

**MASTER OF SCIENCE IN**

**ENGINEERING BUSINESS MANAGEMENT**

**M99EKM MASTERS DISSERTATION**

**CRITICAL SUCCESS FACTORS IMPACTING AGILE MANUFACTURING IMPLEMENTATION IN THE PHILIPPINE AUTOMOTIVE INDUSTRY**

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# ABSTRACT

This study explores the critical factors for the successful adoption of agile manufacturing practices within the Philippine automotive sector. By analysing these factors, the research aims to pinpoint effective strategies that can enhance the agility and competitiveness of Philippine automotive companies, thereby improving their overall organizational performance.

Employing a quantitative approach, data was gathered from diverse automotive and manufacturing professionals through structured questionnaires utilizing a Likert scale. The collected data underwent comprehensive analysis using SPSS, including reliability and regression tests to assess data reliability and validity. The key finding highlighted the pivotal roles of concurrent engineering and manufacturing management in agile manufacturing implementation.

These strategies are essential for organizations navigating dynamic market conditions. The research outcomes offer valuable insights for the Philippine automotive industry, enabling companies to adopt these strategies, optimize their positioning, and boost their competitive edge. Future research directions might delve into the influence of the workforce on the implementation of agile manufacturing, along with investigating the obstacles and challenges linked to adopting agile manufacturing. This exploration could provide valuable insights on overcoming these barriers.

Keywords: Agile Manufacturing, Concurrent Engineering, Organizational Performance, Manufacturing Management, Leadership, Technology, Workforce

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# 1. INTRODUCTION

## 1.1 Introduction

The primary focus of this chapter is on the research topic. This chapter begins by providing background information on the topic, followed by the problem statement, research aim and objectives. The chapter also addresses research questions and discusses the importance of the study, the research approach, and concludes with an outline of the dissertation's structure.

## 1.2 Research Background

In the contemporary business landscape, manufacturing industries are facing growing challenges as they strive to boost productivity and maintain global competitiveness. These hurdles include the need of reducing expenses while ensuring product quality amid unforeseen disruptions, rapid technological advancements, unpredictable market fluctuations, changing customer preferences, and intensified competition on both local and international fronts (Ikome et al., 2022; Nitha & Sunil, 2017; Khan & Dalu, 2015; Iqbal et al., 2018). In response to numerous challenges, organizations have reconsidered their conventional manufacturing approaches, abandoning outdated methods in favour of more advantageous strategies (Dubey & Gunasekaran, 2014). This shift has led to a new paradigm for manufacturing organizations, enabling them to endure heightened market competition (Thilak et al., 2015). Industries facing intricate challenges are turning to Agile Manufacturing (AM) for rapid adaptation, operational excellence, and enhanced performance (Dubey & Gunasekaran, 2015; Jain, 2019; Vinodh et al., 2010; Nejatian et al., 2019).

Agile manufacturing is a manufacturing approach that allows businesses to swiftly adapt to shifting customer demands (Thilak et al., 2015). Matawale et al. (2016) characterized AM as the capacity to adjust and develop new opportunities in a volatile market. AM focuses on cost-effective, rapid, and continuous customization of customer needs, promoting customer satisfaction and organizational goals. Manufacturers find agility beneficial in navigating unpredictable business environments, enhancing variability, customer satisfaction, and organizational objectives (Dumrak et al., 2020). AM methodologies enhance flexibility, efficiency, responsiveness, productivity, product quality and overall business performance (Moradlou & Asadi, 2015; Kumar et al., 2020; Dev & Kumar, 2016).

However, the successful implementation of AM across various manufacturing sectors remains a challenge due to its complexity and associated barriers (Kumar et al., 2020; Soares et al., 2022). Industries such as food, casting, telecommunications, and services have been hesitant to adopt AM due to concerns about high implementation costs and future uncertainties, leading to limited adoption in these sectors (Potdar et al., 2017b). In contrast, certain sectors like the electronics and automotive industries have thrived, largely due to their implicit or explicit adoption of the AM model (Thilak et al., 2015).

The automotive sector, despite embracing early AM principles, is still facing challenges in implementing this contemporary approach in specific parts of the world. The adoption of AM methodologies is vital for the automotive industry due to its pivotal role in propelling economic advancement (Mattioli et al., 2020). Globally, the automotive sector significantly contributes to economic growth. In the Philippines, it constituted 4% of the nation's GDP, contributing PhP300 billion and adding PhP318 billion worth of automotive parts to export revenues in 2017 Favourable policies from the government have drawn investments, yet unexpected obstacles like the worldwide chip shortage and the COVID-19 pandemic have significantly affected this expanding sector (Philippine News Agency, 2023; Natsuda & Thoburn, 2017; Statista, 2023). The industry's capacity to embrace new manufacturing methods, particularly amidst current disruptions and market unpredictability, is essential for ensuring its ongoing growth and competitiveness.

## 1.3 Problem Statement

The automotive industry is navigating through a complex landscape marked by unforeseen disruptions like the global COVID-19 pandemic and the persistent shortages in semiconductor chips (Ramani et al., 2022, p.1). These issues occur within the context of a Volatile, Uncertain, Complex and Ambiguous (VUCA) environment, adding layers of complexity to an already dynamic industry (Hoeft, 2022, p. 260). The unexpected challenges have highlighted the need for the sector to adapt methodologies that are flexible and agile.

Agility in the industry ensures the efficient delivery of customized, reasonably priced, and high-quality products within a set timeframe. It effectively manages internal and external disruptions caused by market uncertainties, aiming to provide the necessary speed to adapt to volatile and unforeseen market changes (Potdar et al., 2017, p. 2023). Numerous studies have explored the implementation of Agile Manufacturing across diverse industries and regions, including pump, construction, electronics, manufacturing, automotive, metal structures, and specific sectors like manufacturing organizations in India, Iran, North America, Europe and Asia (Thilak et al., 2015; Chen et al., 2007; Deif & ElMaraghy, 2007; Goriwondo et al., 2013; Jadoon et al., 2020; Batrhinath et al., 2019; Kumar et al., 2020; Hallgren & Olhager, 2009; Jassbi et al., 2010).

However, research on AM implementation in the Southeast Asian automotive industry is limited. Specific factors influencing AM adoption in this sector have not been extensively studied, creating a gap in understanding. Investigating these factors is crucial for increasing awareness, offering insights, and paving the way for future research on AM feasibility. Therefore, exploring the factors driving AM adoption in the Philippine Automotive sector is necessary.

## 1.4 Research Aim and Objectives

### 1.4.1 Research Aim

Despite the extensive theoretical studies and expanding curiosity in Agile Manufacturing within academic and business circles, there remains a notable gap in research when it comes to knowing the specific factors that affect AM adoption in the automotive sector, particularly in specific regions. This study is specifically designed to fill this gap by exploring the crucial factors that impact the implementation of AM within the Philippine automotive industry.

### 1.4.2 Research Objectives

This study seeks to achieve the following objectives:

1. To review the existing literature concerning Agile Manufacturing and its implementation
2. To identify the critical factors that influence the successful implementation of Agile Manufacturing within the automotive industry.
3. To evaluate how Agile Manufacturing positively impacts organizational performance.
4. To provide recommendations aimed at enhancing the implementation of Agile Manufacturing in the Philippine automotive industry, offering adaptable solutions for similar companies.

## 1.5 Research Approach

The initial phase of this study involved reviewing of existing literature in academic journals and articles. Conducting this literature review was crucial as it enabled the identification and evaluation of pertinent research findings and data analysis methods (Snyder, 2019). Within this literature review, five key factors influencing Agile Manufacturing implementation were identified as independent variables, while organizational performance, the dependent variable, was further explored. This research employed a deductive positivist approach, utilizing quantitative research methods for data analysis (Farghaly, 2018). The study integrated hypothesis testing into the research process to validate the outcomes (Saunders et al., 2019).

## 1.6 Significance of the Research

Various manufacturing sectors, including industrial equipment and the food industry, have successfully implemented Agile Manufacturing as evidenced by prior research (Leite & Braz, 2016; Nitha & Sunil, 2017). Past studies have identified crucial factors affecting AM implementation in diverse organizations (Sriariyawat, 2019; Moradlou & Asadi, 2015). However, the automotive industry, particularly in the Philippines, lacks comprehensive research on these factors. Despite local government efforts to boost the Philippine automotive sector (Sturgeon et al., 2016), there is a notable gap in understanding the specific factors that positively impact AM implementation in this context.

This research seeks to add in the existing understanding of the implementation of AM in the automotive industry, a sector often challenged by disruptions and market uncertainties. By investigating the essential success factors affecting AM adoption in the Philippine automotive context, this study seeks to bridge this gap and provide valuable insights for future studies and potential implementation approaches. Furthermore, the findings from this research could prove beneficial not only to the automotive industry but also to other sectors interested in adopting AM practices in their businesses.

## 1.7 Research Questions

This research seeks to answer the following questions concerning the implementation of Agile Manufacturing practices and their effects on the performance of automotive companies:

1. What constitutes the definition of Agile Manufacturing and its relevance to the manufacturing sector?
2. What are the key success factors for implementing Agile Manufacturing in automotive companies?
3. What are the impact of Agile Manufacturing on organizational performance?
4. What recommendations can be derived for businesses in similar industries based on the research findings?

## 1.8 Structure of the Dissertation

This research is structured into five chapters, outlined as follows:

* Chapter 1 focuses on introducing the research topic, beginning with the background of the study and progressing to the problem statement, research aim, objectives, and questions. It also discusses the importance of the study as well as the research approach employed.
* Chapter 2 provides a comprehensive analysis of recent literature from academic journals, reports, and books that present previous research on AM adoption in the automotive industry. The chapter addresses research questions and establishes a conceptual framework detailing factors influencing AM adoption, and the subsequent organizational performance improvements. Additionally, it identifies gaps in the literature and underscores the research topic's significance.
* Chapter 3 explains the research methods and how the data are collected in the study. The researcher has chosen to follow the research onion model by Saunders et al. (2018).
* Chapter 4 discusses the findings and analysis derived from a survey questionnaire. The data were analysed using SPSS, involving reliability and regression tests. The chapter explores respondent demographics, reliability assessments, and hypothesis testing. The analysis results are used to address the questions of the research comprehensively.
* Chapter 5 offers recommendations concerning vital elements that could enhance the effective implementation of AM in the Philippine automotive sector. It also examines the limitations of the research, suggests future research paths, and concludes the study.

# 2. LITERATURE REVIEW

## 2.1 Introduction

In this chapter, an extensive review of recent academic papers, reports, and publications is undertaken to provide a comprehensive overview of prior studies concerning the adoption of agile manufacturing in the automotive sector. This chapter also aims to address the research questions. Additionally, the chapter develops a conceptual framework for the factors influencing AM adoption and the subsequent enhancements in operational performance achieved through its implementation.

## 2.2 Automotive Industry

### 2.2.1 Global Automotive Industry

The automotive industry has continuously evolved since its humble beginnings in the late 19th century. Henry Ford's pioneering assembly line techniques revolutionized automobile manufacturing, making cars more accessible to the masses and laying the foundation for mass production principles (Hazarika et al., 2019).

Over the decades, the industry expanded globally, with manufacturers diversifying their product lines to cater to a wide range of consumer preferences. As economies grew, so did the demand for automobiles, making the industry a significant contributor to GDP in many countries (Williams & Blyth, 2023).

Today, the automotive manufacturing sector holds a significant position within global industrial production. Despite the substantial challenges posed by recent disruptions like the COVID-19 pandemic and chip shortages, global production of passenger vehicles reached approximately 85 million units (OICA, 2022). Global vehicle production is distributed across various countries and regions, reflecting the industry's diverse and dynamic nature.

### 2.2.2 Agility in the Automotive Industry

Despite its rapid expansion worldwide, the automotive industry grapples with complex challenges, including the need to respond swiftly to evolving customer preferences, adhere to stringent regulatory requirements, and navigate global and technological disruptions, among other complexities (Jadoon et al., 2020; Gruszka & Misztal, 2017). Numerous researchers concur that automakers should adopt contemporary manufacturing approaches like AM to adeptly address these challenges (Azevedo et al., 2016; Elmoselhy, 2013; Goswami & Kumar, 2018). However, implementing agile methodologies in the sector presents significant difficulties due to its complex and highly regulated nature (Potdar et al., 2017b; Poth & Wolf, 2017). Long-established production processes, stringent quality and safety standards, and intricate global supply chains can hinder the swift adaptability and frequent iterations associated with agile methodologies (Schroff, 2022; Azevedo et al., 2016; Ebert & Favaro, 2017). Navigating these challenges requires a careful and strategic approach to ensure that agile practices align with the industry's unique constraints (Soares et al., 2022).

### 2.2.3 Automotive Industry in the Philippines

In recent years, the Philippine automotive industry has experienced substantial growth and transformation, establishing itself as an important player in Southeast Asia (Statista, 2021). Although the sector is smaller in terms of manufacturing impact, the number of companies, and production when compared to Thailand, Malaysia, and Indonesia within the ASEAN region, the Philippine government acknowledges its importance and is actively working to boost its growth and competitiveness (Llanto & Ortiz, 2015). The government's focus on local vehicle manufacturing provides incentives for automotive manufacturers to invest in domestic production, thereby fostering industry growth (PBOI, 2017).

The country’s automotive industry development plan encompasses promoting the simultaneous growth of both vehicle assemblers and parts manufacturers. This strategy entails an economically efficient approach in which increased assembly volumes create economies of scale, ultimately resulting in reduced prices throughout the entire supply chain (PBOI, 2017).

Although there are promising opportunities, the industry still faces a range of challenges, including the need to address limitations in infrastructure, fluctuations in the economy, and disruptions in the supply chain (Llanto, 2016; Pato et al., 2022). Automotive manufacturing businesses in the country must employ contemporary approaches to address these challenges while seizing available opportunities, with one such approach being the implementation of AM techniques.

## 2.3 Agile Manufacturing

### 2.3.1 History and Evolution Agile Manufacturing

The historical foundations of agile manufacturing emerged in the late 20th century, during a time characterized by the global transformation of manufacturing techniques. (Leite & Braz, 2016, p. 562). As traditional mass production systems faced increasing challenges related to globalization, intensified competition, and consumer demand for customization, the need for a more dynamic approach became evident (Thilak et al., 2015, p. 2).

In the early 1990s, the concept of "agile manufacturing" gained recognition due to influential works by industry experts. Presented by the scholars from Iacocca Institute at Lehigh University, this approach was developed to meet the demand for manufacturing systems that could swiftly adapt, shorten lead times, and enhance customer satisfaction (Palsodkar & Pansare, 2018, p. 334).

Since its inception, AM has undergone significant evolution and refinement. These changes have been driven by shifts in business dynamics due to evolving market situations, alterations in customer needs, and heightened global competition (Dubey & Gunasekaran, 2014). The advancement of technology, including digitalization, automation, and data analytics, has also been crucial in empowering manufacturers to enhance their agility (Troise et al., 2022, p. 1; Ghasemaghaei et al., 2017, p. 95). Furthermore, AM principles have been integrated into various industries beyond traditional manufacturing, including electronic, aerospace and automobile industries (Thilak et al., 2015, p. 3).

### 2.3.2 Definition of Agile Manufacturing

Agile manufacturing, at its core, represents a strategic approach to manufacturing characterized by flexibility, adaptability, and responsiveness to changing market conditions and customer demands (Goswami & Kumar, 2018, pp. 276). AM emphasizes the capacity of manufacturing systems to adjust production processes, product designs, and supply chain configurations to meet evolving requirements rapidly and efficiently (Elmoselhy, 2013; Gunasekaran et al., 2019). Dubey and Gunasekaran (2015) highlight that while traditional manufacturing approaches tend to prioritize stability and predictability, AM fundamentally embraces change as a core principle.

### 2.3.3 Benefits of Agile Manufacturing

Adopting agile manufacturing provides numerous benefits that are necessary in today’s rapid and competitive business landscape. According to Kumar et al. (2015), one of its most significant benefits is enhanced responsiveness to market demands (p. 3). AM methodologies empower companies to quickly adapt to turbulent environments with changing customer needs, market trends, and unpredictable external factors, ensuring that products and services remain aligned with customer expectations (Leite & Braz, 2016, p. 562). This adaptability enables businesses to meet customer requirements more effectively, leading to increased customer satisfaction and loyalty (Dubey & Gunasekaran, 2014).

AM also promotes a culture of innovation and continuous improvement within organizations. Agile approaches encourage employees to contribute creative ideas and solutions which results in the creation of new products, services, and manufacturing methods (Kumar et al., 2019, p. 208). Moreover, AM contributes significantly to operational efficiency. Agile practices maximize resource utilization and decrease waste by minimizing excess inventory and reducing lead times. This leads to cost savings and enhanced profitability (Hemalatha et al., 2020, p. 10334). Routroy et al., (2015) cited that AM can also foster better relationships with suppliers and customers. This collaborative approach leads to improved supplier relations, allowing for faster response times and more efficient problem-solving.

A study by Nabass & Abdallah (2019) outlines the diverse advantages that AM offers to organizations, encompassing reduced costs, enhanced business processes, flexibility, improved quality, and increased competitiveness.

## 2.4 Factors Impacting Agile Manufacturing Deployment

A table with check marks

Description automatically generatedNumerous researchers have explored the prevailing conditions of AM implementation, as illustrated in Table 1. Common patterns were identified in research conducted across various sectors, countries, processes, and firms, including the food manufacturing industry in India (Nitha and Sunil, 2017; Nejatian, 2019), smart lean manufacturing firms (Ding et al. 2021), original equipment manufacturers (Dev and Kumar, 2016); multiple industries from the USA, UK, India, Taiwan, Spain, Finland, Iran, Portugal, and Pakistan (Kumar et al., 2019), metal fabrication industry (Bathrinath et al., 2019) and the apparel export industry in Pakistan (Iqbal, 2015). In the literature analysis, five prevalent factors were selected for further investigation in this study.

*Table 1 Factors Impacting on AM Implementation from Different Academic Journals*

## 2.5 Conceptual Framework

The conceptual framework establishes a basis for comprehending the research topic by outlining essential concepts, variables, and their interconnections (Imenda, 2014). As shown in Figure 1, this study's framework delineates the relationship between five important factors: Workforce, Technology, Leadership, Manufacturing Management, and Concurrent Engineering, and their influence on AM implementation. Additionally, the research intends to explore how the successful implementation of AM affects the overall performance of organizations. Figure 1 provides a visual representation of both the independent and dependent variables of the study.

*A diagram of a process flow

Description automatically generatedFigure 1 Conceptual Framework*

### 2.5.1 Workforce

#### 2.5.1.1 Introduction

The impact of the workforce is pivotal in the successful adoption of AM practices. Agility in manufacturing demands a workforce skilled in their areas and proactive, adaptive, and resilient (Sherehiy & Karwowski, 2014). Agile employees, as described by Muduli (2017, p. 47), show a strong inclination for learning and self-improvement, excel in problem-solving, adapt well to change and new technologies, generate creative ideas, and eagerly embrace new tasks and responsibilities. Past research suggests that the agility of manufacturing depends largely on human skills, not just technologies (Muduli, 2017, p. 46).

#### 2.5.1.2 The Impact of the Workforce in Agile Manufacturing Adoption

Developing a workforce with essential skills and training is crucial for successful AM implementation. Acquiring technical skills is especially vital in AM environments where employees often work with advanced technologies and tools (Gunasekaran et al., 2018). Having the necessary skills enables employees to perform a flexible range of tasks, ensuring adaptability (Muduli, 2017, p. 49). Additionally, diverse skills and training can optimize resources, reducing production variability and enhancing flexibility and responsiveness (Ullah & Narain, 2020, p. 274). Continuous training is essential to keep employees updated with the latest advancements, aligning their skills with the evolving demands of AM (Yusuf et al., 2018, p. 17).

The readiness of the workforce to embrace change and adapt to new technologies and processes is another vital factor for the success of AM. Organizational change relies on the members' attitude towards change (Asari et al. 2014, p. 74). Some employees see change as an opportunity for growth, while others resist it (Vakola 2014, p. 196). Resistance to change among employees can hinder the implementation of agile methodologies (Al-ma’aitah, 2022; Harraf et al., 2015). Researchers noted that employees used to traditional hierarchies might struggle to adjust to the decentralized decision-making and cross-functional collaboration integral to agile settings (Moe et al., 2021, p. 100). This resistance, if not effectively addressed, can impede the seamless integration of agile practices within the workforce.

Furthermore, researchers also added the importance of a technologically adept workforce, asserting that employees who readily adapt to new tools and processes facilitate the seamless integration of agile methodologies (Kumar et al., 2016). An organization with a workforce open to change and receptive to new ideas and technologies is better poised to implement agile methodologies effectively (Samanta et al., 2022).

Moreover, the engagement, motivation, and commitment of the workforce play a vital role in the successful deployment of AM strategies. Recent research highlights the substantial impact of an engaged and motivated workforce on the flexibility and responsiveness of manufacturing operations (Li et al., 2023). Engaged and motivated employees are more likely to actively participate in agile initiatives, contribute innovative ideas, and demonstrate a higher level of commitment to the organization's goals (Athamneh & Jais, 2023, p. 9; Sherehiy & Karwowski, 2014). Additionally, committed employees demonstrate a strong sense of ownership and loyalty to the organization, leading to higher levels of productivity and a willingness to go above and beyond to achieve organizational objectives (Oliver, 2012).

Research by Kakar (2020) emphasized that fostering employee engagement in decision-making, problem-solving, suggesting process improvements, and implementing changes cultivate a culture of continuous improvement (p. 8). This culture perfectly aligns with AM principles, empowering employees to propose enhancements and actively participate in problem-solving (Gunasekaran et al., 2019, p. 19). Engaged employees contribute their collective intelligence and problem-solving abilities, enhancing the implementation of AM practices significantly.

The way an organization communicates internally is also a factor that influences its overall agility (Haraf et al., 2015, p. 681). Employees can exchange ideas and information more easily through open and transparent communication channels, keeping them up to date on project advancements, requirement changes, and market demands (Athamneh & Jais, 2023, p. 7). Rajhans (2018) states that good communication helps employees understand the company's strategy, and having the right technological and cultural environment is crucial for effective knowledge-sharing and exploitation. Lassoued et al. (2020) found that good communication practices are essential for overcoming challenges and staying competitive. These practices are closely linked to the agility of the workforce.

#### 2.5.1.3 Gap

Researchers studying AM and its supporting factors, such as an efficient workforce, have often referred to examples from varied manufacturing sectors like electronics, metalworks, textiles, pumps, and automotive (Jadoon et al., 2020; Bathrinath et al., 2019; Thilak et al., 2015; Elmoselhy, 2013). However, this broad approach, spanning different sectors, presents challenges due to significant variations in organizational, market, and customer dynamics. This diversity makes it counterproductive for researchers in one sector to adopt generalized conclusions from a heterogeneous population (Goswami & Kumar, 2018, p. 281). Specifically, there is a lack of research investigating the influence of the workforce on AM adoption within specific industry and country contexts. Moreover, there is no dedicated study exploring the impact of the workforce on AM implementation in the Philippine automotive industry. Addressing this gap through a comprehensive study could significantly contribute to current knowledge in the field.

#### 2.5.1.4 Hypothesis

The hypothesis is as follows:

*H1: Workforce positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

#### 2.5.1.5 Conclusion

The success of AM implementation relies on a proficient workforce capable of embracing agile methodologies and promptly adapting to shifting demands. Skilled and adaptable employees empower organizations to effectively overcome challenges, ensuring the seamless integration of the agile approach into operational processes. Therefore, exploring the impact of the workforce on the implementation of AM suggests the need for additional research investigation.

### 2.5.2 Technology

#### 2.5.2.1 Introduction

In the contemporary manufacturing landscape, technology stands as a crucial force reshaping traditional methods and enabling agility (Park et al., 2017). According to Samizadeh et al., (2019), technology significantly enhances top management decision-making, providing organizations a competitive advantage. Their study also emphasizes technology's role in strengthening integration and agility, vital aspects in navigating today's highly competitive market. Consequently, integrating advanced technologies is essential for the successful execution of AM strategies (Gunasekaran et al., 2018).

#### 2.5.2.2 The Impact of Technology in the Implementation of Agile Manufacturing

Technology is associated with advanced tools, systems, and digital solutions that enable quick responses to market demands, efficient collaboration among teams, and data-driven decision-making, ensuring a highly responsive and adaptable production environment (Kumar & Singh, 2020). These technological innovations serve as the backbone for the implementation of AM strategies, allowing companies to remain flexible, adaptive, and competitive.

In an era of rapid technological advancements, organizations that can adapt quickly to new technologies and processes gain a competitive edge (Natalia & Ellitan, 2019, p. 10). Research from Gunasekaran et al. (2019, p. 20) emphasizes the role of technology adoption in agile supply chains. Embracing advanced technologies enables real-time decision-making and enhances the overall agility of manufacturing processes. Companies that adeptly incorporate these technologies can respond swiftly to market demands and optimize their production, inventory, and distribution processes.

Advanced automation technologies like robotics, artificial intelligence, and machine learning enhance manufacturing efficiency and flexibility, allowing rapid adjustments in operations for agility in the face of market fluctuations (Gunasekaran et al., 2019; Lai et al., 2020). The Internet of Things (IoT) plays a transformative role, connecting devices for data exchange without extensive human intervention, optimizing supply chains, predicting maintenance needs, and enhancing operational visibility (Badarinath & Prabhu, 2017; Diene, 2020). Real-time data collected from IoT devices allows remote monitoring and analytical tools to process this data, providing insights for informed actions and customized programming, enhancing adaptability. However, the adoption of new technologies in manufacturing presents challenges, including significant upfront costs for equipment, software, and training (Sommer, 2015; Tamvada et al., 2022). System integration complexities can lead to operational inefficiencies if not carefully managed, highlighting the need for thoughtful planning to ensure a smooth transition (Tamvada et al., 2022).

Moreover, the implementation of AM strategies relies heavily on advanced design technologies, transforming the product development process (Sindhwani & Malhotra, 2016; Bustelo & Avella, 2006). Software applications such as Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) allow detailed digital prototyping, scenario simulation, and virtual testing (Chang, 2016). 3D printing is another vital technology enabling the direct transformation of digital designs into physical prototypes or final products (Attaran, 2017). These technologies facilitate swift design iterations, empowering manufacturing to efficiently respond to changing market demands.

In terms of team collaboration, utilizing collaborative technologies and tools is a vital aspect of technological agility. Immediate communication platforms enable diverse teams to respond swiftly to business opportunities, reducing costs and travel expenses (Ramzan et al., 2017). Virtual environments are one example, enabling seamless data exchange between entities (Busse & Weidner, 2019). Various digital collaboration tools, regardless of web generation, facilitate daily business operations globally, transcending physical boundaries, time zones, and leadership styles. These platforms enable real-time communication among teams, ensuring rapid decision-making and adaptability to market changes (Busse & Weidner, 2019; Baran & Wonznyj, 2020).

#### 2.5.2.3 Gap

Research on AM is widespread globally, spanning developed, emerging, and underdeveloped nations. The United States takes the lead, accounting for around one-third of the study, followed by the United Kingdom, India, and China (Potdar et al., 2017, p. 2036). Despite this, only a limited number of articles delve into the utilization of advanced technologies and their facilitative role in AM practices across various industries and nations. Consequently, there is a notable gap in understanding how technology could influence AM adoption specifically within the context of the Philippine automotive industry.

#### 2.5.2.4 Hypothesis

The hypothesis is as follows:

*H2: Technology positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

#### 2.5.2.5 Conclusion

The incorporation of advanced technologies in agile manufacturing implementation revolutionizes production processes, enhancing flexibility, precision, and adaptability. As explored earlier, these technologies enable companies to streamline operations, optimize resource usage, and promptly meet changing market needs, emphasizing their crucial role in ensuring successful AM practices. Therefore, examining the impact of technology on successful AM deployment highlights the need for further research investigation.

### 2.5.3 Leadership

#### 2.5.3.1 Introduction

The critical role on how leadership influences the successful deployment of AM practices within organizations is widely recognized (Venugopal, & Saleeshy, 2019, p. 171; Karimi et al., 2016; Veiseh et al., 2014; Raeisi & Amirnejad, 2017). AM demands visionary and adaptable leaders capable of guiding teams through dynamic environments and responding swiftly to changing market demands and technological advancements (Kumar et al., 2019, p. 3). Inadequate analysis of customer needs, competitors' strategies, technological advancements, regulatory changes, and supplier conditions by leaders can result in suboptimal product choices, missed market opportunities, and increased production costs due to inefficient processes (Iqbal et al., 2018, p. 184). Therefore, evaluating leadership skills thoroughly is crucial for achieving the desired organizational outcomes (Kumar et al., 2019).

#### 2.5.3.2 The Impact of Leadership in Agile Manufacturing Deployment

Leadership profoundly influences organizational behaviour and structure (Kim et al., 2021, p. 227). Effective leadership styles, such as supportive and advisory behaviours, active engagement, coaching, and mentoring, shape a strong organizational culture (Khalid et al., 2020, p. 52; N. Bushuyeva et al., 2019). Initiating efforts to combine activities within and across functions enhances efficiency and competitiveness in challenging business environments (Kumar et al., 2019, p. 1398). Leadership support and commitment are essential for cultivating a culture of flexibility and agility within the organization (Hamidifar, 2015).

Strategic leaders possess a deep understanding of organizational culture and can discern which aspects should be retained and what needs to change. In times of significant change, effective leadership involves inspiring others to strive willingly for common goals (Belias & Koustelios, 2014, p. 457). Leaders serve as catalysts for change, but successful execution of the change process can encounter obstacles if not properly defined (Asnan et al., 2015). The formulation of change strategies greatly influences the acceptance of organizational change (Belias & Koustelios, 2014). Therefore, leaders skilled in change management techniques can navigate transformative initiatives such as agile practices more effectively.

Favourable leadership behaviours like active participation and communication enhance employee work engagement (Nikolova et al., 2019). Studies by Saad et al. (2019) indicated strong links between work engagement and positive leadership styles, a consistent finding in various studies where motivated employees contribute to higher support and engagement (DeCuypere & Schaufeli, 2018; Carasco-Saul et al., 2015; Ghadi et al., 2013). Transparent communication by leaders regarding the rationale behind agile practices, their benefits to employees, and their alignment with the organization's strategic objectives fosters a sense of purpose. This openness builds trust, and morale, and strengthens collective commitment to agile initiatives (Nikolova et al., 2019).

Lam et al. (2021) suggest that a corporate culture encouraging open innovation, characterized by trust, collaboration, and learning, can enhance knowledge management practices, thereby boosting the firm's innovation capability. Organizational agility hinges on smooth communication and rapid knowledge sharing among teams (Santos & Goldman, 2015). Leaders facilitating transparent communication channels enable swift exchange of ideas. Effective communication enables the prompt identification and integration of innovative solutions into agile initiatives (Malik et al., 2021).

Agile organizations depart from traditional hierarchical structures, instead emphasizing collaborative teams that operate independently yet collectively (Brosseau et al., 2019). This approach relies on partnership and agreement-based management, where leaders prioritize relationship building, teamwork, breaking barriers, and creating networks. Agile leaders promote active participation, collaborative problem-solving, and shared responsibility, ensuring organizational agility, responsiveness, and innovation amid changing challenges (De Smet et al., 2018).

#### 2.5.3.3 Gap

Previous studies have explored into the connection between effective leadership, organizational performance, and the pivotal role of agile leaders in enhancing overall organizational agility (Attar & Abdul-Kareem, 2020; Sindhwani & Malhotra, 2016; Elmoselhy, 2013). However, a notable gap exists in the literature concerning the specific impact of leadership on AM implementation, particularly within the automotive sector in specific geographic locations. More precisely, there is a lack of research examining how leadership influences AM implementation in the context of the Philippine automotive industry, highlighting the need for focused exploration in this area.

#### 2.5.3.4 Hypothesis

The hypothesis is as follows:

*H3: Leadership positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

#### 2.5.3.5 Conclusion

Effective leadership is critical for the successful adoption of agile AM, enabling adaptability and innovation within organizations. Leaders who encourage collaboration, transparent communication, and a culture of continuous learning are instrumental in driving agile manufacturing initiatives to success. Hence, investigating the impact of leadership on the successful deployment of AM emphasizes the need for additional research studies.

### 2.5.4 Manufacturing Management

#### 2.5.4.1 Introduction

Manufacturing management encompasses the choices and steps taken by an organization in its production procedures, including resource allocation, strong relationships with customers and suppliers, and flexible business practices (Nitha & Sunil, 2017, p. 1235). Agility in manufacturing management involves employing strategies within production processes to meet the company’s goals. It aligns the organization's abilities with market demands, ensuring effective resource utilization and operational efficiency to respond to changing customer requirements and market dynamics (Soepardi et al., 2018, p. 106).

#### 2.5.4.2 The Impact of Manufacturing Management in Agile Manufacturing Implementation

Production planning is essential in manufacturing systems due to the requirements for increased efficiency, shorter life cycle of products, improved quality of the products, and enhanced customer satisfaction (Lee et al., 2014). In a production system involving multiple units with varied functions, production planning focuses on allocating resources effectively to ensure each unit can complete its tasks efficiently. Therefore, being proactive and responsive in resource allocation is a widely recognized strategy for building resilience in manufacturing setups (Peng et al., 2021, p.3). This resilience is vital for implementing AM practices in these environments.

However, inefficiencies in quality management such as inadequate quality control processes allow flawed products to reach consumers, damaging the brand's reputation. Therefore, it is crucial to have a deep understanding of quality management to enhance quality and the allocation of resources to implement these strategies effectively (Alidrisi & Mohamed, 2012). Enhanced product quality can give manufacturers a competitive advantage in the global market competition. Furthermore, a study by Jamal et al. (2015) emphasizes the importance of managing quality in improving operational efficiency and customer satisfaction. Quality management techniques, including Six Sigma and Total Quality Management (TQM), when seamlessly integrated into manufacturing strategies, create a culture of continuous improvement. This culture aligns with the iterative nature of agile methodologies, fostering a mindset of adaptability and innovation among employees.

Research by Dubey and Gunasekaran (2014), stresses the importance of collaboration between manufacturers and suppliers in AM adoption. Collaborative manufacturing management practices facilitate the seamless exchange of information, enabling real-time updates on market demands and customer preferences. By integrating suppliers into the production ecosystem, organizations gain access to vital insights into supply chain dynamics, achieving improved firm performance and customer satisfaction (Kim & Chai, 2017). Additionally, a study by Leite and Braz (2015), highlights the impact of collaboration with customers on AM initiatives. Engaging customers in the production process using collaborative strategies that tap into their experiences, understanding, and knowledge of processes enhances information flow, resulting in improved overall performance (Abdalla & Nabass, 2018, p. 1044). Collaborating with suppliers and customers promotes mutual understanding, ensuring quick and accurate responses to customer requirements. This facilitates swift decision-making and agile adjustments in response to market shifts.

In the constantly changing automotive industry, the successful adoption of AM practices relies on embracing flexible production strategies. These strategies, falling under the domain of manufacturing management, are not just advantageous but imperative for automotive companies striving to maintain a competitive advantage (Elmoselhy, 2013). Flexible manufacturing strategies in the automotive industry allow companies to promptly respond to market demands and consumer preferences, enabling quick adjustments in production levels and the development of new products. These strategies, as highlighted by Mendes (2015, p.2), offer significant advantages to firms. AM aligns with these flexible practices by enabling rapid adaptation to market demands.

Moreover, minimizing risks related to disruptions is a crucial manufacturing management practice. Proactive measures, as highlighted by Alicke and Strigel (2020, p. 8), are essential for maintaining agility and flexibility in the face of challenges. McMaster et al. (2020) underscore the significance of anticipating disruptions through comprehensive risk mapping, enabling strategic resource reconfiguration. Maleki's study (2023) emphasizes the proactive strategies of diversification and redundancy within supply chains. This approach not only helps companies identify vulnerabilities but also facilitates the swift implementation of agile responses.

#### 2.5.4.3 Gap

A review of related literature reveals valuable insights into the influence of various manufacturing management strategies on the deployment of AM (Soepardi et al., 2018; Nitha & Sunil, 2017). Although existing studies tend to summarize previous findings from various industries and regions, there exists a gap in comprehending the precise influence of these manufacturing management practices on AM adoption within specific sectors, including the automotive industry More specifically, limited research delves into the ways manufacturing management strategies affect AM implementation, especially in the context of the Philippine automotive sector. This suggests the need for focused investigations in this particular domain.

#### 2.5.4.4 Hypothesis

The hypothesis is as follows:

*H4: Manufacturing management positively impact Agile Manufacturing adoption in the Philippine Automotive Industry*

#### 2.5.4.5 Conclusion

Manufacturing management is essential for the successful implementation of AM strategies, ensuring alignment with market demands and operational efficiency. Effective management practices enhance resource utilization and flexibility, enabling businesses to adapt rapidly to changing customer needs and market dynamics in the context of AM. Therefore, further research studies are necessary to explore the impact of manufacturing management on the successful implementation of AM.

### 2.5.5 Concurrent Engineering (CE)

#### 2.5.5.1 Introduction

As industries evolve, agility becomes synonymous with competitiveness, demanding strategies that can swiftly adapt to changing market demands. Concurrent Engineering (CE), defined as the practice of integrating and optimizing design, prototyping, and production processes simultaneously, ensures that various facets of product development occur in parallel rather than in isolated, sequential stages (Dongre et al., 2017). CE enables this faster development by allowing tasks to be carried out simultaneously, leading to reduced lead times without compromising the time needed for individual design tasks (Alvarez & Millan, 2021). This reduction in delivery times is a valuable competitive advantage for companies that implement it effectively.

#### 2.5.5.2 The Impact of Concurrent Engineering in the Adoption of Agile Manufacturing

Concurrent Engineering combines innovation and efficiency by integrating different stages of product development. Its key strength is promoting collaboration among cross-functional teams, aligning well with the agile approach (Deshpande, 2013). CE encourages teams from different fields to work together simultaneously. This collaborative work allows instant sharing of ideas and expertise among specialists. However, there's a challenge with CE, it generates a massive amount of data that needs to be managed, stored, and shared (Alvarez & Millan, 2021). A lot of work has been done in the past decade to establish open data exchange standards, such as making communication and data sharing smoother between different design teams and customers (Avnet & Weige, 2010). This process enhances the product's quality and speeds up its time-to-market (Dongre et al., 2017, p. 201).

Another pivotal advantage of CE lies in its capacity to facilitate the swift integration of customer feedback into the design and production processes (Žužek et al., 2020). Traditional, sequential approaches often struggle to incorporate real-time customer inputs effectively. CE, however, encourages the simultaneous involvement of various stakeholders, including customers, throughout the product development lifecycle (Alvarez & Millan, 2021, Bandecchi et al., 1999). This concurrent collaboration allows automotive companies to respond swiftly to customer preferences and aligns with the principles of AM.

Furthermore, CE offers a proactive approach to product development that helps automotive manufacturers avoid these costly pitfalls. CE's core principle involves parallel collaboration among various departments and stakeholders during the design and production phases (Žužek et al., 2020). This minimizes the likelihood of delays and the need for extensive rework, which can be both time-consuming and financially burdensome (Karningsih et al., 2015). Having this benefit is in line with AM methods and could influence how they are applied in the automotive sector.

In conclusion, CE is crucial boosting agility within the manufacturing industry. It allows organizations to quickly respond to evolving customer needs and shorten product development processes (Dongre et al., 2017). By promoting simultaneous collaboration among different departments, CE ensures that customer requirements and market changes are swiftly incorporated into ongoing design and production phases (Pullan, 2014). This immediate adaptability not only boosts customer satisfaction but also shortens operational time, facilitating faster market entry and increasing current revenue, leading to higher profits (Muhammad Ali & Razzaq, 2023). This approach empowers manufacturers, enabling them to be more agile and competitive in a swiftly changing market landscape.

#### 2.5.5.3 Gap

Previous studies have explored the importance of combining CE practices with agile manufacturing strategies in various sectors (Alvarez & Roibas-Millan, 2021; Žužek et al., 2020; Sankaranarayanan et al., 2019). However, there is a notable research gap about the precise influence of concurrent engineering on AM, specifically within the automotive industry and particularly in the context of the Philippine automotive sector. This gap highlights the necessity for targeted investigations in this specific domain.

#### 2.5.5.4 Hypothesis

The hypothesis is as follows:

*H5: Concurrent Engineering positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

#### 2.5.5.5 Conclusion

Concurrent engineering plays a crucial role in AM implementation, enabling seamless collaboration and communication across teams. Its integration enhances adaptability, accelerates product development, and ensures efficient resource utilization, thereby fostering the agile capabilities of organizations. Hence, additional research studies are needed to investigate how concurrent engineering influences the successful implementation of AM practices.

### 2.5.6 Organizational Performance

#### 2.5.6.1 Introduction

Organizational performance encompasses the effectiveness, efficiency, and overall fulfilment of the organization's goals (Almatrooshi et al., 2016). Various researchers have identified essential organizational performance metrics, including cost, quality, new product development, delivery speed, product flexibility, time-to-market for newly-developed products, volume flexibility, and innovation (Jabbour et al., 2013; Leite & Braz, 2016; Abdallah et al., 2016). The following section will explore the influence of AM adoption on organizational performance, considering aspects such as cost efficiency, business operations, flexibility, quality, and competitiveness.

#### 2.5.6.2 The Impact of Agile Manufacturing on Organizational Performance

The importance of adopting AM to improve business competitiveness has been widely recognized. Consequently, companies are embracing agility to enhance their performance (Khalfallah & Lakhal, 2021b; Inman et al., 2011). AM not only emphasizes responsiveness and flexibility but also pays special attention to various competing goals such as cost, quality, and innovation (Soepardi et al, 2018; Potdar et al., 2017). This enables companies to enhance their overall performance and competitiveness (Leite & Braz, 2016; Nabass & Abdallah, 2019).

Agile manufacturing practices impact organizational costs by reducing expenses in industrial sectors. This is achieved through the minimization of waste and the optimization of resource allocation in production and operational processes. By implementing agile principles, companies can streamline their production methods, reduce unnecessary waste, and enhance resource efficiency. These initiatives not only lead to significant cost reductions but also improve overall operational effectiveness (Mittal et al., 2017; Nabass & Abdallah, 2019). For instance, research conducted by Dubey and Gunasekaran (2015) emphasizes the role of AM practices in enhancing environmental performance through waste reduction. Furthermore, Liu and Liang (2015) highlight AM’s continuous effort to optimize resource allocation, resulting in a competitive advantage for businesses. These studies underscore the importance of agile methodologies in achieving cost savings while simultaneously improving operational efficiency and environmental sustainability. Contrarily, Nabass and Abdallah (2019) argued against this notion, contending that AM might not always lead to cost reduction. In practice, companies embracing AM often incur higher expenses, investing in areas like new technologies and business processes.

Adopting agile principles enables companies to establish a flexible and adaptable atmosphere, fostering experimentation and innovation, which in turn boosts the flexibility and performance of the organization. This approach empowers businesses to promptly adapt to market requirements, technological changes, and evolving consumer tastes (Leite & Braz, 2016). AM methodologies facilitate swift iterations, idea prototyping, and the exploration of inventive solutions, ultimately resulting in the creation of new products and services (Kumar et al., 2020; Sanchez et al., 2019; Fritzsche, 2018). Being able to introduce innovative products faster than competitors not only strengthens the company's position but also ensures more effective fulfilment of customer needs (Leite & Braz, 2016; Hallgren & Olhager, 2009). This is especially important in the competitive landscape of the automotive sector.

Additionally, AM places a significant focus on fulfilling customer needs and demands, leading to the enhancement of brand reputation and the cultivation of customer loyalty. By aligning production processes with market demands, businesses can provide products and services that meet customer expectations (Dubey & Gunasekaran, 2015). Customer satisfaction is a strategic goal that companies aim for, and AM serves as one of the strategies to achieve this objective. Agility in manufacturing firms is closely related to swiftly addressing unpredictable customer demands, as this agility is believed to contribute to the satisfaction of the customer (Nabass & Abdallah, 2019).

The successful implementation of AM practices leads to significant improvements in product quality and a reduction in defects. Agility allows the organization to provide customized and high-quality products efficiently and within specified timelines (Potdar et al., 2017). Nevertheless, Qamar et al. (2023) highlighted significant considerations regarding the quality tradeoffs that companies might face while adopting agile principles, particularly in the automotive sector. The research demonstrates that agile companies, especially those in dynamic markets, generate a wider range of products and innovate at a faster pace. However, meeting the heightened demands for both diversity and volume necessitates operational flexibility, which can impact both efficiency and quality.

#### 2.5.6.3 Gap

Several studies conducted by various researchers provide clear evidence of the positive impact of AM implementation on organizational performance. Summarizing these studies, Abdalla and Nabass (2018) highlight how AM influences organizational performance across diverse factors and industries in various regions. However, there is a gap in the research regarding the specific effects of AM on organizational performance within the automotive industry, especially in the context of the Philippines. This indicates a need for further investigation in this area.

#### 2.5.5.4 Hypothesis

The hypothesis is as follows:

*H6: Agile manufacturing implementation positively impacts the automotive industry in the Philippines.*

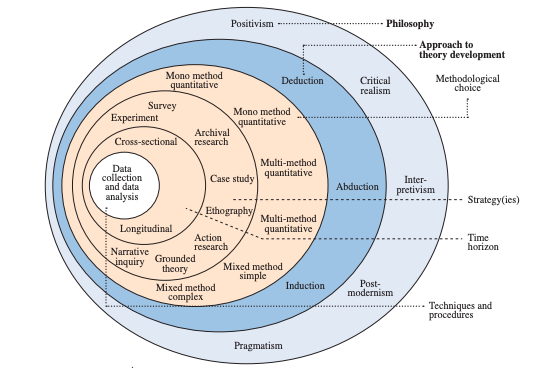
#### 2.5.6.5 Conclusion

The positive impact of AM implementation on the automotive industry highlights its significance in enhancing operational efficiency, responsiveness to market demands, and overall competitiveness. Therefore, further research studies are essential to explore the potential improvements in organizational performance that AM could bring to the automotive industry.

# 3. RESEARCH METHODOLOGY AND TECHNIQUES

## 3.1 Introduction

This chapter details the methodologies and techniques used for collecting the research data. As shown in Figure 2, the researcher has opted to utilize the research onion model introduced by Saunders et al. (2019). This model outlines the phases necessary for creating a comprehensive and effective research study (Orth & Macada, 2021).

*Figure 2 Research Onion*

## 3.2 Research Philosophy

The research philosophy outlines the study, enabling researchers to understand the methods employed and comprehend the underlying expectations guiding their research techniques (Abdelhakim & Badr, 2021, p. 100). Long et al. (2018) identified three primary research philosophies: Pragmatism, Positivism, and Interpretivism. Pragmatism focuses on the practical usefulness of innovative ideas, Interpretivism emphasizes independence from societal influences, and Positivism promotes objective and externally oriented research (Johnson et al., 2017).

Moreover, Positivism utilizes a structured methodology to ensure reproducibility and emphasizes measurable observations suitable for statistical analysis (Saunders et al., 2019). In this research, Positivism was employed to assess quantifiable data concerning the factors affecting Agile Manufacturing Implementation in the Philippine Automotive industry. This approach allowed the formulation and testing of hypotheses based on data collected (Saunders et al., 2019).

## 3.3 Research Approach

Researchers typically employ two primary approaches in their research papers: Deductive and Inductive research approaches. The Inductive approach predominantly relies on qualitative methods which begin with observations to draw generalizations (Abdelhakim & Badr, 2021). Conversely, in Deductive research, the researcher initiates the study with a theory, formulates hypotheses derived from that theory, and gathers data to test the proposed hypotheses (Knight et al. 2022). The deductive approach was chosen for this research as the researcher developed hypotheses derived from the literature reviews.

## 3.4 Research Strategy

### 3.4.1 Method

There are two primary categories of research methods, namely qualitative and quantitative research. These methodologies are utilized to identify, collect, and analyze information, contributing to a deeper understanding of a specific issue (Basias & Pollalis, 2018, p. 92). Qualitative research involves exploring non-numerical data to understand and interpret patterns and processes, prioritizing exploration and comprehension over explanation and variable manipulation. It emphasizes the context and the development process rather than solely focusing on the final research outcomes (Nassaji, 2020, p. 427). Quantitative research entails a methodical and empirical exploration of phenomena using statistics, mathematics, and numerical data processing (Goertz & Mahoney, 2012). The primary goal of the quantitative method is to explore the connection between independent and dependent variables within a specific population (Mehrad & Zangeneh, 2019, p. 2).

In this study, the quantitative research method was employed, utilizing data gathered through online surveys. Sadan (2017, p. 58) noted that surveys and questionnaires are valuable sources of data for quantitative research.

### 3.4.2 Data Collection

#### 3.4.2.1 Primary Data

Primary data is acquired directly from the original sources of information, often from the working environments and employees within industries. Questionnaires serve as the most prevalent tool for collecting data (Sadan, 2020). In this research, the primary data was gathered by conducting a survey using questionnaires. Approximately 100 survey forms were distributed to employees in the automotive and manufacturing industries. Participants were chosen from various levels within the companies and were required to have significant exposure and an understanding of AM practices.

#### 3.4.2.2 Secondary Data

Research usually commences by reviewing existing knowledge about a topic and determining what aspects still require investigation. This involves examining relevant literature and assessing previously collected data (Johnston, 2014, p. 621). Secondary data for this research has been sourced from literature related to AM This includes reputable journals, books, articles, periodicals, proceedings, newsletters, and other publications focusing on the automotive and manufacturing industries. The primary platform used to access selected journal articles is Google Scholar.

#### 3.4.2.3 Sampling Plan

In research, it's not feasible to study every single item in a population. Instead, a smaller group, known as a sample, is chosen for the study. Probability sampling is a common method where each member of the population has a chance to be included. This approach helps reduce errors and biases in the sample (Alvi, 2016, p. 12). Because of the time constraints, this study has opted for Probability Sampling as the research methodology. This method involves selecting a specific group to represent the entire automotive and manufacturing industries.

#### 3.4.2.4 Questionnaire Design

Likert-type scales are frequently utilized in survey questionnaires to gauge observations and attitudes. According to Rahi (2017), a five-point scale is easily understandable for respondents and allows them to express their opinions more effectively. A set of declarative questions utilizing a Likert scale, detailed in Appendix B, was formulated to obtain standardized responses and general perspectives from the participants. The questionnaire, generated using Google Forms, was subsequently shared with the participants online.

## 3.5 Method of Analysis

IBM's Statistical Package for the Social Sciences (SPSS) tool was used to analyse the quantitative data obtained from the questionnaires.. SPSS is a commonly utilized statistical tool by researchers and scholars worldwide. SPSS software simplifies the process of comparing and correlating statistical tests for both parametric and non-parametric approaches (Ong & Puteh, 2017, p.18).

In this study, reliability, validity, and regression tests were employed to validate the data's accuracy, establish its significance, and explore relationships between variables.

## 3.6 Research Plan

As indicated in Appendix A, the dissertation commenced on July 4th, 2023, with an anticipated completion date of October 17th, 2023.

## 3.7 Research Ethics

According to Webster et al.(2014), every research study involving human respondents must be ethically justified, ensuring participants are fully informed about the risks, benefits, and consequences. Their voluntary participation, without coercion, is essential, and maintaining confidentiality and safety is a crucial ethical consideration. In this study, participants are aware that their participation in the survey is voluntary, and the survey materials will only be used for research purposes. Participants' privacy is guaranteed since no personal information is collected within the survey.

# 4. RESEARCH FINDINGS AND ANALYSIS

## 4.1 Introduction

The results and analysis of the survey questionnaire are covered in this chapter. A total of 110 responses were collected and analysed utilizing SPSS, incorporating reliability and regression tests. Participants' profiles, reliability evaluations, and hypothesis testing are also covered in this chapter. Furthermore, the research questions will be addressed using the analysis results produced from the evaluation.

## 4.2 Demographic Analysis

### 4.2.1 Gender of Participant

In this study, a total of 110 responses were collected. Figure 3 illustrates that 68.2% of the participants were male, while 31.8% were female.

*Figure 3 Survey Participant’s Gender*

A blue and red pie chart

Description automatically generated

### 4.2.2 Educational Level of Participant

Figure 4 demonstrates that 91.8% of the participants had achieved a degree or higher education, with 69.1% holding Bachelor's degrees, 21.8% holding Master's degrees, and 0.8% holding a Doctorate. Additionally, 8.2% of the participants had Diplomas and Professional certificates.

*Figure 4 Survey Participant’s Educational Level*

A pie chart with numbers and a few percentages

Description automatically generated

### 4.2.3 Professions of Participant

The participants represent diverse roles within the automotive and manufacturing sectors. According to Figure 5, 61.5% are professionals or engineers, 22.8% hold managerial positions, with 15.5% as managers, 5.5% as supervisors/team leaders and 1.8% as directors. The remaining 13.7% fall into other categories.

*Figure 5 Survey Participant’s Profession*

A pie chart with different colored circles

Description automatically generated

### 4.2.4 Duration of Participant’s Professional Experience

In Figure 6, 27.3% of survey participants have more than 16 years of working experience. Another 22.7% have 10-15 years of experience, and 25.5% have 7-9 years of experience. Additionally, 19.1% of the respondents have 4-6 years of experience. This data shows extensive experience in the automotive and manufacturing sectors. This makes their perspectives on the implementation of AM valuable and credible.

*Figure 6 Survey Participant’s Length of Service*

A colorful pie chart with numbers

Description automatically generated

### 4.2.5 Key Traits of Agile Manufacturing in Participants’ Companies

Figure 7 indicates that the majority of participants' companies, around 81%, prioritize continuous improvement. Customer focus is next at 71%, followed by adaptability and quality focus at 62%. Collaboration stands at 55%, iterative progress at 42%, and empowerment at 30%. The remaining 14% falls under other categories. These findings suggest that most participants' firms do not fully embrace AM qualities. Hence, it is essential to explore further the adoption of AM.

*Figure 7 Key Traits of Agile Manufacturing in Participants’ Companies*

A graph with numbers and a bar

Description automatically generated with medium confidence

## 4.3 Reliability Test (Cronbach’s Alpha Test)

In quantitative research, reliability pertains to the degree of stability and consistency in measurement techniques. Reliability involves two key elements: the measure's consistency across multiple tries and its stability across different time periods (Chan & Idris, 2017, p. 400). Cronbach's alpha is the standard measure used to assess the reliability index of research tools, ranging from zero (α=0) to one (α=1). A higher alpha value indicates that the factors measure the same dimension with greater reliability. Alternatively, a low alpha value suggests a weak correlation, indicating that the factors do not measure the same dimension (Bujang et al., 2018). It is important to highlight that the main reason for measurement errors is the content of the sample (Hajjar, 2018, p.50).

In general, Cronbach's alpha tends to increase when the factors being tested are more closely related. This increase signifies a higher internal consistency and reliability of the test values (Hajjar, 2018, p.50). As shown in Table 2, a reliability score of 0.7 or higher is considered acceptable (Heale & Twycoss, 2015).

*Table 2 Cronbach’s Alpha Classification Table (Gliem & Gliem, 2003)*

|  |  |
| --- | --- |
| **Cronbach’s Alpha** | **Reliability Level** |
| α <0.5 | Unacceptable |
| 0.5 ≤ α <0.6 | Bad |
| 0.6 ≤ α <0.7 | Doubtful |
| 0.7 ≤ α <0.8 | Acceptable |
| 0.8 ≤ α <0.9 | Good |
| α ≥ 0.9 | Very good |

Comparing alpha coefficients is crucial, but these comparisons are often overlooked Researchers frequently need to assess the reliability of different measures given to the same sample or one measure across various samples. Conducting tests comparing two or more alpha coefficients is necessary in these cases to accurately evaluate measurement precision (Diedenhofen & Musch, 2016, p.52).

## 4.4 Cronbach’s Alpha Test Result

The study performed a reliability assessment for all variables using SPSS, as detailed in Tables 3 to 8. The Cronbach's alpha values for the variables ranged from above 0.8 to below 0.92. As shown in Table 4-3, these results meet the acceptable criteria for reliability, rendering them suitable for further analysis (Gliem & Gliem, 2003). More comprehensive details regarding the reliability test results for individual factors is reflected in the appendix section.

### 4.4.1 Workforce (W)

The information from Table 3 indicates that the reliability test for the Workforce factor achieved a score of 87.5%. This implies that the survey data's consistency in this study is satisfactory, affirming its appropriateness for supporting the influence of the workforce on the implementation of AM. This finding aligns with the research conducted by Asari et al. (2014, p.72), which concluded that having an agile workforce is crucial for achieving AM within an organization. Furthermore, the mean for W1 to W5 ranged from 4.6000 to 4.3818, Highlighting that a significant majority of respondents concurred on the importance of the workforce factor.

The data presented in the Item-Total Statistics Table highlights the equal significance of all W factors. Removing any factor, such as W4, leads to a notable decline in Cronbach's Alpha values, dropping the reliability score from 0.875 to 0.846. This emphasizes the crucial role of W4, focusing on workforce engagement, motivation, and commitment as essential components for successful AM strategies. According to Tamtam and Tourabi (2020), the workforce's pivotal role in shaping an organization's overall agility is evident, leading to diverse organizational benefits (p. 411). Moduli (2017) also outlined key traits vital for cultivating an agile workforce, which include motivation, commitment, and engagement. Moreover, Moduli (2017, p. 46) emphasized that intrinsically motivated employees exhibit proactive, adaptive, and resilient behaviors, significantly enhancing the organization's agility. Hence, W4 is important and should be accounted for in the argument and analysis.

If W5 is excluded from the list, Cronbach’s alpha value would also decrease from 0.875 to 0.851, signifying the role of W5 in impacting the reliability score. W5 specifically focuses on the aspects of effective communication and knowledge sharing among the workforce, crucial for the seamless implementation of AM practices. Gunasekaran et al. (2018) highlighted the importance of cooperative networks that foster clear communication and knowledge exchange within agile organizations. These networks are fundamental for leveraging resource capabilities and providing competitive advantage, an essential goal in AM. However, developing effective knowledge sharing and communication within the workforce poses challenges, including managing team members' diverse time zones and geographic locations and resolving issues related to inadequate planning and documentation (Gupta & Bajwa, 2012; Karlsen et al., 2011; Conboy & Morgan, 2011). To fully capitalize on the advantages offered by this factor, understanding the risks associated with these obstacles and developing efficient methods for their management is necessary.

*Table 3 Workforce Reliability Test Result*

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### 4.4.2 Technology (T)

The data presented in Table 4 displays a reliability score of 86.6% for the Technology factor, demonstrating its reliability and suitability to support the impact of the factor in the implementation of AM. Several studies have corroborated the positive impact of advanced technology on the adoption of AM (Tang & Ghobakhloo, 2017; Ghasemaghaei et al., 2017; Setiawati et al., 2022). Additionally, the average scores for T1 to T5 range from 4.3273 to 4.5727, indicating widespread agreement among participants regarding the technology factor.

The Item-Total Statistics Table shows that eliminating any T factor decreases all Cronbach’s Alpha scores, emphasizing their equal significance. Notably, the removal of T2 results in the most substantial decline among the five factors, reducing the Cronbach’s Alpha score from 0.866 to 0.825. The decline emphasizes T2’s influence on the factor’s reliability score. T2 explores the role of technology in enhancing agility by effectively gathering and analysing data in manufacturing. Technologies like Big Data Analytics (BDA) are crucial for processing real data, improving productivity, and enhancing decision-making accuracy (Zhong et al., 2017). Cloud computing, another vital tool, assists in storing and analyzing vast real-time data from diverse sources in industrial manufacturing. It enables smooth communication and collaboration among companies, streamlining manufacturing procedures. Cloud computing promotes agility in digital production by linking companies internationally, facilitating efficient collaboration (Vaidya et al., 2018). Hence, it is important to include T2 in the discussion and analysis.

Similarly, excluding T4 from consideration leads to a minor decrease in Cronbach’s Alpha score, reducing it from 0.866 to 0.859. Although this decrease is slight, it remains significant. T4 focuses on how technologies such as advanced automation and the Internet of Things (IoT) enhance organizational agility. According to Mrugalska and Ahmed (2021, p.13), integrating machines with computers elevates modern manufacturing, enhancing its resilience, flexibility, and agility. Additionally, the IoT facilitates machine-to-machine communication, enabling efficient automation and enhancing technology capabilities and manufacturing system agility (Bueno et al., 2020). However, overcoming challenges like substantial investments and data security is imperative for the effective implementation of advanced technologies, ensuring the promotion of agility in manufacturing environments (Moktadir et al., 2018).

*Table 4 Technology Reliability Test Result*

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### 4.4.3 Leadership (L)

According to the data presented in Table 5, the reliability test for the Leadership factor is 90.70%, indicating its reliability in supporting the impact of the factor in the successful adoption of AM. Effective leadership establishes fundamental principles, devises strategies, and constructs mechanisms essential for implementing manufacturing agility (Attar & Abdul-Kareem, 2020). The survey results reveal that the mean for L1 to L5 ranges from 4.4273 to 4.5363, demonstrating widespread agreement among participants regarding the Leadership factor.

As indicated in the Item-Total Statistics Table, removing any of the L factors leads to a decrease in Cronbach's Alpha scores. This signifies that all L factors carry equal importance in the analysis. Removing L4 from the list would lower the reliability score from 0.907 to 0.872, emphasizing the significance of L4, which cannot be excluded. L4 discusses how effective leadership fosters innovation, playing a crucial role in the successful adoption of AM practices. According to Guzman et al. (2020), Leadership is vital in fostering an innovative culture within organizations. Several researchers summarize the impact of effective leadership within organizations, highlighting its essential role in advancing organizational agility. In this context, leaders motivate and guide team members to innovate and implement changes, enabling the company to adapt and progress toward the agility of organization, especially in challenging and unpredictable environments characterized by volatility and complexity (Neto et al., 2022, p.7). Thus, L2 is important and should be considered in the discussion and analysis.

Furthermore, removing either L1 or L5 from the list results in the same Cronbach’s Alpha score decrease, from 0.907 to 0.891. This suggests that both L1 and L5 factors carry equal significance, emphasizing their equal importance. L1 assesses the critical role of leadership support and dedication in fostering an organizational culture that values agility and flexibility. Gaining this support and commitment is vital for the successful implementation of AM (Sindhwani et al., 2019). Various researchers have emphasized the necessity of such backing to establish internal alliances and promote cooperation, as achieving agility requires reshaping business strategies and implementing new organizational policies (Mishra, 2014; Sindhwani and Malhotra, 2016). On the other hand, L5 underscores the importance of empowering cross-functional teams with decision-making authority in AM. This aspect highlights a crucial element of leadership in this context. Potdar et al. (2018) stated that decentralizing the decision-making process is a fundamental facilitator for AM. Effective leadership plays a primary role in defining and delegating decision-making powers, as well as creating cross-functional teams to enhance organizational agility. Thus, both L1 and L5 are essential for the adoption of AM and should be considered in discussions and analyses.

*Table 5 Leadership Reliability Test Result*

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### 4.4.4 Manufacturing Management (MM)

Based on the data provided in Table 6, the Manufacturing Management factor demonstrates a reliability score of 90.1%. The consistency in the research survey data establishes credible evidence for the significant impact of this factor on AM implementation. Sakthivel & Vidodh (2014) outlined diverse manufacturing management aspects that impact the implementation of AM, such as resource optimization, relationships with customers and suppliers, and quality control, to name a few. Furthermore, the mean scores for MM1 to MM5, ranging from 4.3000 to 4.3273, highlight an agreement among participants concerning the Manufacturing Management factor.

The decline in Cronbach’s Alpha score from 0.901 to 0.869, observed when MM3 is removed from the list according to the Item-Total Statistics Table, justifies its influence on AM implementation. Researchers have consistently emphasized the vital role of manufacturing management in fostering adaptable business practices, achieved through efficient planning, coordination, and resource utilization. This approach significantly contributes to the successful execution of AM strategies (Soepardi et al., 2018; Youssef and Al-Ahmady, 2002). Thus, MM3 holds critical importance in the argument and analysis regarding the implementation of AM.

Same as if MM4 is excluded from the list, the reliability score will decrease from 0.901 to 0.884. This shows how important MM4 is for AM adoption, stressing that it cannot be removed from the list and is essential for the overall analysis. MM4 highlights the significant involvement of manufacturing management in overseeing quality control processes. A study by Vasta & Asteem (2023) points out the link between product quality and agile practices, leading to cost reductions through more efficient processes, decreased waste, and the encouragement of continuous improvement methods. However, several researchers have observed a contrasting relationship between quality and agility. The recent study by Qamar et al. (2023) found out that meeting the demands of both scale and scope, requiring operational adaptability and responsiveness can affect efficiency and quality levels. This contrasts with earlier research suggesting a positive relationship between quality and flexibility, correlating with customer service satisfaction (Boyer & Lewis, 2002; Zhang et al., 2003).

*Table 6 Manufacturing Management Reliability Test Result*

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### 4.4.5 Concurrent Engineering (CE)

The results presented in Table 7 indicate a reliability test score of 91.40% for the Concurrent Engineering factor, affirming its reliability and supporting the research. As highlighted by Sankaranarayanan et al. (2019), Concurrent Engineering plays a crucial role in AM implementation. The mean scores for CE1 to CE5 fall within the range of 4.2182 to 4.2818, signifying strong agreement among participants regarding the significance of the Concurrent Engineering factor.

The Item-Total Statistics Table shows that removing any of the CE factors leads to a decrease in Cronbach’s Alpha scores, underlining their equal importance. Additionally, there are two CE factors with equal Cronbach’s Alpha scores. Removing either CE1 or CE3 from the list reduces the Cronbach’s Alpha score from 0.914 to 0.890. This indicates that both CE factors hold equal importance and are crucial in the analysis. CE1 explains how Concurrent Engineering promotes collaboration across different functions, supporting agile principles like teamwork and communication. CE refers to a cooperative and interdisciplinary method that creates, evolves, and validates a system solution, ensuring its balance throughout its lifecycle to fulfil stakeholders' requirements (ESTEC 2017). This method promotes AM values by facilitating effective communication and data sharing across varied design teams and customers (Alvarez & Roibas-Millan, 2021; Avnet & Wage, 2010). CE3 examines Concurrent Engineering's successful prevention of expensive delays and rework. Keirga et al.'s (2014) study supports this by highlighting CE's multiple benefits, including cost reduction through exploring various product and process options, time savings from reusing existing knowledge, and avoidance of delays caused by sudden changes. Thus, both CE1 and CE2 are important in the discussion and analysis of the study.

Furthermore, if CE5 were removed from the list, the reliability score would slightly drop from 0.914 to 0.902. However, if there is a need to eliminate one of the CE factors, CE5 should be the first to be removed. CE5 discusses how Concurrent Engineering accelerates product development, enhancing the agility of automotive manufacturers. Hartley (2017) supports this idea by emphasizing the advantages of incorporating Concurrent Engineering into product development. These benefits involve reducing lead times, enhancing quality, and reducing costs – all essential elements for automotive manufacturers. Hence, CE5 should remain a crucial consideration in the adoption of AM.

*Table 7 Concurrent Engineering Reliability Test Result*

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### 4.4.6 Organizational Performance (OP)

The Organizational Performance survey results, as reported in Table 8, demonstrates a reliability score of 88.1%. This score emphasizes the data's consistency, rendering it suitable for supporting the implementation of AM. Several researchers have emphasized the beneficial effects of AM on different aspects of operational performance such as competitiveness, flexibility, cost, quality, delivery, and service (Nabass & Abdallah, 2019, p. 647; Vazquez-Bustelo & Avella, 2005). The mean of OP1 to OP5 ranges from 4.2091 to 4.3636, which means participants mostly agree with the questions.

Taking OP4 out of the list, as shown in the Item-Total Statistics Table, leads to a drop in Cronbach’s Alpha score from 0.881 to 0.845. This decline has a significant effect on Cronbach’s Alpha value, highlighting OP4's considerable impact on AM adoption. OP4 explores how AM in the automotive industry can accelerate the creation of new products, offering a competitive edge. As stated by Gunasekaran et al. (2019), manufacturing agility requires the capacity to understand competitive demands, take initiatives, and innovate new product features ahead of rivals. This is crucial for automotive companies aiming to enhance their flexibility and customize products, gaining a competitive advantage in the market (Elmoselhy, 2013). Hence, including OP4 in the discussion and analysis is crucial.

Similarly, removing OP3 from the list results in a decrease in Cronbach’s Alpha score from 0.874 to 0.861. This decline indicates its importance and impact on Cronbach’s Alpha value. OP3 focuses on meeting customer needs, enhancing brand reputation, and encouraging customer loyalty. Customer satisfaction is a primary concern for any organization, and AM enhances this aspect by promptly addressing customer needs (Shin et al., 2015). Although implementing AM is challenging, proper management can enhance the sustainability of manufacturing systems (Venugopal & Saleeshya, 2018). Narkhede et al. (2020) suggested that companies can enhance their brand reputation, customer loyalty, market share, and profitability through successful implementation of AM, addressing challenges such as ineffective organizational management and limited experience in technology adoption.

*Table 8 Organizational Performance Reliability Test Result*

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## 4.5 Hypothesis Testing

### 4.5.1 Introduction

In research, ensuring reliability alone does not guarantee the validity of the findings (Sürücü & Maslakci, 2020). To draw meaningful conclusions from the analysis, it is essential to validate hypotheses. Hypothesis testing allows researchers to make conclusions about an entire population based on sample data, as shown by Schroeder et al. (2016). In this study, hypotheses are evaluated using regression analysis, a statistical method used to explore the relationship between two variables—one acting as an independent factor and the other as a dependent factor (Chatterjee and Hadi, 2015).

### 4.5.2 Hypothesis 1 Testing

*H1: Workforce positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

In this hypothesis test, AM implementation is the dependent variable, while Workforce is the independent variable. According to the test results in Table 9 Model Summary, the R-square value of 0.446 indicates that Workforce can account for 44.6% of the variance that impacts AM adoption. The Sig. F change value in this test result is below 0.001, indicating the important impact of the technology factors. Sindhwani & Malhotra (2017) stated that AM can be deployed effectively with of an empowered and flexible workforce.

The Coefficients table shows that W5 is the most significant factor in comparison to others. The significance value of W5 is 0.016, falling below 0.05 for a 95% confidence interval in this study. W5 examines the significance of effective communication and knowledge sharing among employees in the AM adoption. Several researchers highlighted the significance of communication and the sharing of information in adopting AM (Yli-Ojenpara et al., 2019; Loiro et al., 2019). Mittal et al. (2017, p. 465) pointed out that attributes like transparent information sharing and regular management-employee communication are essential in AM systems. Team members' communication and information sharing are crucial for managing dependencies. Nonetheless, while information holds significance, it can also pose challenges. Establishing a skilled workforce capable of guiding and optimizing AM practices, along with improving communication between the workforce and both internal and external stakeholders, represents the primary hurdles in effectively adopting agile practices within a company (Loiro et al., 2019, p 487). Therefore, it is crucial to uphold ongoing monitoring, control, and continuous improvement initiatives post-implementation (Sharif et al., 2001).

*Table 9 Regression Test Result for H1*

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### 4.5.3 Hypothesis 2 Testing

*H2: Technology positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

In this hypothesis test, AM implementation is the dependent variable, while Technology is the independent variable. According to the test results in Table 10’s Model Summary, the R-square value of 0.519 indicates that Technology can account for 51.9% of the variance that impacts AM adoption. The Sig. F change value in this test result is below 0.001, indicating the significant impact of the Technology factors. Research conducted by Khatri et al. (2018) revealed the crucial role of technology as a facilitator for AM, significantly influencing its adoption.

The Coefficients table shows that T4 is the most significant factor in comparison to others. The significance value of T4 is less than 0.001, which falls below 0.05 for a 95% confidence interval in this study. T4 discusses how technologies like advanced automation and the Internet of Things (IoT) boost the organization's agility. Dev & Kumar (2016, p. 883) highlighted the significant role played by these technologies in enabling the adoption of AM practices. Several of these tools incorporate automation and IoT capabilities. Ding et al. (2019) further stated that technologies like IoT aid in achieving increased agility. For instance, IoT advancements can transform interactions between customers, manufacturers, and suppliers. Customers can have the opportunity to play a more active role in decisions concerning product quality and customization by efficiently integrating advanced technologies (Thames & Schaefer, 2016). However, difficulty in adapting advanced technology poses significant challenges that organizations must further investigate and address to ensure successful AM integration and operation (Potdar et al., 2017).

*Table 10 Regression Table Result for H2*

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### 4.5.4 Hypothesis 3 Testing

*H3: Leadership positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

In this hypothesis test, AM adoption is the dependent variable, while Leadership is the independent variable. According to the test results in Table 11’s Model Summary, the R-square value of 0.389 indicates that Leadership can account for 38.9% of the variance that impacts AM adoption. The Sig. F change value in this test result is below 0.001, indicating the significant impact of the Leadership factors. Several researchers have explored the significance of effective leadership within organizations, emphasizing its crucial role in performance, learning, and achieving agility (Wanasida et al., 2021; Hall & Rowland, 2016; Busse & Weidner, 2020).

The Coefficients table shows that W5 is the most significant factor in comparison to others. The significance value of W5 is 0.045, falling below 0.05 for a 95% confidence interval in this study. L4 explores how leadership plays a vital role in fostering innovation, which then facilitates the successful implementation of AM practices. Neto et al. (2022) emphasized the crucial role of leaders in inspiring and motivating their teams to initiate innovations and changes. These efforts are essential for the company's growth and development, particularly in a challenging environment marked by volatility, uncertainty, complexity, and ambiguity (VUCA). Dabić et al. (2021) support this idea by emphasizing the importance of leaders possessing intellectual agility, which enhances the organization's ability to innovate positively.

However, a significant obstacle in AM system implementation is the absence of commitment from leadership (Sindhwani et al., 2019). Leaders often fail to recognize the potential advantages of the new systems, leading to ambiguous support for their implementation. Overcoming this challenge is crucial for organizations, as achieving agility necessitates the restructuring of business processes and the adoption of new organizational policies, emphasizing the need for internal alignment and cooperation (Sindhwani et al., 2019).

*Table 11 Regression Table Result for H3*

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### 4.5.5 Hypothesis 4 Testing

*H4: Manufacturing Management positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

In this hypothesis test, AM implementation is the dependent variable, while Manufacturing Management is the independent variable. According to the test results in Table 12’s Model Summary, the R-square value of 0.552 indicates that Manufacturing Management can account for 55.2% of the variance that impacts AM adoption. The Sig. F change value in this test result is below 0.001, indicating the significant impact of the Manufacturing Management factors. Potdar et al. (2017) highlighted the impact of manufacturing management on the progress of AM, considering the shifting focus of manufacturing objectives. Soepardi et al. also identified manufacturing management as a significant enabler in the adoption of AM.

The Coefficients table shows that MM3 is the most significant factor in comparison to others. The significance value of MM3 is 0.023, falling below 0.05 for a 95% confidence interval in this study. MM3 discusses how effective manufacturing management contributes to the development of adaptable business management strategies, which in turn help successful implementation of AM practices. Given that AM aims to create innovative products more swiftly than competitors, the company's production flexibility along with its product innovation capacities, is crucial for agility development (Zhang, 2011). Therefore, companies possessing manufacturing management incorporating flexible business strategies, like the ability to swiftly adjust production volume, product varieties, and modifications, play a pivotal role in driving agility (Soepardi et al., 2018; Sanchez et al., 2019).

*Table 12 Regression Table Result for H4*

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### 4.5.6 Hypothesis 5 Testing

*H5: Concurrent Engineering positively impacts Agile Manufacturing adoption in the Philippine Automotive Industry*

In this hypothesis test, AM implementation is the dependent variable, while Concurrent Engineering is the independent variable. According to the test results in Table 13’s Model Summary, the R-square value of 0.539 indicates that Concurrent Engineering can account for 53.9% of the variance that impacts AM adoption. The Sig. F change value in this test result is below 0.001, indicating the significant impact of the Concurrent Engineering factors. The adoption of concurrent engineering is crucial for businesses implementing AM (Sindhwani & Maholtra, 2016, p. 219; Bustelo and Avella, 2006). This approach involves simultaneous developing processes, serving as a connection between the organization, engineering and strategy.

The Coefficients table shows the presence of two significant factors when compared to others. Both CE4 and CE3 have significance values of 0.019 and 0.023, respectively, which are below 0.05 for a 95% confidence interval in this study. CE4 discusses how Concurrent Engineering enhances agility by enabling the organization to promptly respond to changing customer demands. Concurrent engineering plays a vital role in enhancing customer satisfaction by reducing operational time, enabling faster market entry, and subsequently boosting current revenue activities, leading to increased profits (Hoffmann et al., 2022). This speed in delivering products aligns with customer preferences and also shortens the product life cycle, supporting the principles of AM (Muhammad Ali & Razzaq, 2023, p. 430).

On the other hand, CE3 explores how the capability of Concurrent Engineering to prevent expensive delays and rework presents a significant advantage for automotive manufacturers. As stated by Alvarez & Roibas-Millan (2021), Concurrent Engineering facilitates cost savings in both product and process dimensions by exploring various alternatives. It accelerates development timelines by utilizing existing knowledge, preventing delays caused by sudden changes. Furthermore, it reduces risks by evaluating multiple solutions simultaneously. Additionally, Kumar Nag (2023) highlighted that implementing the Concurrent Engineering method efficiently in the early design phases by eliminating unnecessary expenses can result in significant savings in the automotive industry. This aspect aligns with AM principles, promoting cost reduction and the shortened life cycle of products.

*Table 13 Regression Test Result for H5*

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## 4.6 Analysis of Hypotheses Testing Summary

In this chapter, an analysis will be conducted on the factors affecting the adoption of Agile Manufacturing and its impact on organizational performance, addressing research objectives two and three, respectively.

### 4.6.1 Analysis of the Critical Success Factors Impacting the Implementation of AM

As shown in Table 14, the R square values for crucial factors in AM implementation range from 38.90% to 55.20%. The highest R-square values are 0.552 (Manufacturing Management), 0.539 (Concurrent Engineering), and 0.519 (Technology), with the lowest R-square value being 0.389 (Leadership).

Manufacturing Management exhibits the highest R square value among the five key success factors, indicating its importance in successful AM implementation. This finding is consistent with prior research. Sakthivel (2014) ranked Manufacturing Responsibility and Management as the top two facilitators for AM adoption. However, the study by Potdar & Routroy (2018) highlighted that while MM is crucial for AM, its influence is relatively low, relying heavily on other AM enablers like devolution of authority and information transparency. MM oversees manufacturing activities through effective planning, control strategies, and production methodologies, underscoring its essential role in AM implementation.

The factor that has the second-highest R square is Concurrent Engineering. CE, involving simultaneous product design and development, stands as a crucial component in AM. Recognized as a key driver for AM implementation, CE significantly reduces both product development time and lead time (Sankaranarayanan et al., 2019).

Technology has the third-highest R square value. Technology encompasses significant elements like manufacturing setups, product service, product life cycle, design enhancement, manufacturing planning, production methods, automation types, and integrating information technology. Companies with a forward-thinking approach regarding these aspects are deemed better suited for the implementation of AM practices (Ali & Wasim, 2022, p. 9).

The factor with the second-lowest R square is Workforce. This finding is in line with Atiq-Ur-Rehman's (2017) research, which positioned the Workforce as the least significant agility enabler, with management response and supply chain ranking higher. However, Dubey & Gunasekaran (2015) emphasized the importance of a flexible workforce for ensuring organizational agility, ranking both workforce and technology as crucial factors for AM adoption.

This finding corresponds with the research by Kumar et al. (2020), where leadership is recognized as a substantial factor in AM implementation although is ranked lower than information technology and human resource factors. Earlier research efforts have consistently emphasized the vital role of leadership support, emphasizing its involvement in shaping the policies and strategies employed by organizations to facilitate AM deployment (Venugopal and Saleeshya, 2019; Sindhwani and Malhotra, 2016; North & Varvakis, 2016).

*A table with text on it

Description automatically generatedTable 14 Critical Success Factors for AM Deployment*

### 4.6.2 Analysis of AM Implementation on Organisational Performance

The test results in Table 15 indicate an average mean of 4.249 for Organizational Performance. This suggests an agreement among the respondents that AM adoption has a crucial influence on overall organizational performance.

OP3 stands out with the highest mean score of 4.3636 and a standard deviation of 0.68707. The majority of respondents agreed that AM is focused on meeting customer requirements, enhancing brand image, and fostering customer loyalty. This finding corresponds with earlier research emphasizing AM's ability to swiftly and effectively adapt to evolving customer demands, thereby enhancing customer satisfaction and loyalty markets (Khalfallah & Lakhal, 2021a). Additionally, implementing agile practices not only enhances the firm’s brand reputation but also positively impacts its social standing in global business (Hirayani & Mishra, 2022).

OP1 holds a mean score of 4.2545, ranking as the second highest, and has a standard deviation of 0.66961. This indicates that a majority of the respondents acknowledged that AM results in cost savings by reducing waste and optimizing resource allocation in production and operations. Dubey & Gunasekaran (2015) emphasized how AM practices can improve environmental performance by reducing waste. Meanwhile, Liu & Liang (2015) pointed out that AM continuously optimizes resource allocation, providing a competitive advantage. However, Nabass & Abdallah (2019) countered this perspective, stating that AM may not necessarily reduce costs; in fact, companies implementing AM often spend more on operations, such as investing in new technologies and business processes.

OP2 has a mean score of 4.2182 with a standard deviation of 0.80573. This indicates that a majority of respondents acknowledged that AM promotes innovation, resulting in the creation of new products, processes, and business models. This study's findings align with the research conducted by Leite & Braz (2016), which revealed that AM practices, including innovation, enhance organizational performance.

OP4 has a mean score of 4.2091 and a standard deviation of 0.74311. This indicates that the majority of the respondents agreed that AM in the automotive sector can accelerate the creation of new products, providing a competitive edge. Earlier studies conducted by Hallgren & Olhager (2009) substantiated these results by emphasizing AM’s capacity to speed up the introduction of new products to the market and customize products efficiently. This is crucial for automakers as it enhances their product flexibility and overall business performance.

OP5 has a lowest means score of 4.2000 and a standard deviation of 0.68804. This shows that the majority of respondents agreed that effective implementation of AM leads to enhanced product quality and reduced defects. This finding contradicts Amir et al.'s (2019) study, which suggested a trade-off between quality and reduced defects in agility. However, it supports Gunasekaran et al.'s (2016) research, affirming that AM adoption is linked to improved product quality and overall business performance.

In summary, the implementation of AM has a positive and substantial influence on the organizational performance of the Philippine automotive industry, confirming the third research objective.

*Table 15 Regression Test Result for H6*

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# 5. CONCLUSION

## 5.1 Introduction

The adoption of Agile Manufacturing results in positive outcomes across various industries (Nabass & Abdallah, 2019). Similarly, as demonstrated in the preceding sections of this study, AM has a beneficial impact on the automotive sector in the Philippines. As detailed in section 1.4, this chapter provides recommendations regarding crucial factors that can improve the successful adoption of AM in the Philippine automotive industry. Additionally, this chapter discusses the research limitations, and future research directions, and concludes the study.

## 5.2 Recommendation

### 5.2.1 Integration of Agile-Concurrent Methodologies

Integrating AM and concurrent engineering methodologies is advantageous for businesses aiming to meet the demands of contemporary markets, where traditional manufacturing techniques often fall short. This integration provides a competitive edge by ensuring adaptability and efficiency in the face of modern market challenges (Žužek et al., 2020). Both approaches emphasize transparent and interactive communication among stakeholders (Dongre et al., 2017, p. 2768; Ojanpera et al., 2019). This emphasis is particularly crucial in sectors like automotive, where rapid product development is vital to meet market demands. Companies need to provide customers with comprehensive project updates to enable extensive feedback, facilitating the rapid formulation of final requirements and reducing product development lead times (Žužek et al., 2020).

Moreover, both agile and concurrent methodologies recognize the advantages of establishing multidisciplinary teams early in the project and fostering collaboration throughout (Kumar & Singh, 2020; Álvarez & Roibás‐Millán, 2021). Companies should adopt this collaborative approach as it enhances responsiveness, speeds up decision-making, reduces production timelines, and ultimately leads to higher customer satisfaction (Mas'udin & Kamara, 2017).

Understanding these common principles, in addition to the core values of flexibility and rapid adaptation to change, is crucial for companies considering the implementation of the hybrid approach combining agile and concurrent methodologies.

### 5.2.2 Adapting Flexible Manufacturing Management Practices

Flexible AM manufacturing processes allow companies to quickly reconfigure production lines, adjust product specifications, and respond rapidly to changing customer preferences (Esmaaeilian et al., 2016). An example of this is implementing flexible automation systems that can be easily reprogrammed for different tasks enabling efficient production adjustments without significant downtime (Löfvinga et al., 2018, p. 180). Additionally, embracing a modular approach in product design facilitates the incorporation of new features or modifications without redesigning the entire vehicle, reducing time-to-market significantly (Cabigiosu et al., 2013).

Another crucial aspect of flexible business practices in AM is supply chain flexibility. Automotive companies can establish agile and resilient supply chains by diversifying suppliers, employing real-time tracking systems, and fostering collaborative relationships (Butt, 2021; Kshetri, 2018; Shekarian & Parast, 2020). By establishing diverse sourcing options and efficient logistics, companies can alleviate the effects of unforeseen disruptions in the supply chain, such as those caused by recent events like the COVID-19 pandemic and the subsequent global shortage of semiconductor chips. This aligns with AM’s core principles of responsiveness to change and market volatility.

### 5.2.3 Utilization of Advanced Technologies

In the automotive industry, the adoption of advanced technologies is becoming increasingly vital to enhance agility in manufacturing processes. Companies are leveraging cutting-edge technologies to optimize production, improve efficiency, and respond swiftly to market demands. (Giacosa et al., 2022, p.1). Gunasekaran et al. (2018) proposed incorporating emerging technologies like big blockchain, big data and the Internet of Things to influence contemporary AM approaches. IoT sensors embedded in manufacturing equipment and vehicles collect data in real time, allowing predictive maintenance and proactive issue resolution. This predictive capability minimizes downtime, reduces maintenance costs, and ensures seamless production flow, contributing significantly to agile practices (Mourtzis et al., 2016, p. 290).

Robotics and automation also play an important role in AM, particularly in the automotive sector. Collaborative robots work alongside human workers, performing repetitive and time-consuming tasks, thereby improving efficiency and freeing human resources for more complex activities (Costa et al., 2017). Additionally, 3D printing technology offers agility in prototyping and customization. It enables rapid iteration of designs, reducing lead times and costs associated with traditional manufacturing processes (Chen & Lin, 2019). These technologies enhance flexibility, reduce costs, and improve operational efficiency, enabling companies to navigate the complexities of the modern market landscape successfully.

## 5.3 Limitation of Research

There are few limitations in this study. Firstly, the research focused solely on five critical factors influencing the successful implementation of AM within the automotive industry. However, these factors might not provide a comprehensive perspective, making it challenging to definitively establish their impact on AM adoption. Secondly, the methodology and sample used in this study limit the applicability of its conclusions, making them not universally applicable to all companies implementing AM practices. Additionally, the geographic location of the respondents could have influenced their responses, making it challenging to generalize the findings to other regions. Lastly, this review might have missed some high-quality papers related to AM or agility due to the constraints within the search methodology.

## 5.4 Future Research

Limited by time and financial constraints, the study did not extensively explore AM concepts, encompassing the influence of the workforce on the implementation of AM, along with investigating the obstacles and challenges linked to adopting AM, to provide insights in overcoming them. This constrained focus was designed to encourage additional research in this particular domain.

Additionally, the workforce factor, traditionally considered a significant contributor to successful AM implementation, has the least impact according to this study. This contrasts with prior research emphasizing its importance (Goswami et al., 2018). Subsequent studies could explore into the specific impact of the workforce on AM implementation within distinct industries.

Finally, numerous researchers have employed a range of tools, techniques, and methodologies in their studies concerning AM. Enhancing the accuracy of results in this study could be achieved by adopting standardized instruments, strategies, and methodologies, or by integrating these diverse tools and techniques.

## 5.5 Conclusion

The automotive industry functions within an intensely competitive landscape, characterized by swift shifts in consumer preferences, unexpected disruptions, and the constant emergence of new technologies. Recognizing the elements crucial for implementing agile manufacturing in this sector is essential for effectively manoeuvring through the industry's challenging market conditions.

After considering various factors from different sectors and countries, the researcher focused on the top five factors that impact the implementation of AM in the automotive industry in the Philippines for detailed examination. The objective was to comprehend how these factors affect agile manufacturing and, consequently, organizational performance. The research involved a thorough literature review of these chosen factors and utilized an online survey questionnaire to gather data for the hypotheses testing.

From the findings discussed in Chapter 4, it was discovered that agile manufacturing implementation significantly relies on flexible manufacturing management, concurrent engineering practices, and the use of advanced technologies. Moreover, adopting agile manufacturing most profoundly impacts organizational performance by enhancing brand image and fostering customer loyalty.

However, there is still the opportunity for future research to uncover additional crucial factors influencing the adoption of agile manufacturing in the automotive industry in the Philippines and its subsequent impact on the overall performance of the organization.

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# 7 APPENDIX

## 7.1 Appendix A: Master Schedule of the Research

A screenshot of a spreadsheet

Description automatically generated

## A screenshot of a computer Description automatically generated7.2 Appendix B: Questionnaire Survey Form

A screenshot of a cell phone

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A screenshot of a survey

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A screenshot of a survey

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A screenshot of a survey

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A screenshot of a survey

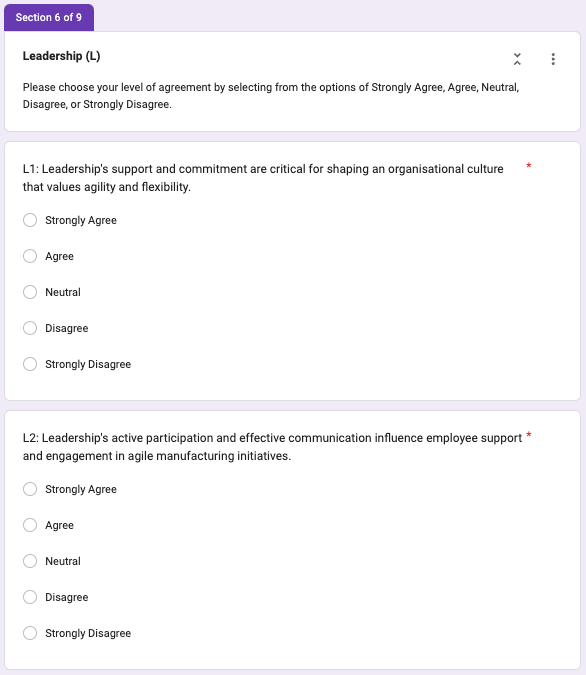
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A screenshot of a survey

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## 7.3 Appendix C: Results of the Reliability Test in SPSS

Workforce Reliability Test Results

A screenshot of a report

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Technology Test Results

A screenshot of a report

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Leadership Test Results

A screenshot of a report

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Manufacturing Management Test Results

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Concurrent Engineering

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Organizational Performance

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## 7.4 Appendix D: Results of the Regression Test in SPSS

Workforce

A screenshot of a spreadsheet

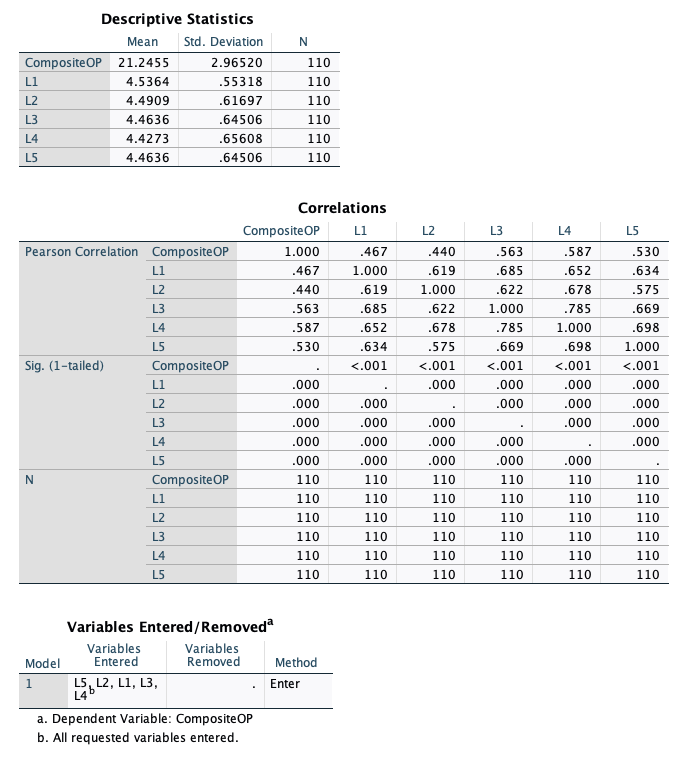
Description automatically generated

Technology

A screenshot of a spreadsheet

Description automatically generated

Leadership



Manufacturing Management

A screenshot of a data sheet

Description automatically generated

Concurrent Engineering

A screenshot of a computer

Description automatically generated