supply chains in these areas. China alone accounts for over 40% of the global demand for EV chips, while India's policy framework, including production linked incentives, stimulates fresh investment. Mexico's ascent as a projected fifth largest vehicle producer by 2025, supported by numerous electrification component suppliers, provides a near shoring option for North American OEMs. These trends collectively enlarge regional chip demand, shorten logistics cycles, and diversify sourcing risks [18].

- Rising Demand for Advanced Safety and Comfort Systems: The global adoption of driver-assistance features and autonomous functionalities is a significant driver for semiconductor content. Systems such as radar, LiDAR, and camera fusion platforms require high bandwidth domain controllers and memory. The ADAS market is projected to approach USD 91.83 billion in 2025, with semiconductor value in this domain representing more than half of incremental chip revenue through 2030. Regulatory mandates for features like automatic emergency braking and lane-keeping assistance in Europe and North America further accelerate this demand. Average chip counts per car are projected to rise from 834 units in 2023 to over 1,100 units by 2029. Safety systems are expected to be the fastest-growing application area, with a 16.2% CAGR to 2030 [18].

- Electrification Boosting Semiconductor Content per Vehicle: The shift towards electric vehicles significantly increases the number of semiconductors per vehicle. Battery Electric Vehicles alone integrate up to 3,500 semiconductors, driving the gross bill-of-materials to over USD 1,500 per car. SiC and GaN devices are critical components, making up 30-40% of traction inverter value due to their superior switching efficiency and high temperature tolerance. Production of EV powertrains is expected to increase from 33.1 million units in 2024 to 53.8 million by 2029, sustaining a double-digit CAGR that outpaces overall vehicle growth. As automakers adopt 800V architectures, demand strengthens for high voltage Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs), compact DC-DC converters, and high-resolution current sensors [18]. Governments worldwide are providing incentives to promote the adoption of EVs, further fuelling this demand [11]. BEVs are projected to post the fastest CAGR of 18.5% through 2030 among propulsion types [18].

- Zonal Electrical/Electronic (E/E) Architectures and Software-Defined Vehicles: The consolidation of numerous ECUs into fewer zonal gateways reduces wiring complexity and simplifies system validation. Up to 45% of global vehicle production is expected to adopt software defined platforms by 2027, increasing demand for high end processors, high bandwidth Ethernet switches, and Flat Panel Display-Link (FPD-Link) serializers [18].

- Government Subsidies for Auto Grade Foundry Capacity: Initiatives such as the CHIPS Act and comparable European programmes are providing financial support for semiconductor manufacturing, aiming to alleviate supply chain constraints [18].

- Adoption of SiC and GaN Power Devices: These advanced power devices are increasingly integrated into EV powertrains to enable faster charging capabilities and enhance efficiency, particularly in 800V architectures. SiC inverters served 28% of battery-electric platforms in 2023, with adoption scaling quickly in premium segments [18].

- Increasing Urbanisation and Rising Disposable Income: These macroeconomic trends contribute to a higher volume of vehicle sales and consequently drive growth in the overall automobile market, which in turn boosts semiconductor demand [20].

- Ongoing Innovations: Continuous advancements in vehicle safety, connectivity, and fuel efficiency are perpetual drivers for market expansion, as new technologies require more sophisticated semiconductor solutions [20].

- Investment in Public Transport Infrastructure: Increasing government focus and investment in public transport infrastructure, especially heavy-duty and long-range buses, drives growth in the commercial vehicle segment of the automotive market [20].

- Growing Popularity of Shared Mobility and Telematics Integration: The rising trend of shared mobility and the integration of telematics, offering features like accident alerts and traffic data, are also significant factors contributing to the automotive industry's expansion [15]. Telematics and infotainment systems, with their advanced capabilities like touchscreens, in-vehicle audio, voice recognition, smartphone connectivity, and GPS tracking, account for a large share of the automotive chip market [16][11]. The deployment of Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication systems is expected to further augment this market segment [11].

2.1.2. Key Industry Product Segments

The contemporary automotive sector is undergoing a profound transformation driven by advancements in electrification, autonomous driving, connectivity, and in-cabin experiences. This evolution is fundamentally enabled by a sophisticated and diverse range of semiconductor products. An analysis of the 2024 annual reports from five industry leaders Texas Instruments, ON Semiconductor, NXP Semiconductors, STMicroelectronics, and Infineon Technologies, provides a comprehensive overview of the critical components these companies supply to the automotive market. Their collective portfolios can be categorized into several key functional areas that constitute the electronic architecture of a modern vehicle.

Vehicle Control and Computation:

At the core of virtually every automotive electronic system are microcontroller units (MCUs) and processors. These components function as the digital brains, handling specific tasks ranging from simple body control functions to complex, real time powertrain management. Specialized automotive processing platforms, such as NXP's S32x family and Infineon's AURIX™ microcontrollers, are specifically designed to meet the stringent safety and reliability requirements of applications like ADAS, engine control, and high speed onboard networks [21], [22], [23].

Power Management and Electrification:

A significant focus for all five manufacturers is the provision of intelligent power technologies essential for managing energy in all types of vehicles, particularly in the rapidly growing EV and HEV segments. The product offerings are extensive, including power management ICs, DC-DC converters, discrete power transistors, and Insulated Gate Bipolar Transistors (IGBTs). There is a clear industry wide investment in advanced wide bandgap semiconductor materials, such as Silicon Carbide and Gallium Nitride, which offer superior efficiency for high voltage applications like EV powertrains, on board chargers, and battery management systems (BMS) [22], [23], [24], [25].

Advanced Driver Assistance Systems (ADAS) and Sensing:

To support the progression toward higher levels of vehicle autonomy, these companies offer a broad suite of intelligent sensing technologies. This category is critical for enabling a vehicle to perceive its environment and includes a wide variety of sensors. Key products include radar systems and sensors, such as NXP’s integrated 77GHz solutions, as well as image sensors, pressure sensors, and magnetic sensors that are foundational to features like adaptive cruise control, lane departure warnings, and blind spot detection [21], [23], [24], [25].

In-Vehicle Networking and Connectivity:

Modern vehicle architectures rely on robust communication networks to connect dozens of ECUs. The semiconductor firms provide a range of transceivers and controllers for established protocols like Controller Area Network (CAN) and Local Interconnect Network (LIN), as well as for higher bandwidth standards such as automotive Ethernet and FlexRay. Furthermore, enhancing vehicle connectivity for safety and convenience is a priority, with offerings in secure car access technologies like Near-Field Communication (NFC) and Ultra-Wideband (UWB).

Secure communication, both within the vehicle and with external infrastructure, is supported by specialized security controllers and processors [21], [23], [25].

Cabin Experience and Comfort:
Finally, a significant portion of the product portfolios is dedicated to improving the in-vehicle experience for drivers and passengers. This includes semiconductors for infotainment and digital cluster systems, audio amplifiers, and controllers for advanced body electronics and lighting. These components enable high resolution displays, premium sound systems, and customizable interior lighting that are increasingly standard in new vehicles [21], [23], [25].

2.1.3. Key Players

Infineon Technologies: Infineon Technologies AG, a world leader in semiconductor solutions, aims to make life easier, safer, and greener through microelectronics. With approximately 58,000 employees, it uses a hybrid manufacturing model, combining in-house facilities and external partners for optimal capital use and flexibility. Its operations are structured into Automotive, Green Industrial Power, Power & Sensor Systems, and Connected Secure Systems segments. Infineon holds a world market leader position in automotive semiconductor solutions. It is a technological leader across the power semiconductor spectrum (Si, SiC, GaN chips) and seeks to enhance its global leadership in power systems and IoT solutions, driven by megatrends like decarbonisation and digitalisation. Its portfolio serves automotive, industrial, data centres (including AI), and specific consumer sectors. Products include power semiconductors, microcontrollers, analogue mixed-signal chips, sensors, RF products, and software for integrated solutions [23].

Infineon targets over 10% average annual revenue growth and a 25% average Segment Result Margin over the semiconductor cycle. It is committed to carbon neutrality by the end of fiscal 2030 and a 70% emission reduction by the end of 2025 (compared to 2019). In fiscal year 2024, revenue was €14.955 billion, an 8% decrease from the prior year. Segment Result was €3.105 billion (20.8% margin), and operating profit declined by 45% to €2.190 billion. A €0.35 per share dividend is proposed for 2024, maintaining consistency [23].

NXP Semiconductors: NXP Semiconductors N.V., incorporated in the Netherlands, operates as a single reportable segment with a hybrid manufacturing model. It is a well-known seasoned issuer and a large, accelerated filer. NXP's core expertise includes cryptography-security, high-speed interface, RF, mixed signal analog digital, power management, digital signal processing, and embedded system design. The Company focuses on automotive, industrial & IoT, mobile, and communication infrastructure markets, positioning itself with sustained competitive differentiation. NXP is a leader in automotive analog and interface products, including 77Ghz Radar for ADAS and battery management, and is a major supplier of high-performance RF amplifiers. Its products support Automotive (ADAS, engine management, secure car access), Industrial & IoT (factory/home automation, energy management, edge solutions), and Mobile (smartphones, wallet, UWB). Communication Infrastructure & Other includes secure edge ID (Identifier) and 5G radio power. NXP also offers Arm processors and semiconductor sensors [25].

NXP's strategy emphasizes deepening customer relationships and broadening reach to reduce sales volatility. The Company intends to sustain similar R&D (Research and development) investment levels in 2025. Acquisitions include Aviva Links ($242.5M), TTTeach Auto ($625M), and Kinara, Inc. ($307M). It invests in ventures like ESMC and VSMC to secure capacity, supported by subsidies through 2029. For fiscal 2024, revenue was $12,614M, down

5.0% from $13,276M in 2023, mainly due to an 11.3% fall in OEM/EMS sales, though distributor sales rose slightly. Net income was $2,510M in 2024. Cash stood at $3,292M and debt at $10,920M as of December 31, 2024 [25].

STMicroelectronics: STMicroelectronics N.V. (STM), incorporated in the Netherlands, is a global semiconductor group that designs, develops, manufactures, and markets a wide range of products for automotive, industrial, personal electronics, and communications equipment. STM operates under a matrix structure combining geographic regions with product lines, supported by shared technology and manufacturing. Its strategy emphasizes long-term value creation through Smart Mobility, Power & Energy, and Cloud Connected Autonomous Things. STM serves a broad customer base, especially in industrial markets, with a wide portfolio, while maintaining a selective approach in personal electronics and communications. Its offerings include discrete components, Application Specific Integrated Circuits (ASICs), and Application Specific Standard Products (ASSPs) across analog, digital, and mixed signal applications, leveraging technologies such as Complementary Metal-Oxide-Semiconductor (CMOS), Fully Depleted Silicon on Insulator (FD-SOI), SiC, GaN, and Micro-Electric-Mechanical System (MEMS). Reportable segments include Analog, MEMS & Sensors, Power & Discrete (P&D), Microcontrollers, and Digital & RF (D&RF). ST also engages in smartcard product manufacturing [21].

STM invests heavily in market driven R&D, spending about 10.1% of revenues in 2023. In Q1 2024, it introduced a new application specific marketing organization to strengthen end market customer focus. The Company targets carbon neutrality by 2027 for Scope 1 and 2, and partially Scope 3 emissions. It also launched a $1,100M share buyback program over three years. For First Half (H1) 2024, revenues were $6,697M, down 21.9% from $8,573M in H1 2023. Net profit was $1,126M, compared to $1,726M in H1 2023. Free Cash Flow stood at $25M versus $416M in H1 2023. As of June 29, 2024, total financial debt was $2,973M [21].

Texas Instruments: Texas Instruments (TI), established in 1930 and headquartered in Dallas, Texas, designs and manufactures semiconductors globally. Its core focus is analog and embedded processing products. TI largely conducts in-house manufacturing, concentrating on 300mm wafer capacity to achieve lower costs and enhance supply chain control. TI strategically emphasises the industrial and automotive markets, which constituted about 70% of its revenue in 2024, identifying them as key growth drivers. Serving over 100,000 customers, TI's strong market channel reach is highlighted by approximately 80% direct sales in 2024 [22].

TI boasts a comprehensive portfolio of over 80,000 products, including analog semiconductors for signal processing and power management, and embedded processors for data handling. Its R&D efforts lead to the annual introduction of hundreds of new products. TI's primary objective is long term growth of free cash flow per share. This is supported by a multiyear elevated capital expenditure cycle focused on building dependable 300mm capacity and improving efficiency. In 2024, TI reported revenue of $15.64 billion, a 10.7% decrease from $17.519 billion in 2023. Gross profit declined by 17.5% to $9.09 billion due to lower revenue and increased manufacturing costs. Despite this, TI increased its dividend by 5% in 2024, maintaining its commitment to shareholders [22].

ON Semiconductor: ON Semiconductor Corporation, operating as ONSemi, was incorporated in Delaware in 1992. It provides intelligent power and sensing solutions, with a primary focus on automotive and industrial markets. As of December 31, 2024, ONSemi operates through three reportable segments: Power Solutions Group (PSG), Analog and Mixed-Signal Group

(AMG), and Intelligent Sensing Group (ISG). The Company employs a hybrid manufacturing model, using both internal facilities and third-party contractors. Its strategy centres on profitable revenue growth by leveraging megatrends in automotive and industrial sectors, supported by technical expertise and strong customer relationships. ONSemi's intelligent power solutions enhance efficiencies, benefiting EV ranges and system costs. The PSG portfolio supports AI/data centre power, automotive electrification, and sustainable energy, featuring Wide Band Gap (WBG) MOSFETs, Silicon Carbide, and IGBTs. ISG products include CMOS image sensors, Single-Photon Avalanche Diode, and Short-Wave Infrared for industrial and automotive applications [24].

The Company emphasizes innovation in AI data centres, EV electrification, and sustainable energy, with significant investments in SiC manufacturing, including the 2025 acquisition of SiC Junction Field Effect Transistor technology. ONSemi targets net zero emissions by 2040. In 2024, it continued business realignment under the "Fab Right" strategy and repurchased 9.1M shares for $650M. For fiscal 2024, revenue was $7,082.3M, down 14.2% from $8,253.0M in 2023, due to weaker automotive and industrial demand. Distributor sales represented 53% of revenue. Net income was $1,572.8M. As of December 31, 2024, cash stood at $2,691.3M and total debt at $3,379.9M [24].

2.1.4. Current Market Size and Research Calculation

According to Infineon Technologies' Q2 2025 (March 2025) investor presentation, the total automotive semiconductor market size in 2024 was reported as USD 64.8 billion. The presentation also disclosed the market shares of the top five automotive semiconductor suppliers, namely Infineon Technologies, NXP Semiconductors, STMicroelectronics, Texas Instruments, and Renesas Electronics [26].

Renesas Electronics was not included in this research because its publicly available financial reports present revenue only in Japanese Yen (JPY) and do not provide the corresponding USD exchange rates. This limitation prevents consistent comparison with other suppliers. Instead, ON Semiconductor (ON Semi) was included in the analysis as an alternative, given that it holds a market share similar as Renesas in the automotive semiconductor domain.

Calculation of 2024 Automotive Semiconductor Market Size: The market size was derived using Infineon's 2024 automotive semiconductor revenue and its reported market share, as follows:

$$Total\ Market\ Size\ = \frac{Infineon\ 2024\ Automotive\ Revenue}{Infineon\ 2024\ Market\ Share}$$

$$Total\ Market\ Size\ = \frac{8{,}760\ Millions\ USD}{13.5\ \%}$$

$$Total\ Market\ Size\ =\ 64.88\ Billions\ USD$$

By applying the above equation in reverse to total market share (47.31%, Table 1) of considered 5 Companies, the total market size will be estimated based on the forecasted results.

Calculation of ON Semiconductor Market Share: The market share of ON Semi was derived by dividing its 2024 automotive semiconductor revenue by the calculated total market size:

$$ONSemi\ Market\ Share\ = \frac{ONSemi\ 2024\ Automotive\ Revenue}{Total\ Automot\ Market\ Size\ (2024)}$$

$$ONSemi\ Market\ Share\ = \frac{3{,}900.8\ Millions\ USD}{64{,}888.8\ Millions\ USD}$$

$$ONSEMI\ Market\ Share\ =\ 6.01\ \%$$

Automotive Semiconductor Market Shares (2024):

Company Name	Market Share (%)
Infineon Technologies	13.5
NXP Semiconductors	10.5
STMicroelectronics	8.8
Texas Instruments	8.5
ON Semiconductor	6.01
Total (Top 5)	**47.31**

Table 1: Automotive Semiconductor Market Share by Company, 2024

2.1.5. Challenges and Volatility

Despite its robust growth trajectory, the global automotive semiconductor market is characterized by significant challenges and inherent volatility. The most impactful recent disruption was the 2020-2023 global chip shortage, which impacted over 169 industries worldwide, with the automotive sector being among the most severely impacted [8], [9], [14]. This crisis was a "perfect storm" resulting from a confluence of factors: the COVID-19 pandemic disrupting global supply chains and leading to factory closures, a sudden surge in demand for consumer electronics due to remote work and digital lifestyles, and unforeseen events such as the Texas winter storm Uri in February 2021 and a fire at Japanese manufacturer Nittobo in July 2020 [8], [14].

The consequences for the global automotive industry were profound, leading to unprecedented production halts, significant delays, and substantial lost revenue [14]. The global automotive industry was projected to lose US$210 billion in revenue in 2021 alone due to the chip shortage. Major automakers worldwide were forced to scale back production or temporarily halt assembly lines, unable to meet consumer demand for new vehicles, which led to depleted inventories at dealerships [14]. The shortage primarily affected advanced features in vehicles, such as infotainment systems, driver assistance technologies, and engine management systems, all of which heavily rely on semiconductor components [14].

This crisis exposed critical vulnerabilities in global supply chains, particularly the fragility of just-in-time manufacturing practices, which proved inadequate when faced with widespread disruptions [10]. The complexity of automotive supply chains meant that disruptions at one stage had cascading effects, impacting suppliers, subcontractors, and ultimately the end consumer. As a direct lesson, companies are now signing long-term contracts with semiconductor suppliers to ensure consistent supply and are exploring localization efforts to build more resilient supply chains [10].

Beyond supply chain disruptions, the rising cost of integrating advanced semiconductors creates a critical balance for automakers between innovation and affordability, impacting overall vehicle production costs [10]. Geopolitical factors and potential tariffs on semiconductors also pose a considerable cost challenge. For instance, proposed 25% tariffs on certain imported semiconductors could add significant costs per vehicle (estimated at around $200 per US vehicle if broadly applied, or $65-$70 effectively), disrupting cost structures and sourcing strategies for OEMs and potentially leading to higher consumer prices [27]. These factors contribute to the inherent volatility of the automotive semiconductor market [7], necessitating robust and adaptable forecasting and its methodology.

2.2. The Impact of External Global Variables

This section reviews existing literature on the influence of the four selected global variables on the automotive semiconductor market, providing academic justification for their inclusion in the SARIMAX model. Each variable represents a critical external factor that can significantly impact on the market's dynamics, beyond historical trends.

2.2.1. BEV Sales

Electromobility, encompassing battery electric vehicles and hybrid electric vehicles, is consistently identified as a key driver of increased semiconductor demand per vehicle [22], [23], [24], [25]. These vehicles, along with software defined vehicle architectures, significantly increase the value and number of semiconductors installed in each vehicle [23].

The global adoption rate of BEVs is a profound and direct driver of demand for automotive semiconductors. As the world transitions towards sustainable transportation, EVs require significantly higher semiconductor content typically two to three times more chips than traditional ICE vehicles. This increased demand is not merely additive but stems from the fundamental architectural differences of EVs, which rely extensively on electronic systems for propulsion, power management, and connectivity [1], [2], [3], [10].

The impact of global BEV sales on the semiconductor market is multifaceted:

- Increased Power Semiconductor Demand: EVs necessitate robust power semiconductors (e.g., SiC, GaN) for efficient charging, energy conversion, and motor control, accounting for 30-40% of total automotive semiconductor demand [1], [10].
- Battery Management Systems (BMS): Sophisticated electronic systems are required to monitor and optimize battery health, ensuring longevity and safety [5].
- Advanced Features: The integration of ADAS and infotainment systems, which are prevalent in EVs, further drives demand for high-performance computing chips, memory, and sensors [1], [10].

Global EV sales were projected to reach approximately 20 million units in Q1 2025, marking a 17% increase over the previous year [2], [3], [13]. This accelerating global growth, fueled by government incentives, advancements in battery technology, expanding charging infrastructure, and lower long-term ownership costs, directly translates into a surging demand for automotive semiconductors [1][2]. Therefore, global BEV sales serve as a critical exogenous variable, reflecting a fundamental shift in vehicle architecture and a direct indicator of semiconductor consumption.

2.2.2. G20 GDP

Global economic growth is a fundamental determinant of the worldwide semiconductor market [23]. Downturns or volatility in general economic conditions directly translates to fluctuations in demand for end user products that incorporate semiconductors [22], [24], [25].

The automotive industry is widely recognized as a critical driver of macroeconomic growth, stability, and technological advancement, with its performance closely linked to overall economic conditions, particularly Gross Domestic Product [28]. As a cyclical industry, the sector is highly sensitive to economic fluctuations, with multiple studies establishing a strong and positive relationship between GDP growth and vehicle sales [19], [28]. For example, a 2-3% change in GDP can lead to approximately a 25% change in car sales [19]. Empirical evidence supports this: Dynaquest (2002) identified a close relationship between new car sales and nominal GDP, while Smith and Chen (2009) found that growth in U.S. vehicle sales typically requires GDP growth of at least 3% [28]. Similarly, Babatsou and Zervas (2011) observed a high linear correlation between GDP and passenger car sales in the European Union, and Kongsberg Automotive (2008) confirmed strong global correlations between GDP and car sales. Furthermore, in a study of top automobile producing nations, a 100% rise in GDP was found to generate a 26.95% increase in automobile sales, assuming constant conditions [28].

This GDP automobile sales link has significant implications for the automotive semiconductor market. As semiconductors are indispensable in modern vehicles, rising car sales inevitably translate into increased semiconductor demand. Economic prosperity not only boosts consumer purchasing power and willingness to invest in vehicles but also drives the adoption of advanced electronic systems, thereby raising semiconductor content per car [19]. In this context, global GDP serves as an essential exogenous factor shaping automotive semiconductor demand. However, evidence also suggests that while global car production leads to semiconductor sales by roughly three months, other macroeconomic and technological variables may better capture the sector's cyclical dynamics, indicating that the relationship, though strong, is not entirely linear [19].

The G20 comprises the world's largest economies, accounting for roughly 85% of global GDP, 75% of international trade, and approximately two-thirds of the global population. Its aggregate economic performance provides a useful proxy for broad global demand conditions. Accordingly, the G20 GDP growth rate is included in this study as an exogenous variable [29].

2.2.3. Global Financial Stress Index

Periods of global financial stress, characterised by increased volatility, instability, and unfavourable economic conditions, make it difficult to forecast demand trends [25]. It can lead to uncertainty in global financial markets, affecting access to capital and investment decisions [22], [24].

The Global Financial Stress Index (FSI) is a vital indicator of market uncertainty and systemic financial stress, which can significantly impact various economic sectors, including technology and consumer spending. The Office of Financial Research Financial Stress Index (OFR FSI), for example, provides a daily market-based snapshot of stress in global financial markets, constructed from 33 financial market variables such as yield spreads, valuation measures, and interest rates [9]. A positive OFR FSI indicates above average stress levels, reflecting disruptions in the normal functioning of financial markets [9].

Academic literature demonstrates that a positive shock on a financial stress index translates into a negative effect on stock market performance, which can subsequently dampen consumer confidence and investment in durable goods like vehicles [19]. Financial crises, often preceded or accompanied by elevated stress indices, are associated with protracted economic recoveries. For the automotive semiconductor market, heightened global financial stress can lead to:

- Reduced Consumer Spending: Consumers become more cautious with discretionary spending, delaying or foregoing new vehicle purchases [30].

- Tightened Credit Conditions: Financial stress can lead to higher borrowing costs for both consumers and automakers, impacting sales and production [31].
- Investment Uncertainty: Automakers and semiconductor suppliers may delay investments in new technologies or production capacity due to market instability [32].

Therefore, the Global Financial Stress Index serves as a critical exogenous variable, capturing the broader financial market sentiment and its potential to introduce volatility and uncertainty into the global automotive and semiconductor supply chains.

2.2.4. Polysilicon Price

Polysilicon, a highly purified form of silicon, is a fundamental material for electronic-grade semiconductors, essential for microchips, transistors, and sensors used in the automotive sector. Achieving purity levels exceeding 99.9999% is critical for these applications [33].

By the end of 2023, China had become the dominant global producer of polysilicon, accounting for approximately 93% of the global effective production capacity and over 90% of the output [34]. This market dominance is largely attributable to significant advantages Chinese manufacturers hold in raw materials, electricity, and labor costs, along with substantial domestic demand from downstream silicon wafer manufacturing. In contrast, overseas polysilicon production in regions such as Germany, the United States, and Malaysia has experienced slower growth due to factors like electricity restrictions and high electricity costs [34].

Historically characterized by a "pork cycle" of shortage and oversupply driven by semiconductor demand, the polysilicon market's dynamics have shifted. With the solar industry now a major consumer, China's rapid expansion has led to a new paradigm of sustained oversupply, though occasionally interrupted by brief shortages [35]. Polysilicon prices exhibit regional variations; for instance, in August 2025, the mainstream price in North America was US$24.19/KG, while in Northeast Asia it was US$5.64/KG [33]. These prices are influenced by immediate cost drivers, underlying feedstocks, market futures, and current supply/demand imbalances [33].

For the automotive sector, which constituted 14% of the $574 billion global semiconductor market in 2022, polysilicon price fluctuations have a profound impact [36]. Increases in polysilicon prices directly translate into higher manufacturing costs for silicon wafers and, consequently, for all automotive semiconductor components, including integrated circuits, microchips, and sensors [33]. This can affect the overall production costs for vehicles and potentially influence consumer prices. Furthermore, China's near monopoly in polysilicon production introduces significant supply chain vulnerabilities and geopolitical risks, as highlighted by regulations such as the Uyghur Forced Labor Prevention Act, which has created a separate, higher priced market segment for non-Chinese polysilicon [35]. This concentration poses a risk of price volatility and supply disruptions. That is why an exogenous variable which drive the raw material supply is essential to be taken in consideration for the automotive semiconductor market forecast.

2.3. Forecasting Methodologies

This section provides an overview of common forecasting models and justifies the selection of SARIMA and SARIMAX as the most appropriate methodologies for this research, particularly given the characteristics of the automotive semiconductor market data and the influence of external global variables.

2.3.1. Overview of Forecasting Models

Forecasting is a technique for predicting the future based on historical data, involving detailed analysis of past and present trends to anticipate future events and help enterprises prepare for uncertainty. It fundamentally considers the temporal dimension using time series data [37].

Forecasting methods are broadly categorised. Qualitative techniques are subjective, relying on expert opinions, especially when historical data is unavailable for moderate or long-term decisions [37]. Time Series Analysis include exponential smoothing e.g. Holt-Winters, ARIMA models, VAR & BVAR model, and state space models, which utilise recursive schemes [38]. Nonlinear and Nonparametric Forecasts, such as threshold models and kernel density estimation, capture more complex data structures. Increasingly, Machine Learning (ML) methods like Artificial Neural Networks, Random Forest, and Gradient Boosting are employed, demonstrating superior accuracy in detecting intricate patterns in recent competitions [38]. Causal models also constitute a type of forecasting method [37].

The previous studies, such as by Chow and Choy (2006) [39], indicate that the most appropriate forecasting method to predict semiconductor sales for a time horizon of 7 to 12 months is the Bayesian Vector Autoregression (BVAR) model. Other research by Tom Winter [19], suggest that seasonal ARIMA model was found to outperform the other used forecasting model for semiconductor market forecast.

BVAR and ARIMA are the time series analysis model, rely on historical data to generate forecasts. In this study, both approaches were applied and evaluated. The results indicate that the Seasonal ARIMA (SARIMA) model is more appropriate for this research context, primarily because the dataset employed was not sufficiently large to support the effective implementation of the BVAR model. Therefore, the SARIMA model will be employed for forecasting.

2.3.2. The Case for SARIMA

Historically, the semiconductor industry followed a four-year cycle, characterised by a sharp down cycle and a long up cycle, with all parts of the supply chain typically conforming to this pattern [40].

The Seasonal Autoregressive Integrated Moving Average (SARIMA) model is a highly suitable choice for forecasting time series data that exhibits pronounced seasonality [41]. SARIMA extends the traditional ARIMA model by explicitly incorporating seasonal autoregressive, differencing, and moving average components [41]. This capability allows SARIMA to capture both short term dependencies and long-term periodic fluctuations, which ARIMA models often fail to encapsulate adequately, thereby compromising forecasting accuracy in seasonal contexts [41]. By modelling seasonal lags, SARIMA achieves greater stationarity and reduces residual errors, leading to improved forecast accuracy and reliability. Furthermore, SARIMA models are generally easy to understand and interpret, with fewer hyperparameters, making them robust for time series analysis [41]. This makes SARIMA an ideal baseline model for capturing the inherent seasonal patterns in the automotive semiconductor market's financial data.

2.3.3. The Case for SARIMAX

While SARIMA effectively handles seasonality, real world time series data, particularly in dynamic markets like automotive semiconductors. While the market is often influenced by external factors. This is where the SARIMAX (Seasonal Autoregressive Integrated Moving Average with eXogenous variables) model offers a significant advantage [42]. SARIMAX is an extension of SARIMA that explicitly incorporates exogenous variables external factors that affect the time series but are not part of the series itself [42], [43].

The inclusion of these external global variables (BEV Sales, G20 GDP, Global Financial Stress Index, and Polysilicon Price) allows SARIMAX to capture more complex patterns in the data, leading to improved forecasting accuracy and a better understanding of the underlying market dynamics [44]. SARIMAX offers increased flexibility, capable of handling a wide range of continuous and categorical exogenous variables[44]. Academic studies have demonstrated that SARIMAX models yield better forecasts compared to traditional SARIMA and other models in various applications, including sales and economic forecasting, by effectively leveraging external information [42], [43].

Moreover, SARIMAX models are particularly suitable for scenarios involving smaller datasets, as they can effectively leverage the available information from exogenous variables to enhance predictive performance and realism, even when the primary time series data might be limited. This makes SARIMAX exceptionally well suited for forecasting the automotive semiconductor market, where external global variables play a critical and quantifiable role in shaping demand and supply, and where the robustness of the model with potentially smaller datasets is a key consideration.

3. Methodology

This chapter details the methodological framework used to forecast the global automotive semiconductor market. It outlines the process of data collection and preparation, provides a detailed description of the chosen forecasting models, and explains how external global variables were integrated into the analysis. This methodology is designed to provide a transparent and replicable approach for addressing the research questions outlined in Chapter 1.3.

3.1. Data Collection

Each dataset used in this research is open source and publicly available, none of this data has been bought or purchased from any company or provider. All automotive revenue figures used in this research are expressed in USD for consistency and comparability across companies. The units of measurement for the external variables employed in the analysis are described in detail in Chapter 3.1.2 of this report. In this research, the symbol $ is used to denote the United States Dollar (USD).

Values obtained through manual transcription underwent independent dual review; the same validation procedures were applied consistently across all datasets. For transparency and reproducibility, all data used in this research on whether company financials or external variables were stored together with their original source documents, source URLs, and access dates in the Reference Chapter and in Project Repository. Both raw and processed datasets, along with extraction metadata and source files, are archived to facilitate auditing, verification, and full replication of the research.

3.1.1. Semiconductor Companies

Infineon Technologies: Quarterly automotive segment revenue for Infineon Technologies AG was collected manually from the company's official quarterly Financial Reports & Presentations webpages [45]. The extracted series covers every quarter from Q1 2009 through Q1 2025. For each quarter the automotive revenue figure was transcribed exactly as published (reported currency: EUR; reported units as stated in the source).

Infineon reports its automotive segment figures in EUR, to enable cross company comparability the reported EUR values were converted to USD using a quarter specific, firm level exchange rate estimated from parallel revenue observations from Macrotrends [46]. Specifically, for each Quarter (q) the effective Exchange Rate (ERq) was computed as:

$$ER_q = \frac{Infineon\_Revenue_{USDq}(From\ Macrotrends)}{Infineon\_Revenue_{EURq}(From\ Infineon)}$$

And the converted Automotive Revenue in USD was calculated as:

$$Automotive\_Revenue\_USDq = Automotive\_Revenue\_EURq * ERq$$

This firm level parallel reporting method uses Infineon's own quarterly figures to calculate the EUR→USD conversion rate, instead of relying on a single daily market rate. Because companies aggregate sales over a quarter and may apply internal translation rules or rounding, a quarter specific rate better reflects the currency basis used in Infineon's reports and reduces mismatches caused by intra quarter timing differences. For transparency and reproducibility, both the original EUR values and the converted USD values were kept in the dataset. Appendix A presents the historical time-series data of Infineon Technologies' automotive revenue.

NXP Semiconductors: Quarterly automotive segment revenue for NXP Semiconductors was obtained directly from the company's official Financial Results webpage [47]. The dataset comprises every quarterly financial release that reports the Automotive segment from Q1 2010 through Q1 2025. Because NXP reports its segment revenues in USD, the collected figures were transcribed and recorded without currency conversion, the original reported USD values were preserved as the canonical series for subsequent analysis. Appendix A presents the historical time-series data of NXP Semiconductors' automotive revenue.

STMicroelectronics: Quarterly automotive segment revenue for STMicroelectronics (STM) was collected from the company's official Quarterly Releases webpages [48]. The extracted series spans Q1 2011 through Q1 2025. STM did not make available official quarterly automotive figures for Q1 2009-Q4 2010, therefore those quarters are omitted from the STM series used in this study. During the observation window STM revised its segment reporting several times. To preserve focus on the automotive market, the following segment labels and timeframes were used to extract comparable automotive revenue figures (as reported by STM earnings release) for this research:

- Q1 2011 - Q3 2015: Automotive Product Group (APG)
- Q4 2015 - Q2 2023: Automotive and Discrete Group (ADG)
- Q3 2023 - Q1 2025: Microcontrollers, Digital ICs and RF products (MDRF)

Where segment names changed, revenue series were aligned by matching the product descriptions and disclosure notes that explicitly reference automotive applications. Appendix A presents the historical time-series data of STMicroelectronics' automotive revenue.

Texas Instruments: Quarterly revenue data for Texas Instruments Incorporated (TI) were obtained from the company's official Earnings Releases and Annual Reports available on the TI investor relations website [49]. The dataset covers every fiscal quarter from Q1 2009 through Q1 2025. Unlike several peer firms, TI does not report a discrete "Automotive" segment on a quarterly basis. Instead, TI discloses revenue by End-Market in its annual Form 10-K / annual report, where the automotive end-market is reported as a percentage share of total revenue for the fiscal year. To derive quarterly automotive revenue series consistent with the remainder of this study, the annual automotive percentage was applied to each quarterly total within the corresponding fiscal year. Formally, for quarter (q) falling in fiscal year (y):

$$Automotive\_Revenue_q = Tota\_Revenue_q * Automotive\_Pet_y$$

Where $Total\_Revenue_q$ is TI'S reported total revenue for quarter (q), and $Automotive\_Pet_y$ is the automotive end-market percentage reported in the annual filings for year (y).

All quarter-level total revenues were transcribed from TI's quarterly earnings releases and recorded in USD as published. The annual automotive percentages were transcribed from TI's annual report (Form 10-K) [49]. Appendix A presents the historical time-series data of Texas Instruments' automotive revenue.

ON Semiconductors: Quarterly automotive revenue for ON Semiconductor Corporation (ON Semi) was extracted from the company's official Financials Investor Relations webpage [50], specifically from the quarterly Form 10-Q SEC (U.S. Securities and Exchange Commission) filings and accompanying earnings releases. Each 10-Q report provides revenue broken down by end-market in USD, which enabled direct transcription of the automotive end-market figures without currency conversion. The assembled series covers Q4 2010 through Q1 2025; ON Semi did not publish (or did not make publicly accessible) end-market breakdowns for the earlier quarters Q1 2009-Q2 2010, and those periods are therefore excluded from the ON Semi time series used in this study. Appendix A presents the historical time-series data of ON Semiconductors' automotive revenue.

3.1.2. Global Variables

BEV Sales: Quarterly BEV sales were obtained from the Open EV Charts Beta project [51], an open source initiative that aggregates passenger car sales and registration statistics from multiple countries to monitor EV adoption [52]. The dataset includes country level and an aggregated global series and covers sales volumes (number of BEVs sold) at a quarterly frequency from Q1 2017 through Q1 2025. Because the project explicitly reports both individual country time series (22 countries) and a consolidated global series, the global quarterly BEV sales series was used directly as the primary exogenous indicator in this study. Appendix B.1 presents the historical time-series data for BEV Sales.

G20 GDP: The exogenous macroeconomic indicator used in this study is the year-over-year quarterly growth rate of aggregate G20 gross domestic product. The series expressed as a percentage change relative to the same quarter in the prior year. It was obtained from the Organization for Economic Co-operation and Development (OECD) database [53]. The data set covers the period Q1 2009 through Q1 2025 and was downloaded in its published quarterly form [53]. This variable was selected to capture broad global demand conditions that affect vehicle production and, by extension, the demand for automotive semiconductors. Appendix B.2 presents the historical time-series data of G20 GDP.

Global Financial Stress Index: The Financial Stress Index (FSI) produced by the U.S. Department of the Treasury's Office of Financial Research (OFR) is a daily, market based measure of stress in global financial markets constructed from 33 financial market variables, positive values indicate above average stress, and negative values indicate below average stress. The index also reports stress contributions by three regions: the United States, other advanced economies, and emerging markets [54]. For this study, the daily average OFR FSI was exported for the period 1 January 2009 - 30 Jun 2025 [54], and the daily series was converted to quarterly frequency by computing the three month average for each calendar quarter. The analysis therefore uses the quarter level FSI series from Q1 2009 through Q1 2025. Appendix B.3 presents the historical time-series data of FSI.

Polysilicon Price: The polysilicon price index was incorporated in this study as an external variable. Price data were manually extracted from Business Analytiq [55], for the period Q1 2018 through Q1 2026. The source provides quarterly polysilicon prices for three regions: United States, Europe and China, with all values reported in USD per kilogram (USD/kg). Although China accounts for the majority share of global polysilicon production (≈93%) [34], individual buyers typically source from multiple regions and suppliers. Therefore, to reflect a pragmatic market price input for the model, this research uses the arithmetic mean of the three regional prices as the polysilicon price series. Appendix B.4 presents the historical time-series data of Polysilicon Price.

3.2. Model Description

3.2.1. SARIMA

The Seasonal Autoregressive Integrated Moving Average (SARIMA) model was selected as the foundational methodology for this study due to its proven effectiveness in forecasting time series data that exhibits both trend and seasonality. SARIMA is an extension of the ARIMA model, specifically designed to capture and model periodic fluctuations within the data.

The model is formally denoted as SARIMA$(p, d, q)(P, D, Q)m$, where:

- (p, d, q) represents the non-seasonal components:

  p: The order of the Autoregressive (AR) component.

  d: The degree of non-seasonal differencing required to achieve stationarity.

  q: The order of the Moving Average (MA) component.

- $(P, D, Q)m$ represents the seasonal components:

  P: The order of the Seasonal Autoregressive (SAR) component.

  D: The degree of seasonal differencing required to achieve stationarity.

  Q: The order of the Seasonal Moving Average (SMA) component.

- m: The length of the seasonal period

The general mathematical equation for the SARIMA model [56] can be expressed compactly using the backshift operator (B), where $By_t = y_t - 1$:

$$\phi_p(B)\Phi_P(B^m)(1-B)^d(1-B^m)^D y_t = \theta_q(B)\Theta_Q(B^m)\epsilon_t$$

Here, $\phi_p(B)$ and $\Phi_P(B^m)$ are the non-seasonal and seasonal AR polynomials, respectively, while $\theta_q(B)$ and $\Theta_Q(B^m)$ are the non-seasonal and seasonal MA polynomials. The terms $(1-B)^d$ and $(1-B^m)^D$ represent the differencing operations, y_t is value of variable (y) at time (t), and ϵ_t is the white noise error term.

While this standard equation provides theoretical basis, the practical implementation for this thesis involved a specialized computational framework designed to robustly handle the specific characteristics of the automotive semiconductor market's financial data. This framework automates several key steps, including data pre-processing, hyperparameter optimization, and adaptive modeling to ensure the most accurate forecast possible. The process is detailed below.

1. Data Pre-processing and Imputation

Real-world financial data often contains missing values. To address this, a sophisticated imputation technique based on seasonal decomposition was implemented. Instead of simple interpolation, which can ignore underlying patterns, missing data points were filled using values reconstructed from the series' trend and seasonal components. This method preserves the inherent structure of the data, providing a more reliable basis for the model. The process involves:

1. Temporarily filling gaps using linear interpolation.
2. Applying an additive seasonal decomposition to this temporary series to isolate its trend and seasonal elements.

3. Reconstructing a smoothed series from the trend and seasonality.
4. Using the values from this reconstructed series to fill the original missing data points.

2. Hyperparameter Optimization and Model Selection

A key challenge in time series forecasting is selecting the optimal model parameters $((p, d, q)(P, D, Q)m)$. To overcome this, an exhaustive grid search methodology was employed. The framework systematically iterates through a predefined range of values for each parameter to identify the combination that yields the most accurate forecast. Appendix C present the model parameters range employed in this research.

3. Performance Evaluation

The performance of each model configuration was evaluated based on its Root Mean Squared Error (RMSE), calculated as a percentage of the mean of the validation period. This ensures the selection of a model that is not only statistically sound but also practically significant.

RMSE calculates the square root of the average of the squared differences between the actual and predicted values [57]. This metric provides a measure of the average magnitude of the errors, with larger errors contributing more significantly due to the squaring effect [57]:

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \widehat{y_t})^2}$$

Where n represent the sample size, y_t is the actual value at time t, $\widehat{y_t}$ represent the forecasted value at time t, and $\sum$ denotes the sum over all observations from t=1 to n.

4. Adaptive Data Transformation

Financial time series often exhibit non-constant variance (heteroscedasticity), which can violate model assumptions and impair forecast accuracy. To mitigate this, the framework incorporates an adaptive, two-stage transformation approach:

Normalization: Initially, all-time series data is scaled to a range of [0, 1] using a Min-Max Scaler. This standardizes the data and often helps stabilize the model's training process.

Model Training: The model is designed to train itself in historical input data, enabling it to automatically learn the underlying patterns and dynamics of the time series. This adaptive approach improves the model’s ability to generate accurate forecasts by capturing both long-term trends and short-term fluctuations present in the historical record.

Conditional Log-Transformation Fallback: After running the full grid search on the scaled data, the best model's percentage RMSE is checked against a predefined threshold (25%). If the error is above this threshold and the series contains only positive values, it indicates that simple scaling was insufficient. In this case, the framework automatically initiates a second grid search, this time applying a logarithmic transformation to the data. Log-transform is a powerful technique for stabilizing variance. The final forecast is then converted back to its original scale via an exponential transformation.

This adaptive methodology ensures that a more potent transformation is applied only when necessary, creating a robust process that tailors the modeling approach to the specific statistical properties of each individual time series. This specialized SARIMA framework provides the foundation for the baseline forecast, which will be further enhanced by the inclusion of exogenous variables in the subsequent SARIMAX model.

3.2.2. SARIMAX

While the SARIMA model effectively captures historical patterns and seasonality, the automotive semiconductor market is strongly influenced by external macroeconomic and industry specific factors. To account for these dynamics and improve predictive accuracy, the model was extended to a Seasonal Autoregressive Integrated Moving Average with eXogenous Regressors (SARIMAX) framework. This advanced model enhances the SARIMA structure by integrating the explanatory power of external variables.

The mathematical formulation of the SARIMAX model builds upon the SARIMA equation by adding a term for the exogenous variable. For a single external variable x_t , the equation can be expressed as [57]:

$$\phi_p(B)\Phi_P(B^m)(1-B)^d(1-B^m)^D y_t = \boldsymbol{c} + ß x_t + \theta_q(B)\Theta_Q(B^m)\epsilon_t$$

Here, c is the interception of the regression model, x_t represents the value of exogenous variables at time t, and ß is its vector containing corresponding coefficient, which quantifies the variable's impact on the target series y_t.

The implementation of the SARIMAX model leveraged the same robust computational framework developed for the SARIMA analysis, including the decomposition-based imputation and adaptive log-transformation. However, several critical modifications were made to integrate the external variables and optimize the modeling process.

1. Integration and Alignment of Exogenous Data

A crucial step in the SARIMAX implementation is the precise temporal alignment of the external variables with the target time series. The framework was engineered to automatically load the exogenous data which includes both historical values and future projections and align it with the corresponding quarterly timestamps of the semiconductor revenue data. This ensures that the model is trained using the correct historical context and, critically, is provided with the required future values of the external variables to generate its forecast. Both the endogenous (target) and exogenous variables were scaled independently using a Min-Max Scaler to standardize their ranges without introducing data leakage.

2. Computationally Efficient Hyperparameter Tuning with Early Stopping

To enhance the efficiency of the hyperparameter grid search, an "early stopping" mechanism was introduced. While the framework still searches for the optimal model parameters by evaluating numerous combinations, it now incorporates a performance threshold (an RMSE of 10%). If a model configuration is found that meets or exceeds this accuracy target, the grid search is terminated immediately, and that model is selected. This optimization significantly reduces computational time without compromising the quality of the forecast, as it prevents the model from continuing an exhaustive search once a sufficiently accurate solution has been identified.

By incorporating these global variables and refining the optimization process, the SARIMAX model provides a more nuanced and contextually aware forecast. It moves beyond simple extrapolation of past trends to explain and quantify how external market forces contribute to the trajectory of the automotive semiconductor industry.

3.2.3. Integration of External Variables

To assess the predictive power of the selected global variables, each was individually integrated into the SARIMAX forecasting framework. A critical prerequisite for the SARIMAX model is that future values for all external variables must be provided for the full forecast horizon. This involved a distinct data preparation pipeline for each variable to create a complete quarterly time series encompassing both historical and future data points that could be synchronized with the semiconductor revenue data.

The automated framework was then used to generate a separate forecast for each of the four scenarios, allowing for a direct evaluation of each variable's impact. The specific preparation and integration steps for each variable are detailed below.

BEV Sales:
Source and Transformation: Quarterly global sales data for Battery Electric Vehicles (BEVs) was sourced from the Open EV Charts project [51]. The historical time series extended to Q1 2025. To prepare the data for the model, this series was extended by forecasting the subsequent four quarters using the specialized SARIMA model described previously.

Model Integration: The complete BEV sales series, including the forecasted values, was loaded into the framework. The model used the historical sales data as an explanatory variable during training and was provided with the corresponding future sales projections to generate the semiconductor market forecast. This variable is intended to capture the direct impact of vehicle electrification on semiconductor demand. Appendix B.1 presents the historical and forecasted time-series data for BEV Sales.

G20 GDP:
Source and Transformation: The year-over-year quarterly growth rate of the aggregate Gross Domestic Product (GDP) for the G20 nations was obtained from the Organization for Economic Co-operation and Development (OECD) database [53], with historical data available from Q1 2009 to Q1 2025. The series was extended by forecasting the next four quarters with the SARIMA framework.

Model Integration: This complete series was integrated to represent the influence of broad global economic health on the market. A positive GDP growth rate is hypothesized to correlate with higher consumer demand and industrial production, thereby increasing demand for automotive semiconductors. Appendix B.2 presents the historical and forecasted time-series data of G20 GDP.

Global Financial Stress Index (FSI):
Source and Transformation: The daily Financial Stress Index from the Office of Financial Research (OFR) was used as a measure of global market stability [54], with data available from Q1 2009 to Q2 2025. To align this high-frequency data with the quarterly revenue figures, the daily index values were aggregated by calculating the three-month arithmetic average for each calendar quarter. The resulting quarterly series was then extended by forecasting the next three quarters using the SARIMA model.

Model Integration: The resulting complete quarterly FSI series was fed into the SARIMAX model. This variable aims to capture the impact of financial market volatility and uncertainty on the automotive sector. Higher levels of financial stress are expected to have a dampening effect on market growth due to constrained investment and reduced consumer confidence. Appendix B.3 presents the historical and forecasted time-series data of FSI.

Polysilicon Price:
Source and Transformation: Quarterly price data for polysilicon, a critical raw material for semiconductor manufacturing, was sourced from Business Analytiq [55]. The source data included from Q1 2018 to future projections Q1 2026, covering the required forecast horizon. To create a representative global price index, the arithmetic mean of the prices from three major regions (United States, Europe, and China) was calculated for each quarter. As the necessary future values were already provided, no additional forecasting step was required for this variable.

Model Integration: The average quarterly polysilicon price was integrated as an indicator of supply-side cost pressures. Fluctuations in this variable are expected to influence the production costs and, ultimately, the pricing and supply dynamics of the automotive semiconductor market. The model was trained on historical prices to learn about this relationship and used the price forecasts provided to inform its predictions. Appendix B.4 presents the historical and forecasted time-series data of Polysilicon Price.

4. Result and Analysis

All subsequent values presented in further research refer to the total automotive revenue forecast derived from the combined results of the five companies: Infineon Technologies, NXP Semiconductors, STMicroelectronics, Texas Instruments, and ON Semiconductor.

4.1. Baseline Forecast (SARIMA)

The baseline forecast uses a Seasonal ARIMA model without any external variables, providing a point of reference for comparison. Figure 1 illustrates the SARIMA model's forecast from Q2 2025 through Q1 2026, along with the historical data up to Q1 2025. The baseline model captures the underlying trend and seasonality of the automotive semiconductor market, extrapolating recent patterns into the near future. Notably, the forecast suggests a moderation in growth: the projected revenue for Q2 2025 is $7.8078 billion, which then slightly declines to $7.3837 billion in Q3 2025. A modest uptick is observed in Q4 2025 forecast $7.586 billion, followed by a further dip to $7.0016 billion in Q1 2026. This pattern implies a possible seasonal effect, for example a typical year-end increase (Q4) and a weaker first quarter as well as an overall leveling off the previously rapid growth. In essence, the SARIMA baseline is projecting that after the strong expansion seen in recent years, the market may enter a plateau or slight correction in the coming year.

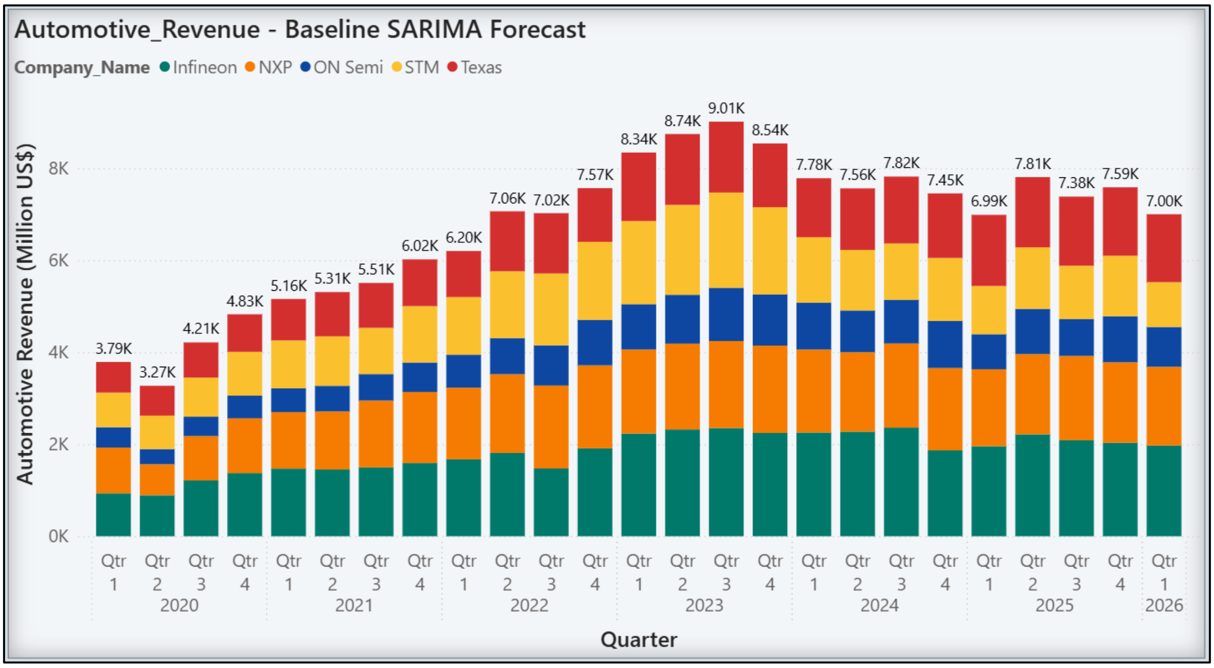

Figure 1: Baseline SARIMA Forecast

Overall, the baseline SARIMA forecast provides a benchmark, it reflects the expected trajectory of the automotive semiconductor market if current endogenous trends (trend, seasonality, and past values) continue without considering any external shocks or drivers. The slight decline in forecasted revenue by early 2026 could imply that the industry's post-pandemic surge and chip shortage boom is stabilizing. We will next examine whether incorporating external global variables can alter this outlook or improve forecast accuracy.

The company-level forecast results generated using the SARIMA baseline model are presented separately in Appendix D.

4.2. SARIMAX Forecasts

In this section, we introduce one global external variable at a time into the SARIMA model (thereby using a SARIMAX framework) and observe how each factor influences the forecast. Four key SARIMAX scenarios are presented here, each corresponding to one global variable. Figures 4.2 to 4.5 show the forecast results of these models (with each figure overlaying the historical data and the SARIMAX forecast). Below, we discuss each forecast in turn, focusing on how the inclusion of the external variable changes the predicted trajectory relative to the baseline and what it implies. The company-level forecast results generated using the SARIMAX model are presented separately in Appendix E.

4.2.1. Forecast with BEV Sales (SARIMAX - BEV Sales)

Battery Electric Vehicle (BEV) sales are included in this model as an exogenous predictor to capture the impact of EV adoption on semiconductor demand. Intuitively, higher BEV sales should drive higher demand for automotive semiconductors (since electric vehicles typically require more semiconductor content). The SARIMAX forecast for BEV sales is shown in Figure 2 Notably, the inclusion of BEV sales alters the forecast trajectory compared to the baseline. The model forecasts for Q2 2025 at $7.1416 billion, which is significantly lower than the baseline's $7.8078 billion for the same quarter. This suggests that given the state of BEV sales at Q2 2025, the model anticipates the semiconductor market starting at a more conservative level than the baseline did. One possible interpretation is that the baseline (relying only on past semiconductor sales) might have overestimated Q2, whereas incorporating actual BEV sales data corrected the forecast downward perhaps reflecting a temporary softness or slower-than-expected EV sales growth in that quarter.

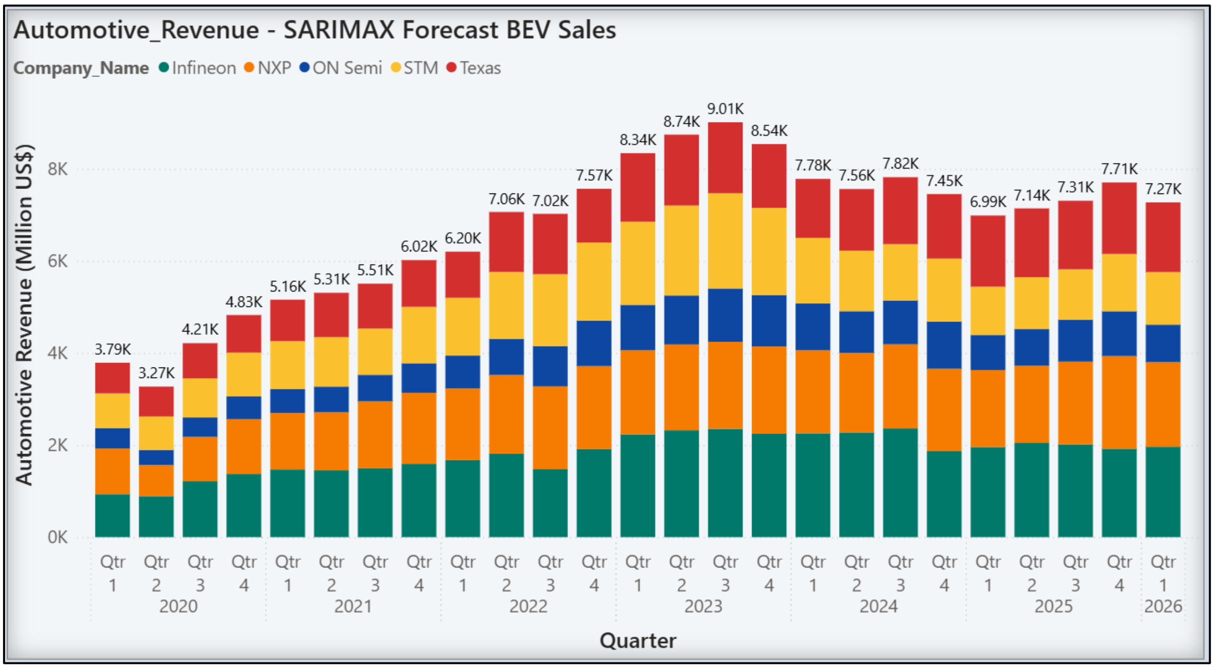

Figure 2: SARIMAX Forecast with BEV Sales

After Q2 2025, the BEV augmented forecast shows a rising trend, it projects $7.3078 billion in Q3 2025 and $7.7050 billion in Q4 2025. By Q4 2025, the BEV model's forecast $7.7050 billion slightly exceeds the baseline forecast ($7.5860 billion). This indicates that by the end of 2025, the model with BEV sales expects a stronger market than the baseline had predicted. The rationale could be that as EV adoption accelerates toward late 2025, the demand for automotive chips gets a boost beyond what the baseline trend alone would suggest. Finally, in Q1 2026, the BEV model forecasts $7.2721 billion, which remains above the baseline's $7.0016 billion for that quarter. In summary, including BEV sales leads to a forecast that starts lower but ends higher than the baseline forecast. The model implies a short-term dip followed by a faster recovery/growth, possibly mirroring an assumption that EV sales growth will translate into semiconductor revenue growth with a slight lag.

It's important to note that, while the BEV enhanced model changes the forecast shape, we must assess if it improved accuracy. As we will see from the comparative analysis (Section 4.3), this model's forecast errors were larger than the baseline's. This might mean that the BEV sales data, at least by itself, did not provide a straightforward predictive boost potentially due to delays in effect or other confounding factors. Nonetheless, qualitatively, this scenario highlights how strong EV adoption could drive a rebound in chip demand after an initial adjustment period.

4.2.2. Forecast with G20 GDP (SARIMAX - G20 GDP)

This SARIMAX model incorporates G20 GDP as an exogenous variable, representing the overall macroeconomic environment of major economies. The reasoning is that a strong global economy (higher GDP growth) generally supports greater automotive sales and indirectly higher demand for automotive semiconductors, whereas economic slowdowns would dampen demand. Figure 3 presents the forecast when G20 GDP is included.

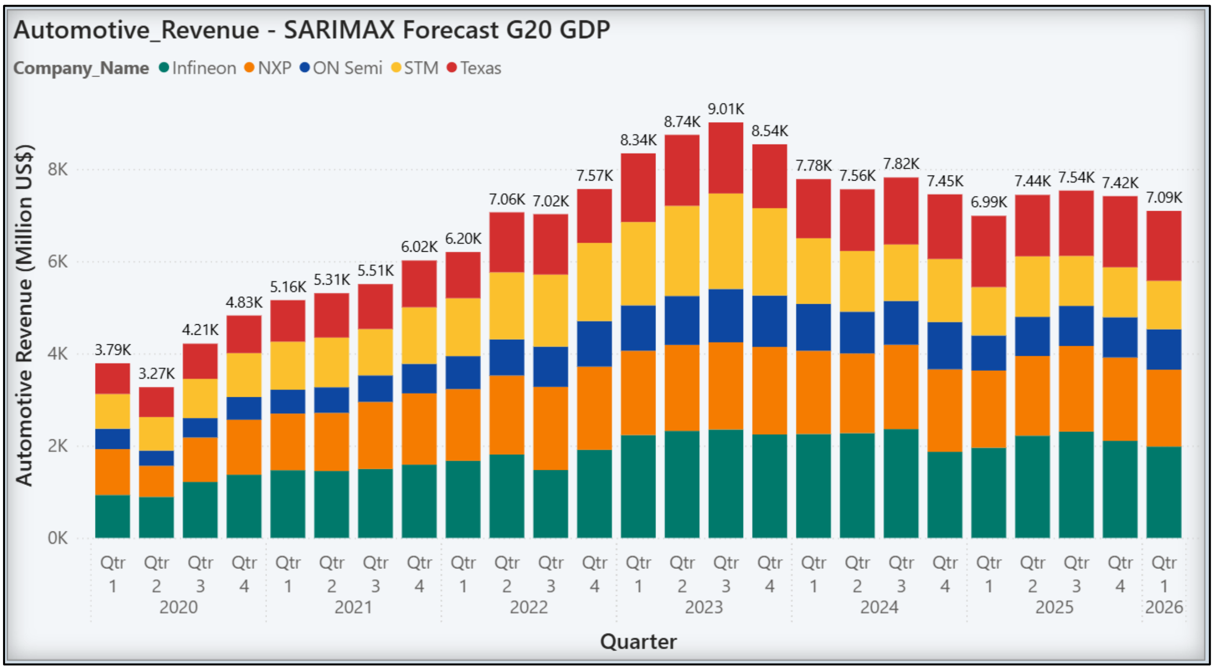

Figure 3: SARIMAX Forecast with G20 GDP

With G20 GDP in the model, the forecast is moderately adjusted relative to the baseline. The Q2 2025 forecast is $7.4418 billion, which is lower than the baseline's $7.8078 billion. This suggests that the model, informed by the state of global GDP, predicts a less exuberant immediate outlook possibly reflecting that economic indicators did not fully support the high growth the baseline projected for mid-2025. Interestingly, the Q3 2025 forecast rises to $7.5355 billion, slightly exceeding the baseline's Q3 forecast ($7.3837 billion). This indicates a more tempered decline and even a mild uptick going into Q3, implying that steady global economic growth might help sustain semiconductor revenues through the middle of 2025 better than the baseline expected.

Moving into the end of the year, the G20 GDP model forecasts \$7.4154 billion in Q4 2025, which is below the baseline's \$7.5860 billion for that quarter. This suggests the model does not predict as strong of a year-end bump as the baseline did, perhaps because the baseline's seasonal trend was optimistic whereas the GDP linked forecast remains cautious (if, for instance, global GDP growth forecasts for late 2025 are moderate). By Q1 2026, the SARIMAX with GDP predicts \$7.0949 billion, which is slightly above the baseline forecast of \$7.0016 billion for that quarter. Overall, the GDP informed forecast is smoother, it does not swing as high or as low as the baseline in any quarter. It implies that the macroeconomic context could stabilize the market trends, preventing both excessive surges and steep drops.

From a performance standpoint, G20 GDP had mixed results. The forecast differences are not as dramatic as with BEV sales, and as will be shown later, this model achieved better accuracy than most other SARIMAX variants (though still not surpassing the baseline). The takeaway is that macroeconomic conditions play a role in shaping the forecast, introducing a stabilizing effect. The presence of G20 GDP made the model a bit more conservative during the high season (lower Q2 and Q4 predictions) and slightly more optimistic during the low season (higher Q3 and Q1 predictions), which aligns with the idea that a healthy global economy can buffer downturns but also may cap extreme growth expectations.

4.2.3. Forecast with Global Financial Stress Index (SARIMAX - FSI)

In this scenario, we add the Global Financial Stress Index (FSI) as the exogenous input to the SARIMA model (see Figure 4 for the forecast). The FSI is essentially a measure of stress or instability in global financial markets higher values indicate greater stress (which usually correlates with economic uncertainty or downturns), while lower values indicate stable financial conditions. We expect the FSI to have an inverse relationship with market demand: if financial stress is high, automotive sales and investments might fall (hurting semiconductor demand), whereas low stress (stable financial markets) would correspond with healthier demand.

The forecast including FSI reflects a pattern consistent with the above intuition. For Q2 2025, the model predicts \$7.2937 billion, considerably lower than the baseline's \$7.8078 billion. This suggests that at the time of forecasting, the FSI level signaled substantial financial stress or risk, leading the model to anticipate a weakened semiconductor market in mid-2025 (perhaps expecting that the lingering effects of financial instability, such as tighter credit or cautious spending, would dampen car sales and thus chip demand). The forecast remains subdued into Q3 2025 at \$7.2730 billion (virtually flat from Q2, and again below the baseline's \$7.3837 billion). This flatness Q2 to Q3 (as opposed to the baseline's sharper drop in Q3) might imply that after an initial drop, the model expects the market to bottom out sooner, stabilizing by Q3 at a low level.

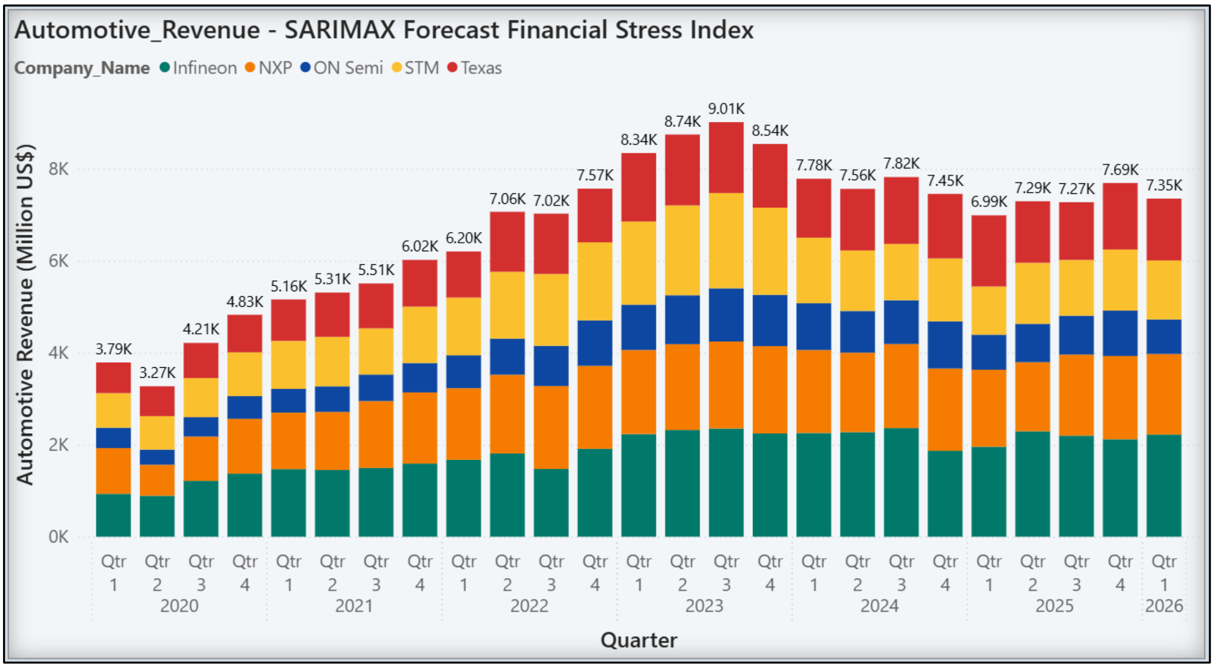

Figure 4: SARIMAX Forecast with Global FSI

By Q4 2025, the FSI augmented model forecasts a significant rebound to \$7.6906 billion, which overtakes the baseline's Q4 forecast (\$7.5860 billion). This rebound suggests that the model anticipates financial conditions improving by late 2025 (a lower FSI), thereby releasing pent-up demand or enabling a catch-up in semiconductor sales that were previously suppressed. In Q1 2026, the forecast is \$7.3515 billion, still higher than the baseline's \$7.0016 billion. This indicates that the recovery effect is expected to carry into early 2026, with the market remaining stronger than the baseline had projected for that quarter.

In summary, the inclusion of the Global Financial Stress Index yields a forecast that dips more sharply early (Q2-Q3 2025) and then recovers more strongly by Q4 2025-Q1 2026 relative to the baseline. It paints a scenario of a stress driven downturn followed by relief driven bounce back. This aligns with a narrative where perhaps financial turbulence in 2024/25 initially constrained the automotive semiconductor market, but as conditions normalize, the sector experiences a mini surge. However, it must be emphasized that this model's accuracy was not superior to the baselines. In fact, as we will discuss, the FSI model had relatively high forecast error (indicating that while it provides an interesting what-if scenario, the variable by itself didn't dramatically improve predictive power). Nonetheless, it provides insight into how financial market health might impact on the semiconductor outlook. A high FSI can foreshadow weakness, while a normalization in FSI can coincide with recovery.

4.2.4. Forecast with Polysilicon Price (SARIMAX - Polysilicon Price)

The final SARIMAX model considered here includes the Global Polysilicon Price as an external regressor (see Figure 5 for the forecast). Polysilicon is a critical raw material for semiconductor manufacturing, and its price can be viewed as an indicator of supply side conditions and cost pressures in the semiconductor supply chain. Rising polysilicon prices typically increase the cost of producing silicon wafers and chips, potentially constraining supply or raising prices for semiconductor components. Conversely, falling polysilicon prices can reduce production costs and potentially increase supply. Thus, this variable was tested to see if fluctuations in material cost/supply conditions carry predictive information for the automotive semiconductor market.

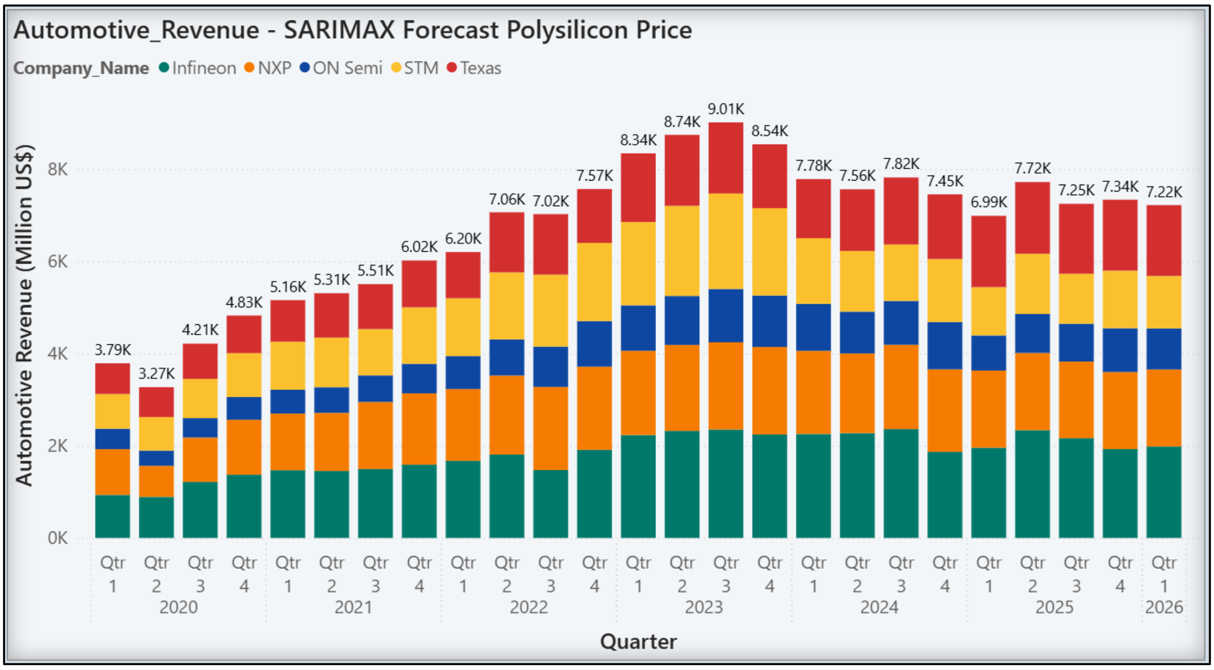

Figure 5: SARIMAX Forecast with Polysilicon Price

The SARIMAX forecast with polysilicon price differs from the baseline in subtle ways. For Q2 2025, the model forecasts \$7.7209 billion, which is slightly below the baseline's \$7.8078 billion. This marginal reduction suggests that the polysilicon price at that time might indicate a bit of headwind for the market possibly elevated costs or supply tightness tempering the revenue compared to what pure time-series momentum predicted. The difference becomes more pronounced in Q3 2025, with a forecast of \$7.2477 billion (versus the baseline's \$7.3837 billion). This larger drop for Q3 implies the model expects a softer third quarter, perhaps reflecting a scenario where high polysilicon prices (or a supply bottleneck) continue to dampen production or increase costs, thus limiting semiconductor shipment growth in late 2025.

Interestingly, the Q4 2025 forecast is \$7.3367 billion, which remains lower than the baseline's \$7.5860 billion for Q4. Unlike the baseline (and the other SARIMAX models) which predicted a notable Q4 uptick, the polysilicon informed model shows only a mild improvement from Q3 to Q4. This could suggest that if polysilicon prices were expected to remain high or only slightly at ease by end of 2025, the usual year-end surge in semiconductor sales might be muted due to persistent supply chain or cost constraints. Finally, for Q1 2026, the model forecasts \$7.2200 billion, which is higher than the baseline's \$7.0016 billion. In this scenario, by early 2026 the polysilicon situation might be assumed to normalize (e.g., prices easing or supply improving), giving a lift to semiconductor production/sales relative to the baseline projection. In effect, the polysilicon SARIMAX model envisions a more pronounced dip through late 2025 (lower Q3 and Q4 than baseline) followed by a smaller decline or quicker recovery by Q1 2026.

In qualitative terms, including the polysilicon price suggests that elevated material costs in 2025 could suppress semiconductor market growth, delaying some sales from late 2025 into 2026 when conditions improve. This narrative aligns with industry intuition, if key input prices are high, manufacturers might face production limits and buyers' higher prices, softening demand but once those costs fall, unmet demand can materialize. However, as with the other single variable models, the true benefit of including polysilicon price needs to be judged by its impact on forecast accuracy. We will see next that this model's error was also higher than the baseline's, indicating that the polysilicon price alone did not dramatically enhance forecasting precision for our data. It may be that polysilicon price movements, while conceptually important, did not directly translate to short-term semiconductor revenue changes in a simple linear way, or that their effect overlaps with existing trends already captured by the baseline model.

4.3. Comparative Analysis of Forecasts

Having examined each model separately, we now compare the different forecasts side by side to understand how each external variable affected the outlook and to determine which model performed best. Table 2 provides a consolidated summary of the forecasts for each model (baseline and each SARIMAX variant) for the four quarters of interest (Q2 2025 through Q1 2026), as well as the average forecast RMSE as a percentage. This table allows a direct comparison of the numerical predictions and the overall forecast accuracy.

The forecasts were conducted separately for each company and for each external variable. To evaluate model performance, the RMSE for a given variable was calculated as the average of the five individual company-level RMSE values:

Forecast Model	**Forecast in Billion USD**				
	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Final Average RMSE (%)
Baseline (SARIMA)	7.8078	7.3837	7.586	7.0016	6.516
SARIMAX (BEV Sales)	7.1416	7.3078	7.705	7.2721	8.926
SARIMAX (G20 GDP)	7.4418	7.5355	7.4154	7.0949	7.362
SARIMAX (FSI)	7.2937	7.273	7.6906	7.3515	8.722
SARIMAX (Polysilicon Price)	7.7209	7.2477	7.3367	7.22	7.994

Table 2: Forecast Result by Quarter and RMSE Value

Looking at the forecast values, we can draw several comparative insights:
Baseline vs. SARIMAX Levels: The baseline SARIMA forecast generally started higher in mid-2025 (Q2) than any SARIMAX model's forecast. For instance, at Q2 2025 the baseline predicted $7.8078 billion, whereas all SARIMAX models predicted between $7.14 billion and $7.72 billion. This suggests that the pure time-series momentum was more optimistic for Q2, and every external variable introduced caused a downward adjustment to that quarter, perhaps indicating that external data (be it softer EV sales, moderate GDP, financial stress, or cost pressures) did not fully support the baseline's high projection. By Q4 2025, however, two of the SARIMAX models (BEV and FSI) projected higher values than baseline, while GDP and Polysilicon remained lower. By Q1 2026, all SARIMAX forecasts ended up higher than the baseline (ranging from $7.09 billion to $7.35 billion vs baseline $7.00billion). In other words, the baseline forecast envisages the lowest trough in early 2026, whereas the models incorporating external info foresee a somewhat softer landing or even slight continued growth into Q1 2026.

Patterns and Turning Points: The inclusion of different variables led to different forecast shapes. The BEV Sales and FSI models both show a dip followed by a robust rebound (they start well below baseline in Q2 but end above baseline by Q4/Q1). This creates a "U-shaped" deviation relative to baseline likely because both EV sales growth and financial stress relief would impact with some delay and then accelerate demand later. Meanwhile, the G20 GDP model's forecast is more linear and steadier, it doesn't dip as low as others in Q3 and doesn't rise as high in Q4, indicating a stabilizing effect (a smoother trajectory with a peak at Q3). The Polysilicon model's forecast stays mostly below baseline until the very end, suggesting a more prolonged dampening influence with only a late minor catch-up. These differences highlight how each factor uniquely interacts with the market dynamics:

- BEV Sales: Introduced an initially low forecast that later exceeds baseline, highlighting the potential of late-2025 EV-driven growth after a slow start.
- G20 GDP: Smoothed out the forecast volatility, implying macro-economic stability lends consistency (avoiding both the high peak and deep trough that the baseline had).
- FSI: Caused a pronounced downturn and recovery, emphasizing the role of financial shocks and recoveries in creating a boom bust pattern.
- Polysilicon Price: Depressed much of the forecast period, hinting that supply side cost pressures could mostly restrain growth, with relief only coming later.

Relative Accuracy: In interpreting the baseline forecast, it's important to ensure the model is reliable. We used the Root Mean Square Error (RMSE) of the forecast as the primary diagnostic measure of model performance. The baseline SARIMA model achieved the lowest RMSE (6.516%), outperforming all the SARIMAX models in this one-step-ahead forecasting exercise. Among the SARIMAX models, the one including G20 GDP had the next best accuracy (7.362% RMSE), suggesting that G20 GDP was the most useful single external predictor of the four tested. The Polysilicon price model followed with about 7.994% RMSE. The models incorporating BEV sales and FSI had the highest errors (8.926% and 8.722% respectively), indicating that those forecasts deviated more from actual outcomes (or from a hold-out sample) on average. It is noteworthy that none of the SARIMAX models managed to improve upon the baseline's accuracy in fact, adding any one of these variables in isolation slightly degraded the forecast precision in this case.

This consistency in RMSE across models suggests that the differences in their forecasts can be attributed to the influence of the external variables rather than to any model misspecification or error issues. Since all models were found to be statistically sound in terms of forecast accuracy, we can confidently interpret the variations in their predictions as the true impact of the different external factors on the automotive semiconductor revenue forecast, rather than as noise or unreliable modeling. This RMSE-based validation across all models ensures that our comparison of forecasts is grounded in robust and credible model performance.

This result may seem counter intuitive at first (we often expect that adding relevant external information should improve forecasts). However, there are a few possible explanations:

The baseline SARIMA model might already capture the essential trend and seasonal pattern so well that the marginal benefit of a single external variable is limited. Given the relatively short forecast horizon (just 1 year ahead), the time-series momentum could be the dominant predictor.

The external variables themselves might not have a synchronous or linear relationship with the quarterly semiconductor revenue, at least not one easily exploited by a simple linear SARIMAX. For example, BEV sales are indeed rising, but the effect on semiconductor revenue might involve lags (new car sales today might translate to chip orders that were placed quarters earlier) or be confounded by other supply issues. Similarly, the Financial Stress Index could be capturing broad conditions, but automotive chip sales may depend on more specific industry factors beyond what FSI reflects in the short term.

There is also the possibility of overfitting or noise adding an exogenous variable increases model complexity. With limited data, a SARIMAX might overfit quirks of the sample period rather than true signal, leading to worse out-of-sample performance. For instance, the BEV sales time series may not be long enough or may be highly exponential in growth, which a linear model might not handle perfectly, causing the forecast to veer off.

In summary, the comparative analysis shows that each external factor changes the forecast in a meaningful way, offering different "what-if" perspectives, but the baseline model remained the most accurate predictor for the period in question when considering each variable individually based on RMSE. This suggests that the automotive semiconductor market, as captured by our data, might be predominantly driven by its own internal dynamics and trend cycle components in the near term. External factors like EV sales, macroeconomic health, financial conditions, and input prices certainly influence the narrative of the forecast, but capturing their effect in a univariate model may require more sophisticated approaches or perhaps combining multiple variables at once (since these factors can interact).

4.4. Forecasting Market Size

In addition to the comparative analysis of SARIMA and SARIMAX models, the results can be aggregated to provide a consolidated view of the forecasted market size of the automotive semiconductor sector. This section quantifies the expected trajectory by translating company-level forecasts into industry-wide market size estimates.

Table 3 presents the combined 2025 automotive revenues of the five semiconductor companies based on findings of this study. These figures represent the empirical basis for calculating total market size.

Year	Automotive Revenue Million $ (based on 5 Companies)
2025 (SARIMA Baseline)	29765.024
2025 (BEV)	29141.979
2025 (G20 GDP)	29380.204
2025 (Financial Stress Index)	29244.803
2025 (Polysilicon Price)	29292.789

Table 3: Total Automotive Revenue by Year for Five Companies (Million USD)

Total Market Size based on SARIMA Baseline Forecast:

The following mathematical procedure is applied to calculate the total market size, illustrated here using the SARIMA baseline forecast as an example. For the calendar year 2025 (Q1 2025-Q4 2025), the total automotive revenue corresponds to the combined revenues of the five companies considered in this study. The corresponding aggregate market share is reported in Table 1.

$$Total\ Market\ Size\text{ - }2025\ = \frac{Total\ Automotive\ Revenue\text{ - }2025}{Combine\ Market\ Share}$$

$$Total\ Market\ Size\text{ - }2025\ = \frac{29{,}765\ Millions\ USD}{47.31\ \%}$$

$$Total\ Market\ Size\text{ - }2025\ =\ 62.95\ Billion\ USD$$

The same approach is extended to the forecast horizon up to Q1 2026 (Q2 2025-Q1 2026), where the total automotive revenue represents the combined revenues of the five companies over that four-quarter period. Using this procedure, the total market size is derived from all forecast models. The resulting estimates are presented in Table 4.

Model	Total Market Size end of 2025 - Forecast	Total Market Size end of Q1 2026 - Forecast	CAGR based on 2013 to 2025 (%)	YOY Growth end of 2025(%)
Baseline (SARIMA)	$62.95B	$62.95B	11.48	-2.79
SARIMAX - BEV Sales	$61.60B	$62.20B	11.30	-4.83
SARIMAX - G20 GDP	$62.10B	$62.30B	11.37	-4.05
SARIMAX - Global FSI	$61.82B	$62.59B	11.33	-4.49
SARIMAX - Polysilicon Price	$61.92B	$62.42B	11.34	-4.33

Table 4: Estimated Market Size (USD Billions), CAGR, and YOY Growth by Model

Detailed Discussion:
The baseline SARIMA forecast indicates a total market size of $62.95 billion by both Q4 2025 and Q1 2026, corresponding to a CAGR of 11.48% since 2013. While this reflects a strong long-term growth trajectory, the YOY decline of -2.79% in 2025 signals that the market may enter a short period of stabilization or correction after years of double-digit expansion. This could be linked to inventory adjustments after the semiconductor shortage, cyclical demand patterns in the automotive industry, or macroeconomic moderation. In other words, the baseline model suggests that the industry is not in decline but is moving into a more balanced growth phase.

The SARIMAX models add further nuance:
BEV Sales: With the lowest market size in 2025 ($61.6B) and the sharpest YOY contraction (-4.83%), this scenario highlights the volatility of the EV market. While BEV adoption is a major structural driver of semiconductor demand, short-term fluctuations in consumer uptake, charging infrastructure rollouts, or subsidy policies can lead to temporary dips. The recovery by Q1 2026 ($62.2B) indicates resilience, but the near-term risk is clear: heavy reliance on EV growth can expose the semiconductor market to abrupt demand shifts.

G20 GDP: At $62.1B in 2025, this forecast is slightly lower than the baseline but projects a steadier progression into 2026 ($62.3B). The YOY decline of -4.05% reflects how global economic cycles directly influence automotive demand. Strong GDP growth translates into more car sales and thus higher chip demand, while weaker GDP drags the sector down. This model reinforces the idea that the semiconductor industry is closely tied to macroeconomic stability.

Global FSI: The forecast shows a 2025 market size of \$61.82B, but with the strongest recovery to \$62.59B by Q1 2026. The sharper decline in 2025 (-4.49% YOY) reflects the effect of financial stress reduced lending, tighter consumer credit, and lower investor confidence. However, once stress subsides, pent-up demand is released, leading to a quicker rebound. This underscores the sensitivity of the market to financial stability, disruptions can suppress growth temporarily, but recovery can be equally strong.

Polysilicon Price: With \$61.92B in 2025 and \$62.42B by Q1 2026, this model points to supply side cost pressures as a limiting factor. Elevated polysilicon prices increase semiconductor manufacturing costs, constraining supply and profit margins. The YOY decline of -4.33% suggests that if raw material prices remain high, market expansion will be muted. The modest rebound into early 2026 indicates some expected stabilization, but the forecast shows how input costs can cap short-term growth even when demand fundamentals are strong.

Key Insights:
Long-term growth remains robust: All models project a CAGR above 11% from 2013 to 2025, underscoring the structural expansion of semiconductors in vehicles driven by electrification, automation, and connectivity.

Short-term headwinds are likely: Every model shows a negative YOY growth rate in 2025, ranging from -2.79% (baseline) to -4.83% (BEV). This indicates a consensus that the market will face a temporary slowdown before recovering.

External variables shape the trajectory:

- Demand-side drivers (BEV sales, GDP) influence the depth of contraction.
- Risk factors (financial stress, raw material costs) determine the pace of recovery.

Most optimistic scenario: The FSI model, with the strongest rebound by Q1 2026 (\$62.59B).

Most conservative scenario: The BEV model, which forecasts the lowest market size and steepest decline in 2025.

Overall, these results suggest that while the automotive semiconductor market remains on a solid long-term growth path, the next 12 months will be shaped by global economic conditions, EV adoption rates, financial market stability, and raw material costs. Understanding these dynamics is critical for industry stakeholders planning capacity, investments, and supply chain strategies.

4.5. Concluding Remarks

The results presented in this chapter highlight both the strengths and limitations of forecasting the automotive semiconductor market using SARIMA and SARIMAX models. The baseline SARIMA forecast provided a clear picture of underlying trends, while the SARIMAX models demonstrated how external factors such as BEV sales, global GDP, financial stress, and polysilicon prices influence market dynamics. The addition of chapter 4.4 quantified these findings into industry-wide market size estimates, offering a consolidated perspective that connects company-level revenues with total market potential.

Taken together, the results indicate that although the automotive semiconductor market is on a long-term upward trajectory, short-term outcomes remain sensitive to both demand and supply side pressures. The insights gained from this chapter provide an essential foundation for the strategic implications and recommendations that will be discussed in Chapter 5.

5. Discussion

5.1. Interpretation of Results

All five forecasts cluster tightly around the low-$62B mark. At the aggregate level, historical revenue series contains a strong seasonal and autoregressive pattern that dominates short-term behavior. The baseline SARIMA captures that internal structure most succinctly and produces the lowest RMSE. The dollar-equivalent RMSEs quantify practical uncertainty, plan for one-year outcomes that can reasonably be several billion USD above or below the point estimate. In operational terms, the forecast indicates continued, moderate market scale rather than dramatic near-term contraction or runaway expansion.

The SARIMA baseline directly models seasonal repetition and the autoregressive dynamics in the pooled company revenues (Q1 2009–Q1 2025). When a time series exhibits stable seasonal cycles and persistence, economical seasonal ARIMA structures tend to produce robust short-horizon forecasts because they exploit within series inertia and repeatable patterns without introducing additional noise from external data sources. In this research the SARIMA's lower RMSE indicates those internal dynamics explaining the bulk of short-term variation.

SARIMAX allows explicit testing of causal or leading indicators. Among the single-regressor SARIMAX models tested, G20 GDP provided the largest improvement in explanatory content (it is the best-performing SARIMAX). That implies macroeconomic demand conditions are a consistent, directionally reliable driver of the automotive semiconductor revenues in combined-company series. Other regressors (BEV sales, FSI, polysilicon) each carry plausible economic narratives but when introduced individually, added measurement noise or timing mismatch that slightly degraded point forecast reliability relative to the SARIMA baseline.

Practical reading of each SARIMAX result:

- BEV sales are strategically meaningful because the semiconductor content per electric vehicle is higher, but when BEV sales are used as a single regressor they introduce noise. The elevated RMSE shows that BEV sales alone are not a stable short-horizon predictor in this dataset.
- G20 GDP emerged as the best single external predictor in this analysis and can be used as a macro-sensitivity lever for scenario analysis and early directional signaling.
- The Financial Stress Index (FSI) tends to dampen demand during periods of elevated financial stress. When included as a lone regressor it increases forecast uncertainty rather than producing a tighter point estimate.
- Polysilicon price is an indirect, cost-related variable that is informative for margin management and procurement planning, but it provides only a moderate signal for aggregate revenue forecasting when used in isolation.

Answering the research questions:

- How to create a robust forecasting model?
  Build a strong baseline seasonal time-series model (SARIMA) first, then judiciously add exogenous variables within a SARIMAX framework that are well-measured, appropriately lagged, and jointly evaluated. In this study the most effective single exogenous addition was G20 GDP.

- What will be the market size in the next 12 months?
  The central estimate for the next 12 months is approximately $62 billion, with a plausible deviation on the order of ± $4–5.5 billion depending on the model chosen.

- How will external global variables affect market size?
  External global variables modify the point estimate only modestly, G20 GDP provides the most stable and reliable adjustment, while the other single regressors are better used for scenario development than for producing precise short-term point forecasts on their own.

5.2. Strategic and Practical Implications

Operational and planning implications for producers (manufacturers / suppliers):

- Use the SARIMA baseline as the operational planning anchor for fab throughput, production schedules and inventory targets because it captures the dominant seasonal and persistence effects in the revenue series.

- Apply the G20-GDP SARIMAX as a macro-sensitivity overlay: material moves in GDP indicators should trigger proportional adjustments to capacity commitments, procurement cadence, and wafer-sourcing decisions.

- Maintain capacity flexibility and safety buffers sized to cover the RMSE band (several percent of demand) to reduce the risk of costly shortfalls or excess inventory.

- Treat BEV, FSI and commodity-price signals as scenario levers rather than sole decision drivers and activate targeted product or capacity responses only when multiple indicators confirm a directional change.

- Prioritize flexible production lines that can shift between high-margin power devices (SiC/GaN) and high-volume mixed-signal/MCU families to respond to scenario signals without large retooling costs.

- Use the polysilicon/commodity SARIMAX outputs to inform procurement tenor and hedging decisions for critical inputs.

Implications for investors and financial planning:

- Incorporate the RMSE bands directly into valuation sensitivity tables because the error bands quantify plausible revenue swings that materially affect discounted cash-flow outcomes.

- Monitor G20 GDP as the primary macro early-warning indicator because it is the most informative single external predictor in this analysis.

- Prefer companies with operational flexibility, secured capacity (in-house fabs or long-term foundry agreements), and strong balance sheets for medium to long-term exposure given modest point estimate growth and quantified short-term uncertainty.

- Diversify exposure across product categories (power devices, MCUs, sensors, analog) since different families have distinct demand drivers and margin profiles.

- Tilt allocations toward firms with secured capacity or demonstrated access to flexible foundry capacity, as these firms are less vulnerable to supply shocks.

- Use forecast-derived uncertainty (RMSE bands) to set position sizing limits and rebalance thresholds so that portfolio risk stays aligned with quantified revenue volatility.
- Factor regulatory and geopolitical risk (trade restrictions, subsidy changes) into allocation decisions and prefer firms with diversified geographic footprints or clear mitigation plans.

5.3. Limitations

- **Limited open-source dataset:** Public data availability constrained both the automotive revenue series and the global variable coverage, which reduces the representativeness of the dataset and prevents the use of richer and more advanced model classes.
- **Considering only five companies:** The analysis was restricted to five major semiconductor firms, which provides a meaningful but incomplete view of the total market and omits the influence of regional players or niche suppliers that may impact global demand.
- **Integration of one variable at a time:** The SARIMAX specifications in this study incorporated only a single regressor at a time, which means that interactions between external drivers could not be captured, and the results are therefore exposed to omitted-variable bias.
- **External variables differ regionally:** The use of global aggregates, such as global BEV sales or polysilicon prices, masks the geographic heterogeneity of markets, so the global signal produced by the model may not accurately reflect regional divergences.
- **Forecasting model parameters not industry tuned:** The SARIMA and SARIMAX models used in this study employed generic parameterizations, which may not fully capture industry shocks or structural breaks in the semiconductor market.
- **More suitable multivariate methods infeasible given data:** Richer econometric approaches, such as Bayesian Vector Autoregression (BVAR), could have provided stronger structural insights and better captured the interactions between variables, but they were not implementable due to the limited sample size and restricted variable breadth available in the dataset.

5.4. Recommendations for Future Research

Future research should expand the dataset to include a broader group of semiconductor manufacturers, and where possible, incorporate OEM semiconductor spending. This would allow aggregate forecasts to better reflect the entire market and capture contributions from smaller or region-specific players that were excluded from this study. When sufficient data is available, future studies should employ multivariate frameworks such as Bayesian Vector Autoregression (BVAR) or multivariate SARIMAX. These methods would enable the estimation of dynamic interdependencies between multiple drivers and provide a clearer understanding of how shocks propagate through the system.

Instead of testing external drivers one at a time, future work should build SARIMAX models that incorporate several exogenous variables simultaneously. Distributed lag structures should also be tested so that delayed impacts of these variables on semiconductor revenues can be properly captured. Because external variables and cost inputs differ substantially across regions, the same forecasting methodology should be applied separately for different regions. Regional forecasts are likely to be more actionable for local decision-making and will help account for heterogeneous growth patterns.

Future research could also examine the demand for different semiconductor product types, recognizing that each category is driven by distinct variables, regional dynamics, and OEMs strategic planning. A more granular approach focusing on specific product families, geographic regions, or individual companies would provide deeper insights and enable more targeted and actionable forecasts.

For long-term projections, future research should complement traditional econometric models with machine-learning techniques such as random forests, or gradient boosting. These methods can capture non-linear relationships and structural shifts, such as the acceleration of semiconductor content per vehicle. Instead of relying solely on point forecasts, future research should present full predictive intervals and scenario-based results (baseline, downside, and upside). This would provide stakeholders with range-based guidance, making forecasts more robust and useful for planning under uncertainty.

6. Conclusion

6.1. Summary of Findings

This research addressed three central questions.

First, concerning how to create a robust forecasting model for the automotive semiconductor industry, the study demonstrates that a Seasonal Autoregressive Integrated Moving Average (SARIMA) model offers the most reliable short-term forecasts. It captures the sector's strong seasonal and autoregressive dynamics with the lowest forecast error. The SARIMAX framework, which integrates external variables, provided additional scenario perspectives, but only the inclusion of G20 GDP consistently improved explanatory content. Other variables, such as BEV sales, the Financial Stress Index, and polysilicon prices, while economically relevant, did not improve accuracy when used in isolation, highlighting the importance of selective and combined variable integration for robustness.

Second, in response to what the global automotive semiconductor market size will be in the next twelve months based on financial data, the forecasts converge on a central estimate of approximately USD 62 billion. The results show a temporary moderation in 2025, with year-over-year growth turning slightly negative after years of expansion. This moderation, however, does not signal a downturn, but rather a stabilization phase in the industry's growth trajectory.

Third, regarding how external global variables affect the market size, the analysis shows that their impacts are directional but varied. G20 GDP provides a stabilizing influence, aligning demand for automotive semiconductors with broader macroeconomic performance. BEV sales and the Financial Stress Index introduce volatility, often producing dip-and-recovery patterns. Polysilicon prices act as a supply-side constraint, suppressing short-term growth when elevated. Overall, these variables did not surpass the accuracy of the baseline model individually, but they provided critical scenario perspectives on how macroeconomic and technological factors influence market outcomes.

6.2. Contributions to Knowledge

This thesis contributes to knowledge by presenting one of the first quantitative, company-level integrated forecasts of the global automotive semiconductor market that systematically incorporates external economic and industry drivers. By developing a transparent SARIMA baseline enriched with SARIMAX variants, this study demonstrates the relative importance of endogenous industry patterns versus exogenous macroeconomic shocks for near-term forecasting. The methodology pooling firm-level automotive revenues from major semiconductor suppliers and aligning them with global variables provides a replicable framework for both academic research and industry practitioners. The findings also highlight that while external factors are strategically significant, their predictive power depends on careful variable selection, lag structure, and combined evaluation, thereby refining the discourse on forecasting approaches in this highly dynamic sector.

6.3. Final Thoughts

The automotive semiconductor market stands at the intersection of technological transformation and global economic uncertainty. This research shows that its near-term trajectory is anchored in strong internal momentum, yet subject to modulation by wider financial, economic, and supply-chain factors. As vehicles become increasingly defined by software, electrification, and connectivity, semiconductors will remain the strategic backbone of innovation. The developed forecasting framework underscores that resilience in this industry cannot rest solely on historical patterns, it requires continuous integration of global signals into decision-making.

The findings reaffirm that while the industry faces short-term volatility, its long-term growth path remains robust, cementing the role of semiconductors as indispensable enablers of the future of mobility.

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Project Repository: Link

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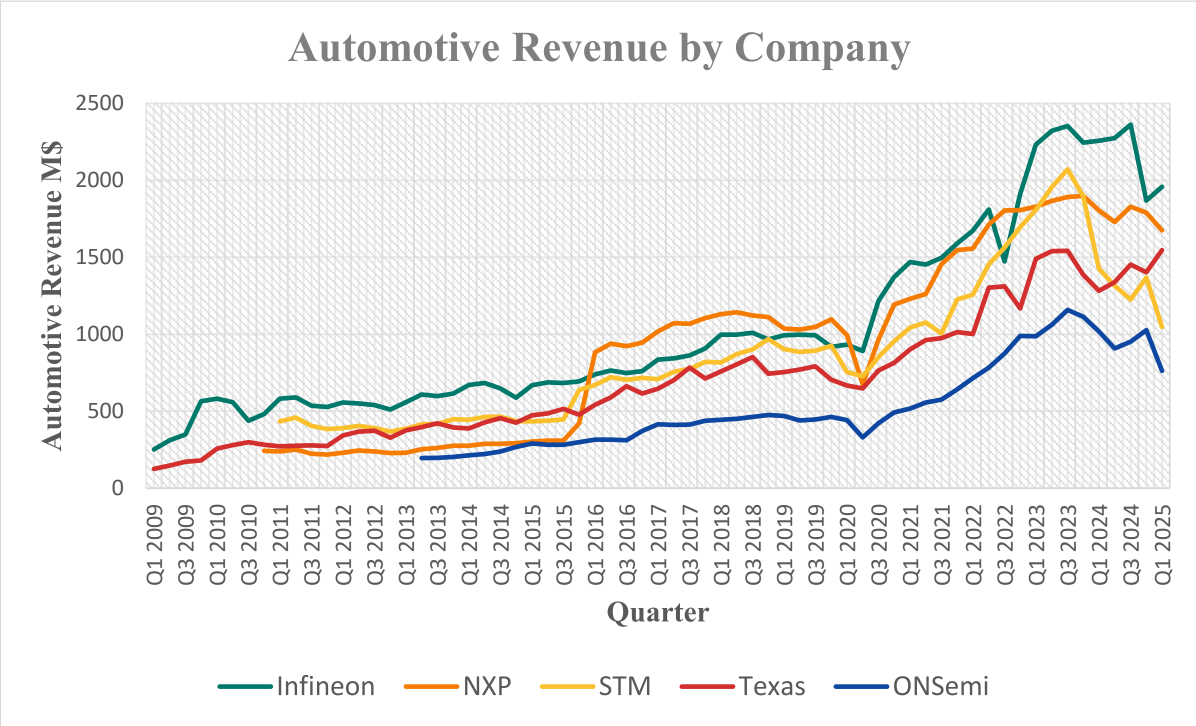
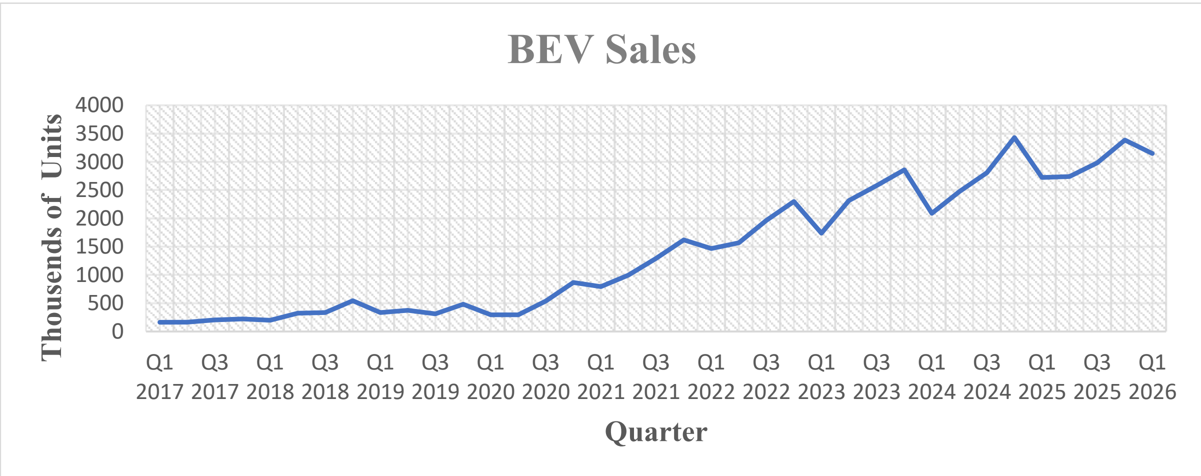
Appendix A: History Time Series Automotive Revenue by Company

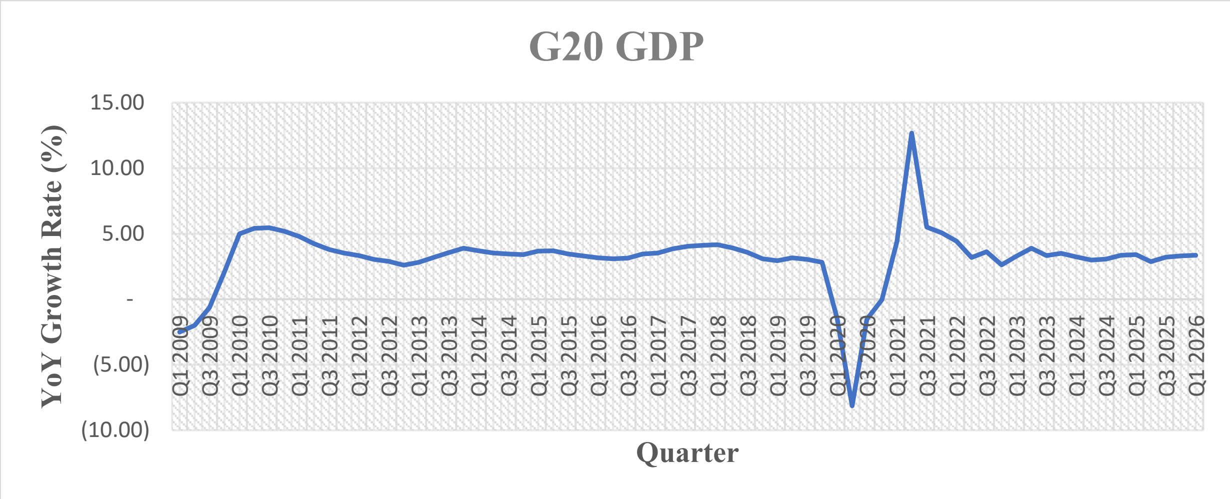


Appendix B: History and Forecast Time Series of Global Variables

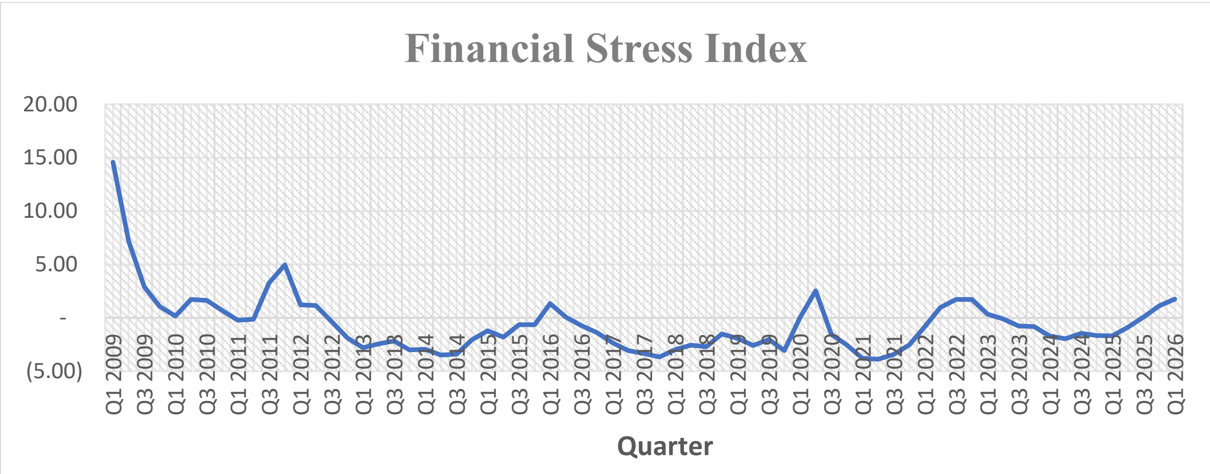
B.1 BEV Sales



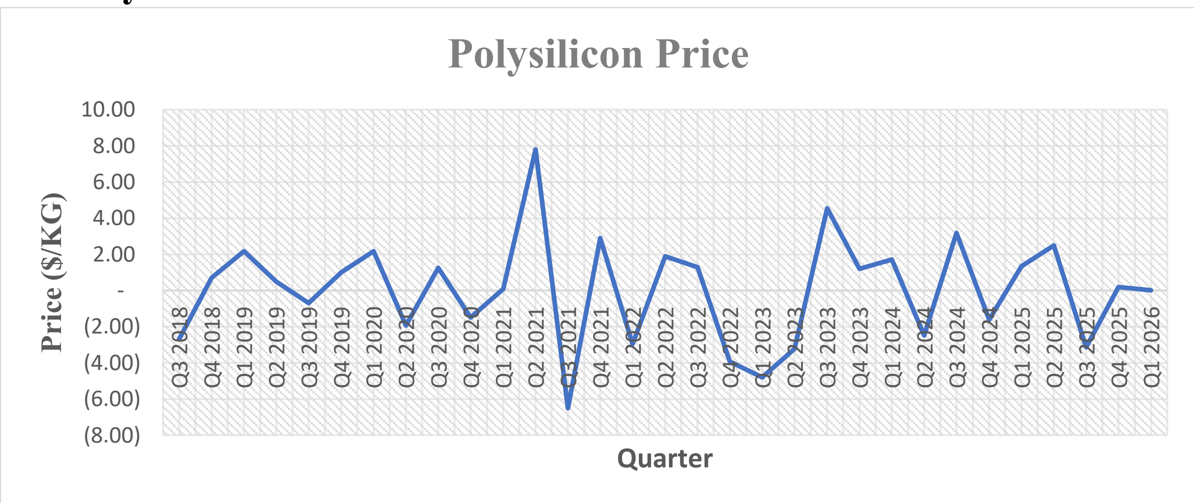
B.2 G20 GDP



B.3 Financial Stress Index



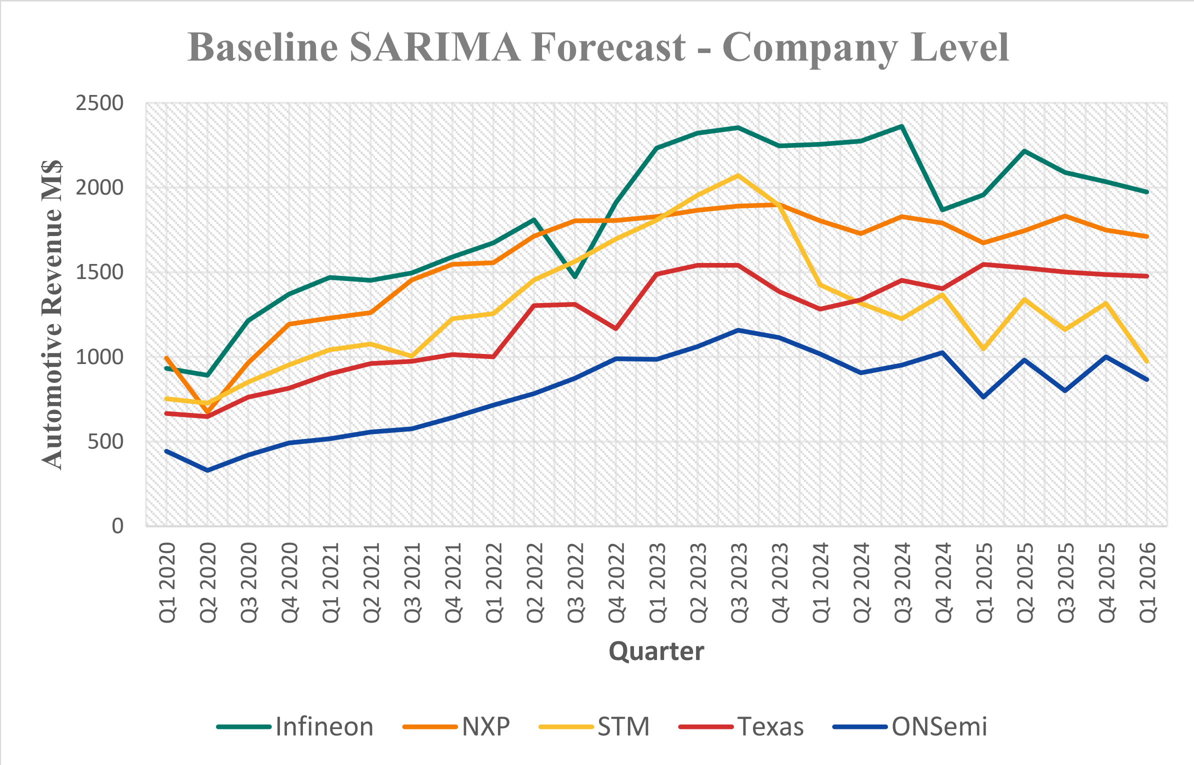
B.4 Polysilicon Price



Appendix C: SARIMA & SARIMAX Model Parameters Range

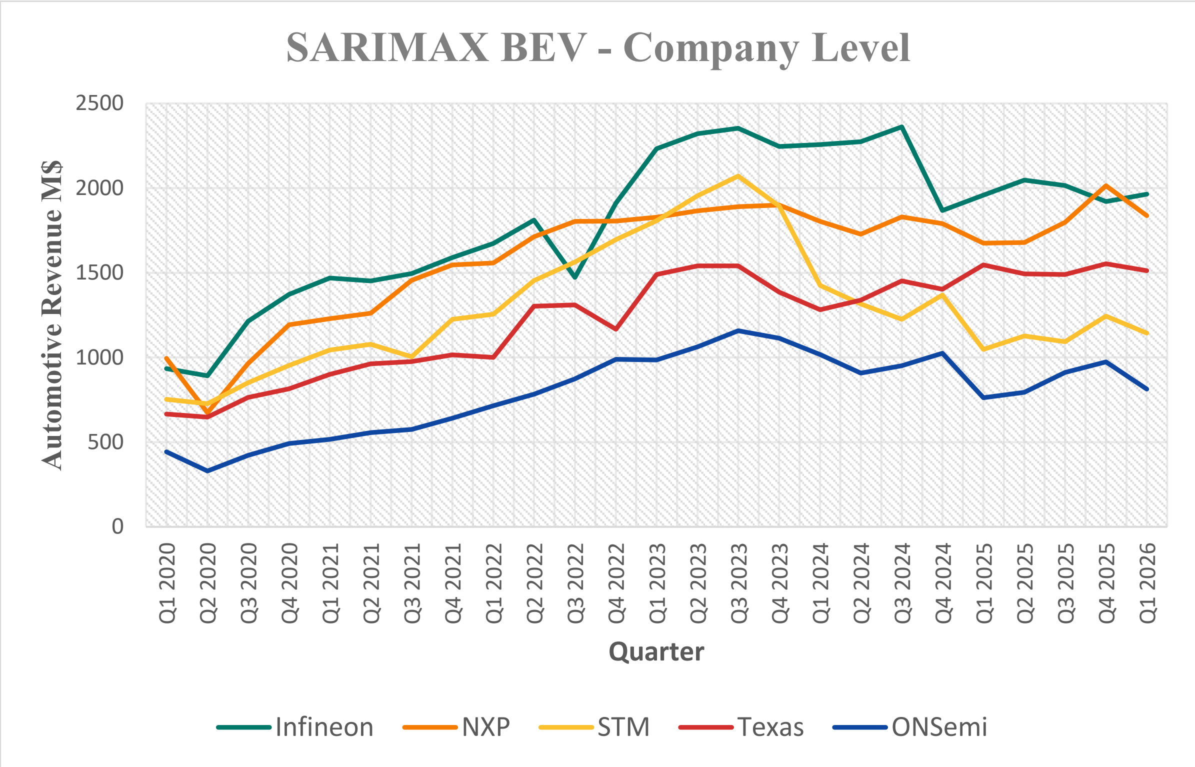
Parameters	Range
p	(0, 4)
d	(0, 3)
q	(0, 4)
P	(0, 3)
D	(0, 2)
Q	(0, 3)
m	16; For Automotive Revenue 4; For Global Variables

Appendix D: Baseline SARIMA Forecast - Company Level

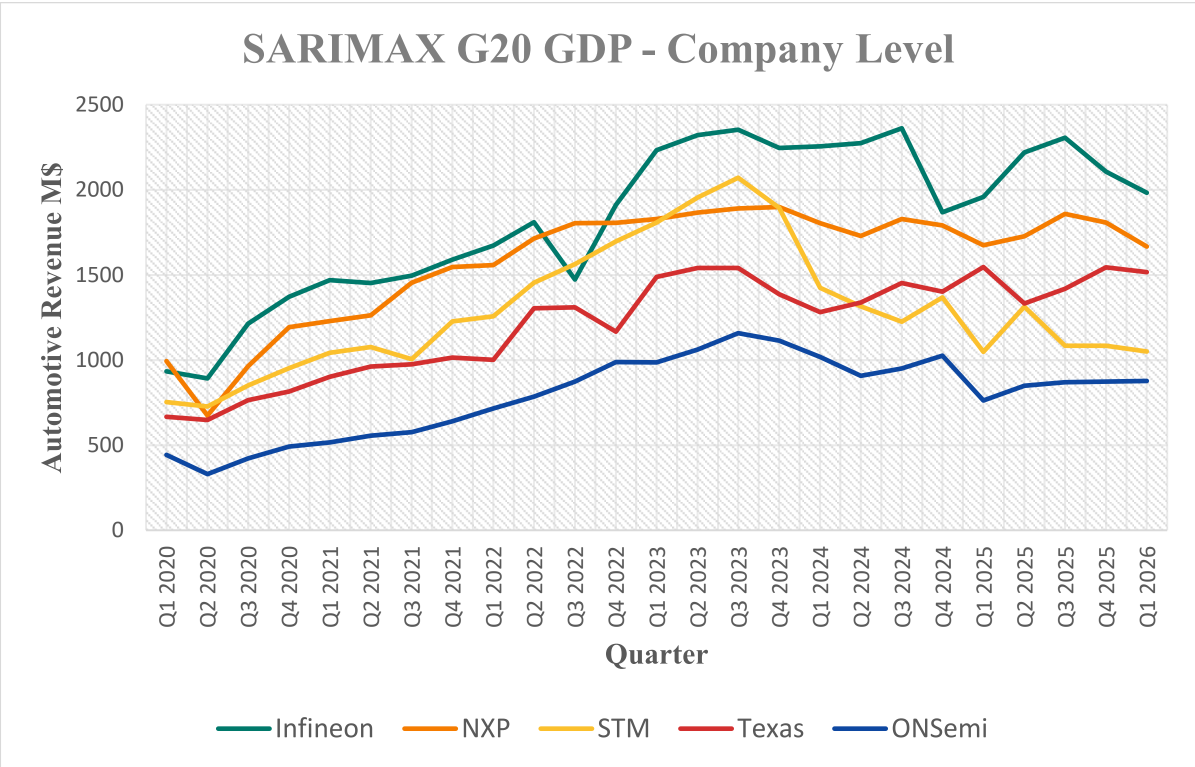


Appendix E: SARIMAX Forecast - Company Level

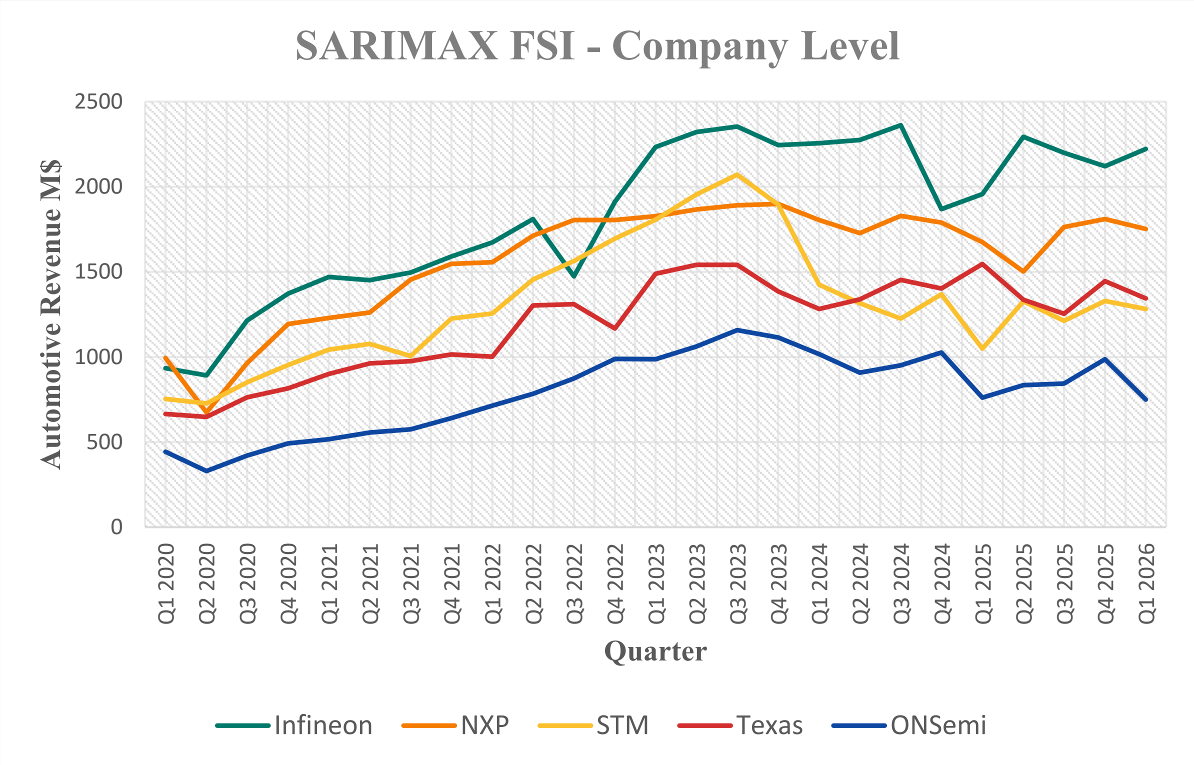
E.1 SARIMAX BEV - Company Level



E.2 SARIMAX G20 GDP - Company Level



E.3 SARIMAX FSI - Company Level



E.4 SARIMAX Polysilicon - Company Level