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Integrated Defence Manufacturing Ecosystem Approach for the UAE (IDEA-UAE)

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Integrated Defence Manufacturing Ecosystem Approach for the UAE (IDEA-UAE)

Khalifa Murad Alblooshi

A thesis submitted in partial fulfilment of the requirements of

Sheffield Hallam University

for the degree of Doctor of Philosophy.

June 2024

Declaration

I hereby declare that:

1. I have not been enrolled for another award of the University or other academic or professional organisation, whilst undertaking my research degree.

2. None of the material contained in the thesis has been used in any other submission for an academic award.

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5. The word count of the thesis is 38060**.**

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Date	June 2024
Research Institute	Industry & Innovation Research Institute
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Acknowledgement

With extensive experience in the UAE defence manufacturing sector, I have always wanted to pursue a PhD. This aspiration was made achievable through the exceptional guidance of my supervisory team and the steadfast support of my family and colleagues.

From the outset, Prof. Terrence Perera, my Director of Studies, was pivotal in shaping my research proposal and overseeing my work. His invaluable guidance, professional support, and inspiring leadership were instrumental in my early progress. His kindness and dedication to my research development were remarkable, fostering an environment where I could thrive academically. Even after Prof. Perera's retirement in March 2020, the transition was seamless thanks to Dr. Hongwei Zhang, who assumed the supervisory role. Dr. Zhang continued to provide outstanding support and advice, maintaining the high standards set by Prof. Perera. I am deeply grateful for his unwavering commitment and insightful guidance.

The journey through the rigours of a PhD study is fraught with challenges and overcoming them would have been impossible without the unwavering support of my family. Their constant encouragement, understanding, and belief in my abilities were crucial in sustaining my motivation and perseverance. Their support extended beyond emotional encouragement and created a conducive environment for my studies, allowing me to focus on my research.

In addition to my family and supervisory team, I am immensely grateful to my colleagues and friends who contributed to this journey. Their intellectual companionship, constructive feedback, and moral support enriched my research experience. Special thanks go to those who meticulously proofread my thesis. Their patience, attention to detail, and dedication significantly enhanced the readability and quality of my work.

Abstract

Research undertaken, personal experience, and industry insights indicate a need to develop a comprehensive ecosystem for the UAE defence manufacturing sector. The sector lacks such an ecosystem, which is crucial for fostering innovation, sustainability, and economic growth. Developing a robust ecosystem involves integrating government entities, private companies, research institutions, and educational facilities into a collaborative environment that drives technological advancements and innovative solutions. This synergy enhances the quality and competitiveness of defence products globally.

Supported by extensive literature reviews, surveys of industry professionals, and analysis of industry reports, it is clearly identified that there is a pressing need for research in this area. A comprehensive analysis of defence manufacturing practices in newly industrialised countries and developed nations has paved the way to identify best practices that have significantly contributed to the growth of their defence manufacturing industries. Among these best practices, having a robust ecosystem emerges as a major feature.

The Integrated Defence Manufacturing Ecosystem Approach for the UAE (IDEA-UAE) is developed by systematically synthesising various ecosystems. This approach covers a range of critical areas, such as supply chain management, talent development, technological innovation, regulatory compliance, and strategic partnerships. Each ecosystem is explored in depth to support the creation of an integrated approach, and its main actors are identified. Given the importance of Industry 4.0 in manufacturing, the most promising framework for defence manufacturing is also identified.

Contents

Chapter 1: Introduction and Research Aim & Research Questions

1.1 Introduction

The chapter commences with a detailed explanation of the principal characteristics that describe the defence manufacturing industry, alongside an analysis of the growth and evolution of the defence manufacturing sector in the United Arab Emirates (UAE). It proceeds to outline the challenges and difficulties experienced by the UAE's defence manufacturing sector. Subsequently, this chapter presents the overarching aim of the research and articulates the specific research questions that the study attempts to answer. In addition, it offers an overview of the subsequent chapters of the thesis, thereby providing a preliminary understanding of the structure and content of the research study.

1.2 Nomenclature

The terms "defense" and "defence" are often used synonymously in academic literature. For consistency in this thesis, "defence" is the preferred term, except in instances where "defence" is retained to reference publications and diagrams from external sources accurately. Similarly, "defence manufacturing base" and "defence manufacturing industry" have been used interchangeably. To ensure uniformity, the term "defence manufacturing industry" will be used consistently throughout this thesis.

1.3 Evolution of the Defence Manufacturing Industry

Conflicts among nations have been a common phenomenon since the dawn of humanity. Strategic intelligence and advanced weaponry have often been critical elements in determining the outcomes of these conflicts (O'Brien, 2015). The inception of weapon production can be traced back to the Bronze Age, around 5000 BC, which was marked by crafting metal daggers and swords (Uckelmann & Mödlinger, 2011). The intensification of regional conflicts and two World Wars in the 19th century led to the evolution of the weapons manufacturing sector into a significant industry, now recognised as the defence manufacturing industry.

Wars are profoundly tragic, causing loss of lives, enduring emotional and psychological trauma, and economic destabilisation (Modell & Haggerty, 1991; Glick & Taylor, 2010).

Regrettably, the harsh lessons from the two World Wars and subsequent 20th-century conflicts seem to have been disregarded, with disputes still escalating in the 21st century (Sampa, 2017). These ongoing conflicts and the necessity to safeguard nations are driving the demand for defence equipment.

Initially, defence manufacturing was dominated by industrialised countries, primarily serving to supply their military forces. However, as many nations lacked technological and manufacturing capabilities, the defence sector eventually emerged as a global marketplace (Thurner et al., 2019).

1.4 United Arab Emirates Defence Manufacturing Sector

The United Arab Emirates (UAE) is a federation of seven states that has transformed from a tranquil backwater into one of the Middle East's most significant economic hubs. In light of regional tensions (Davidson, 2009), the UAE has strengthened its military base over the years, primarily through acquiring military hardware from Western countries (Gaub & Stanley-Lockman, 2017).

In 2014, the UAE's military spending was estimated at $22.8 billion (Figure 1.1), accounting for 5.6% of its GDP, making it the second-largest military spender in the Middle East and 14th globally, with a significant increase of 136% in expenditure from 2006 to 2014 (Wezeman & Kuimova, 2019).. The UAE's arms imports surged nearly fourfold from 1999–2003 to 2004–2008, then decreased but remained high, ranking it the fifth-largest arms importer from 2009 to 2018 (Figure 1.2). The country has modernised its military, acquiring advanced aircraft, naval vessels, and missile defence systems. It enhances its intelligence and reconnaissance capabilities, including procuring radar systems and surveillance satellites.

Figure 1.1: Military expenditure by Iran, Saudi Arabia, Qatar and the UAE,1994–2018 (Wezeman & Kuimova, 2019)

Figure 1.2: Major arms imports by Iran, Saudi Arabia, Qatar and the UAE,1994–2018 (Wezeman & Kuimova, 2019)

The sustainability of the UAE's defence expenditure and imports is a matter of concern due to several factors. Firstly, the high level of military spending places a significant burden on the national budget. Secondly, the heavy reliance on imported arms can lead to a dependency on foreign suppliers, making the UAE vulnerable to geopolitical shifts and trade disruptions. Additionally, the rapid pace of military modernisation and advanced technology acquisition necessitates continuous training and maintenance investment, further straining financial resources. Moreover, the fluctuating global oil prices, which significantly impact the UAE's economy, can lead to financial instability, making such high levels of defence spending and imports unsustainable in the long term (Roberts, 2020).

Given the above scenarios, the UAE strives to enhance its domestic arms production capacity. This initiative aims to lessen its political reliance on the United States and other major powers leading the global defence industry, broaden its economic base, assert its status and prestige within the region and boost its military standing (Borchert, 2021).

1.5 UAE Defence Manufacturing Industry Ambitions

The defence industrial base of the UAE is considerably more recent than that of Egypt and Saudi Arabia. Only about two decades ago, the UAE's state-owned enterprises started to delve into defence services and maritime security industries. Nevertheless, the UAE stands out as the most promising among Arab nations aspiring to become emerging arms producers (Gaub & Stanley-Lockman, 2017). Notably, the UAE has been more forthright in its ambition to become a net arms exporter, setting itself apart from other regional actors. This ambition is partly supported by the stronger position of the Emirati economy, which is more conducive to fostering a knowledge-based economy. In 2023, the UAE was ranked 26th out of 140 countries on the Knowledge-economy Index, and the United Arab Emirates maintained its leading position among the Arab countries (European Bank for Reconstruction & Development, 2023). The UAE's Vision 2021 explicitly aims to transition to a knowledge-based economy, with goals to be among the top ten countries in innovation within 11 years, triple its research and development (R&D) expenditure to 1.5%, and nearly double the proportion of 'Knowledge Workers' in its workforce (Livsey, 2019).

1.6 Barriers to rapid growth

Despite its ambitious goals to emerge as a leading player in the defence manufacturing sector, the UAE has encountered numerous obstacles in developing its industry. These challenges stem from various factors that have impeded its progress.

The relative infancy of the UAE's defence industry means it lacks the historical depth and experience found in more established defence manufacturing nations. This inexperience has made it difficult to rapidly build a comprehensive industrial base capable of competing on a global scale (Borchert, 2021)

Technological advancement is another major hurdle. Developing cutting-edge military technology necessitates substantial research and development (R&D) efforts and access to advanced scientific and engineering knowledge. The UAE has invested in these areas, but technology transfer restrictions and developing indigenous capabilities from scratch have been challenging (Papaspyridis & Zalan, 2017).

The global defence market is highly competitive and dominated by long-established companies from countries with strong military-industrial complexes. For the UAE, breaking into this market and establishing a foothold requires significant financial investment and the development of unique and competitive products (Kurç & Neuman, 2017).

Moreover, the regulatory environment and strategic alliances play a crucial role in shaping the opportunities and limitations of the defence manufacturing sector. International arms trade regulations and the UAE's strategic and diplomatic considerations influence its ability to export and import defence-related products and technologies (Heidenkamp et al., 2015)

Developing a skilled workforce is essential for the growth of the defence manufacturing industry. The UAE needs to cultivate a pool of local talent capable of driving innovation and managing the complex processes involved in defence production. This requires focused educational and training programs to build expertise in defence technology and manufacturing (Karasik & Dempsey, 2017).

Whilst it is possible to argue that any nation might experience the above barriers at the early stage of development, there are other specific factors as well.

1.7 Personal reflections of the researcher

The researcher has more than 15 years of experience in the UAE defence industry and has been directly involved with various government initiatives. In addition to the barriers identified in section 1.6, the researcher observed the following, which may have impeded the industry's growth.

(a) Inadequate integration of Small and Medium-Sized Enterprises (SMEs) into broader business ecosystems

Small and Medium-Sized Enterprises (SMEs) are vital in the defence manufacturing industry, providing essential innovation and flexibility. They supply unique components and services, enhancing the supply chain's resilience and adaptability to new technologies. SMEs' agility and specialised expertise foster a competitive environment, driving technological advancements in defence. Their integration into larger defence ecosystems strengthens the industry by broadening the base of innovation and expertise. Moura & Oudot (2017) present the critical role of SMEs in developing France's defence industrial base.

(b) Delays in forming a single coordinating entity for the defence manufacturing sector

In nations where the defence manufacturing industries are firmly established and highly developed, a centralised authority or singular organisation is typically designated to assume the leadership role. This entity oversees the strategic direction, coordination, and integration of various activities within the sector. For example, in the UK, the Defence Equipment and Support (DE&S) is the single body responsible for defence manufacturing and procurement. Only in 2014 did the government of the UAE establish the Emirates Defence Industries Company EDIC to coordinate the sector's activities (Alazazi, 2017). Five years later, EDIC was rebranded as EDGE to reflect a shift in strategy and positioning in the global defence industry (Samaan, 2024). This delay in forming an innovation-focused central entity must have adversely affected the development of the indigenous defence manufacturing sector in the UAE.

Figure 1.3 below visualises the underlying causes.

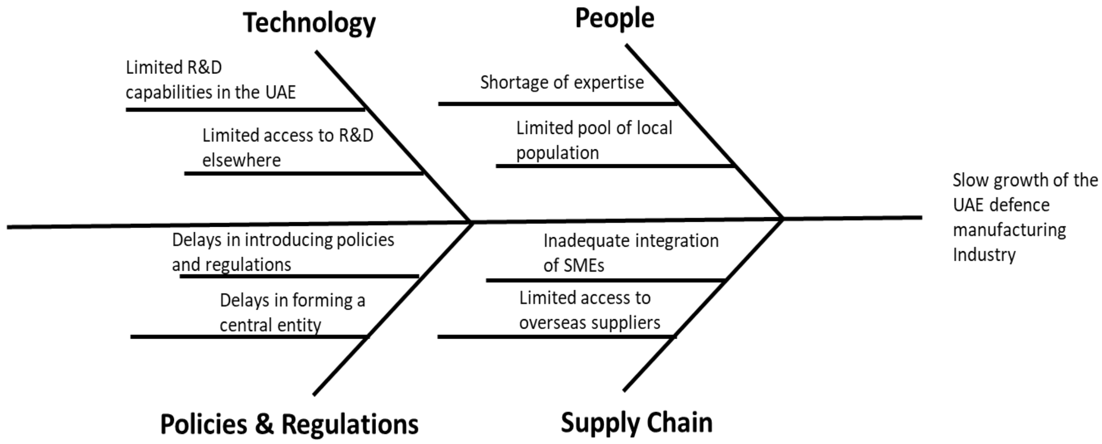

Figure 1.3: Underlying causes of the slow growth of the UAE defence manufacturing industry

1.8 Developing a Robust Ecosystem and Embedding Industry 4.0

As pointed out, the UAE defence manufacturing sector lacks a comprehensive ecosystem. Developing a robust ecosystem for the defence manufacturing sector brings numerous benefits, fostering innovation, sustainability, and economic growth. A well-integrated ecosystem connects government entities, private companies, research institutions, and educational facilities, creating a collaborative environment that drives technological advancements and innovative solutions. This synergy enhances the quality and competitiveness of defence products globally. Furthermore, it supports the development of a skilled workforce through targeted education and training programmes, ensuring that the sector has access to talent with the necessary technical and engineering skills. Economically, a strong defence manufacturing ecosystem attracts investment, encourages entrepreneurship, and stimulates job creation, contributing to the overall health of the national economy. Additionally, it can reduce dependence on foreign technology.

As the development of a robust ecosystem is considered, it is prudent to embrace emerging technologies such as Industry 4.0. For example, integrating Industry 4.0 technologies into the defence manufacturing ecosystem represents a significant leap forward in efficiency, innovation, and security by harnessing the power of advanced digital technologies.

1.9 Aim, Objectives & Research Questions

Aim: This research aims to design a conceptual framework for a robust and comprehensive defence manufacturing ecosystem for the UAE.

Key objectives:

(i) Conduct a comprehensive literature review to establish current knowledge and identify research gaps.

(ii) Conduct a questionnaire survey to assess the current state of the UAE defence manufacturing industry.

(iii) Critically review the successes and challenges of recently established defence industries

(iv) Identify best practices in the defence manufacturing industry from established and recently developed industries.

(v) Develop a framework for designing an ecosystem supported by Industry 4.0

(vi) Validate and refine the framework.

Research Questions:

This research study aims to seek answers to the following research questions.

Research Questions 1: What best practices can be derived from rapidly developed defence industrial bases in recent years?

Research Questions 2: What are the key elements of the defence manufacturing ecosystem, and how can they be adapted to develop the UAE's defence industrial base?

Research Question 3: Given the benefits of Industry 4.0 technologies, how can the concept enhance UAE defence manufacturing capabilities?

1.10 Contribution to Research

The research presents several potential contributions to the field of defence manufacturing, particularly within the context of the United Arab Emirates. By designing a conceptual framework for a robust and comprehensive defence manufacturing ecosystem, the study aims to significantly enhance the UAE's defence capabilities. This research is expected to fill critical gaps in the existing literature by offering an in-depth analysis of the challenges and opportunities within the UAE's defence sector, thus providing valuable insights into best practices and strategic initiatives. Moreover, integrating Industry 4.0 technologies into the defence manufacturing process promises to revolutionise efficiency, innovation, and security. The findings and proposed frameworks from this study could serve as a model for other emerging defence industries globally. Additionally, this research emphasises the importance of developing a skilled workforce and integrating SMEs into the defence ecosystem, which could drive technological advancements and economic diversification. Overall, this study can substantially contribute to academic knowledge and practical applications within the defence manufacturing industry.

1.11 Structure of the Thesis

Chapter 1: Introduction and Research Aim & Research Questions

This chapter sets the stage for the research by providing an overview of the study's context and significance. It outlines the primary aims of the research, clearly defining what the study intends to achieve. Additionally, it poses the key research questions that will guide the investigation, ensuring a focused and coherent exploration of the topic.

Chapter 2: Literature Review

This chapter reviews existing literature and previous studies relevant to defence manufacturing and ecosystems. It critically examines the theoretical frameworks and empirical findings that inform the research, identifying gaps and areas for further exploration. This comprehensive review establishes a solid foundation for the current study and situates it within the broader academic discourse.

Chapter 3: Research Methodology

This chapter details the research design and methodologies to address the research questions. It discusses the chosen methods, such as qualitative or quantitative approaches, data collection techniques, and analytical tools. The chapter also justifies the methodological choices and explains how they align with the research aims, ensuring the study's validity and reliability.

Chapter 4: Questionnaire Survey & Viewpoints from Industry Research

Here, the focus is on the data collection through questionnaire surveys and interviews with industry experts. The chapter describes the design and distribution of the questionnaires, the sampling methods, and the analysis of the responses. It also presents insights and viewpoints gathered from industry professionals, adding practical perspectives to the research findings.

Chapter 5: Comparative Analysis of Defence Manufacturing Bases

This chapter provides a comparative analysis of various defence manufacturing bases worldwide. It evaluates their strengths, weaknesses, and unique features, drawing parallels and contrasts. The analysis aims to identify best practices and strategic advantages that could inform the development of a robust defence manufacturing sector.

Chapter 6: Defence Manufacturing Ecosystems

This chapter explores the concept of defence manufacturing ecosystems in depth. It examines the interconnected networks of suppliers, manufacturers, and other stakeholders involved in defence production and highlights the importance of these ecosystems in enhancing efficiency, innovation, and competitiveness in the defence sector.

Chapter 7: Integrated Defence Manufacturing Ecosystem Approach for the UAE – (IDEA-UAE)

This chapter proposes a tailored approach for developing an Integrated Defence Manufacturing Ecosystem in the UAE. It outlines the strategic initiatives and policy recommendations necessary to foster a cohesive and efficient defence manufacturing environment. The IDEA-UAE model aims to leverage the UAE's unique strengths and position it as a leader in the global defence industry.

Chapter 8: Conclusions, Contribution to Knowledge and Further Work

The final chapter summarises the research's key findings and conclusions. It reflects on the study's contributions to academic knowledge and practical implications for the defence industry. Additionally, it suggests areas for further research and potential future developments, ensuring the continued advancement of the field.

Chapter 2: Literature Review

2.1 Introduction

This chapter offers an in-depth overview of the comprehensive literature review conducted as an introductory research element. The primary goal is to present the significant academic contributions made by the broader scholarly community within this field of study. A critical analysis will scrutinise the relevant literature, evaluating the strengths and shortcomings of existing research.

Moreover, this aims to identify research gaps related to the UAE defence manufacturing industry and justify the need for the proposed study.

2.2 Evolution of Global Defence Manufacturing Industry

The history of defence manufacturing is a captivating journey spanning centuries, mirroring the evolution of military technologies and strategies. From the initial days of basic weaponry to the sophisticated systems of contemporary warfare, this section explores the key milestones and transformative shifts that have shaped the field of defence manufacturing.

(a) Ancient Warfare and the Birth of Defence Manufacturing (3000 BC- 500 AD): The origins of defence manufacturing trace back to the ancient civilisations of Egypt, Mesopotamia, and China, where basic weapons like spears, swords, and bows were crafted for combat. The advent of bronze and iron metallurgy led to significant advancements, resulting in stronger and more effective weapons and armour. Ancient civilisations often depended on skilled artisans and blacksmiths to produce these instruments of war, contributing to the emergence of defence manufacturing as a specialised craft (Carman & Harding, 2009).

(b) Medieval Advances and the Rise of Artillery (500 AD - 1500 AD): The medieval era saw notable advances in defence manufacturing, primarily due to the rise of siege warfare. The construction of castles and fortified city walls necessitated the creation of powerful siege engines, such as trebuchets and catapults, crucial for breaching enemy defences. The production of artillery expanded during this period, with improvements in engineering and Metallurgy allowing for manufacturing more durable cannons and firearms (Kinard, 2007).

(c) Industrial Revolution and the Mechanisation of Warfare (1500 AD - 1914 AD): The Industrial Revolution marked a pivotal moment in defence manufacturing, as mechanised production processes revolutionised the industry. Steam power, mass production techniques, and interchangeable parts facilitated weaponry and equipment mass production. The development of rifled barrels and cartridge-based ammunition significantly improved the accuracy and firepower of firearms. Moreover, the Industrial Revolution spurred the creation of naval fleets, ironclad warships, and steam-powered engines, transforming maritime warfare (Anand, 1999; Searle, 2017)

(d) World Wars and Technological Knowhow (1914 AD - 1945 AD): The First and Second World Wars hastened the pace of technological advancements in defence manufacturing. During this period, the deployment of chemical weapons, tanks, aircraft, submarines, and radar systems transformed the battlefield. Manufacturing became increasingly centred on mass production, standardisation, and assembly line techniques, ensuring a consistent supply of weapons and equipment for the military forces engaged in large-scale conflicts (Mohanty, 2000; Hayward, 2001).

(e) Post-World War Era and the Rise of High-Tech Defence (1945 - Present): The post-World War II era witnessed remarkable advancements in defence manufacturing driven by rapid technological progress. The onset of the Cold War and the space race between the United States and the Soviet Union fuelled competition for superior military capabilities (Lovering, 2020). This led to the development of missile systems, advanced aircraft like supersonic jets, precision-guided munitions, and the miniaturisation of electronics. Defence manufacturing increasingly depended on cutting-edge research, development, and collaboration with the private sector to harness technological breakthroughs (Seagrim, 1997).

The history of defence manufacturing highlights the dynamic relationship between warfare, technology, and manufacturing processes. From the ancient civilisations to the modern era, pursuing military dominance has prompted innovation, creating increasingly sophisticated weaponry and equipment.

2.3 Defence Industry Product Categories

Defence products can be categorised based on their application, domain, and functionality. These products range from small arms and ammunition to large-scale items like tanks, submarines, and aircraft (Figure 2.1). Defence products are crucial for military operations and are significant in disaster response, peacekeeping missions, and international security efforts.

Land Systems:

- Armoured vehicles (tanks, infantry fighting vehicles, armoured personnel carriers)
- Artillery systems (howitzers, mortars, rocket launchers)
- Small arms and light weapons (rifles, machine guns, handguns)
- Unmanned ground vehicles (UGVs)

Naval Systems:

- Surface ships (destroyers, frigates, corvettes)
- Submarines and underwater vehicles
- Naval aircraft (maritime patrol aircraft, anti-submarine warfare helicopters)
- Unmanned maritime vehicles (UMVs):

Air and Space Systems:

- Combat aircraft (fighters, bombers)
- Transport aircraft (cargo planes, aerial refuelling)
- Helicopters (attack, utility, transport)
- Unmanned aerial vehicles (UAVs or drones)

Electronic Warfare and Cybersecurity:

- Radar and sensor systems
- Communication systems
- Electronic countermeasures
- Cyber defence tools and software

Missile Defence and Weapons Systems:

- Ballistic missiles
- Cruise missiles
- Anti-tank guided weapons
- Surface-to-air missiles (SAMs)
- Anti-ballistic missile defense systems

Chemical, Biological, Radiological, and Nuclear (CBRN) Defence:

- Detection and monitoring equipment
- Protective gear and suits
- Decontamination systems
- Medical countermeasures

Support and Logistics:

- Military engineering equipment
- Maintenance and repair systems
- Logistics and supply chain management
- Training and simulation systems

Figure 2.1: Defence Industry Product Categories

2.4 Supply Chain Structure of The Defence Manufacturing Industry

Given the complexity of end products, the defence manufacturing industry has a complex and multi-tier supply chain, as shown in Figure 2.2.

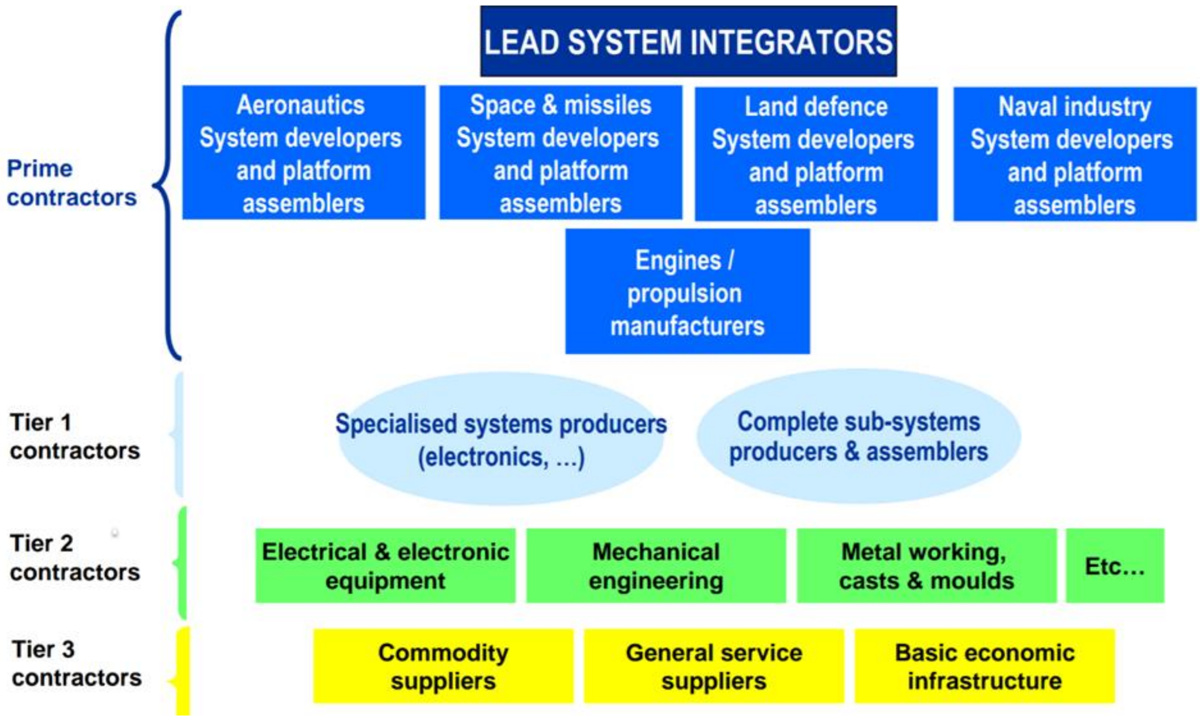

Figure 2.2: A typical structure of the defence manufacturing supply chain (Bergstrom et al., 2018)

Prime contractors are known as "contractors" because they are private companies that enter contracts with government entities. Prime Contractors are responsible for combining various subsystems and components into a fully functional system. This includes integrating hardware and software from different sources to ensure they work together seamlessly (Gansler et al., 2009). They manage the entire lifecycle of a defence project, from the initial design and development stages through testing, implementation, and support. This involves coordinating between various teams and stakeholders and managing budgets, timelines, and resources. BAE Systems (UK) and Lockheed Martin (USA) are the leading prime contractors in the global defence industry.

2.5 Defending and Protecting UAE's Interests

The United Arab Emirates (UAE) has emerged as a significant player on the global stage, necessitating a robust defence strategy to safeguard its interests, stability, and sovereignty.

There are several reasons behind the UAE's need for a strong defence, focusing on geopolitical, economic, and internal security factors.

(a) Geopolitical Context: The UAE's strategic location at the crossroads of major trade routes between the East and West places it in a region of high geopolitical significance. It borders Oman and Saudi Arabia and is in close proximity to Iran and the Strait of Hormuz, one of the world's most crucial chokepoints for oil transit. This location exposes the UAE to regional tensions and conflicts (Riad, 1986; Guéraiche, 2016).

(b) Regional Instability: The Middle East has been a hotspot for conflicts and power struggles, with issues like the Iranian nuclear programme (Albright & Stricker, (2010)., the Qatar diplomatic crisis (Rende, 2017),) impacting regional stability. The UAE must maintain a strong defence to deter potential threats and protect its interests in these volatile surroundings.

(c) International Relations: As the UAE strengthens its global economic and political ties, it becomes more involved in international affairs, necessitating a capable defence force to support its foreign policy objectives and contribute to international peacekeeping efforts (Miller & Verhoeven, 2020)

(d) Economic Considerations: The UAE's economy, heavily reliant on oil and gas exports, requires defence capabilities to secure its critical infrastructure and trade routes.

(e) Protection of Economic Assets: Ensuring the security of oil production facilities, refineries, and shipping lanes is vital for the UAE's economic health. Any disruption in these areas could have significant economic repercussions.

(f) Economic Diversification: As the UAE diversifies its economy into sectors like tourism, finance, and technology, it needs to protect these new investments and ensure a stable environment for continued growth and foreign investment.

(g) Internal Security: The UAE's internal security is crucial for maintaining its status as a safe and prosperous nation.

(h) Counterterrorism: The threat of terrorism is a significant concern, with the UAE being a target for extremist groups due to its geopolitical significance and alliances. A robust defence is essential to prevent attacks and ensure public safety.

(i) Cybersecurity: With the increasing digitisation of the economy and state functions, the UAE must defend against cyber threats that could undermine national security and economic stability.

The UAE's need for a robust defence is driven by its strategic geopolitical position, economic vulnerabilities, and internal security requirements. To navigate the complexities of regional politics, protect its economic lifelines, and ensure the safety of its citizens, the UAE must continue to invest in and prioritise its defence capabilities.

2.6 Evolution of UAE Defence Manufacturing Industry

To address the above necessities, the United Arab Emirates initiated the development of its defence manufacturing sector shortly after gaining independence in 1971. This development journey can be categorised into four distinct phases.

(a) Purchasing - Foundations of the UAE Defence Manufacturing Industry (1971-1990): The UAE defence manufacturing industry began its journey following the nation's formation in 1971. Initially, the UAE relied heavily on defence imports to meet its military requirements, hence ***the UAE offset programme***. When a government or organisation purchases military equipment, they may require the supplier (often a defence contractor) to undertake certain offset obligations as part of the contract. These offset obligations typically involve the supplier investing in or providing economic benefits to the purchasing country (Markowski & Hall, 2014). In the early 80s, the ***UAE Offset Group*** was set up to handle offset programmes with defence contractors (Kirchwehm, 2014).

(b) Development - Defence Industrialisation and Technological Advancements (1991-2000): The 1990s marked a significant phase in the development of the UAE defence manufacturing industry. The UAE recognised the importance of technology transfer and knowledge acquisition to bolster its indigenous capabilities. Strategic alliances were forged with leading international defence manufacturers, mainly in Western countries, enabling acquiring advanced technologies and expertise (Modarress et al., 2014). In 1992, the UAE Offset Group became the ***Tawazun Economic Council*** to manage this broader remit. It was responsible for (a) the development of the UAE's defence and security industry, (b) economic diversification through strategic partnerships and investments, (c) management of offset programmes, (d) policy and regulatory framework development and (e) the promotion of innovation and technology (Harhara, 2014).

(c) Diversification - Enhancing Capabilities through Diversification and Innovation (2001-2010): The early 21st century witnessed a concerted effort by the UAE to diversify its defence manufacturing capabilities and explore new avenues of innovation. Several state-owned entities related to the defence industry emerged during this period. In 2002, ***Mubadala Development Company*** (Abdelal, 2009). was set up to support the UAE's economic diversification. In 2006, ***Emirates Advanced Investments Group (EAIG)*** was established with a primary focus on defence and advanced technologies (Borchert & Widdershoven, 2016). Then, in 2007, ***Tawazun Holding*** was created as a strategic investment firm focused on defence manufacturing and related sectors (Borchert & Widdershoven, 2016). Each of these state-owned entities had subsidiaries in the defence industry.

(d) Consolidation - Indigenous Production and Technology Development (2011+): During this period, the UAE's defence manufacturing industry made significant strides towards developing indigenous production and technology. Notable achievements included establishing specialised defence manufacturing companies, such as EDIC and EDGE Group, which consolidated various entities under a unified umbrella. In 2014, Mubadala Development Company, Emirates Advanced Investments Group, and Tawazun Holding joined forces to establish **Emirates Defence Industries Company (EDIC),** which brought together 11 different defence companies under one roof (Ibish, 2017). In 2019, a significant consolidation occurred, merging 14 additional companies, resulting in 25 defence companies forming **EDGE** (Samaan, 2024). The purpose of setting up EDGE was to consolidate the country's fragmented defence industry and create a conglomerate that could compete globally (Table 2.1).

1971-1990	1991-2000	2001-2010	2011+
Purchasing	Development	Diversification	Consolidation
UAE Offset Group (early 80s)	Tawazun Economic Council (1992)		Tawazun Council (2021)
		Mubadala Development Company (2002)	EDIC - Emirates Defense Industries Company (2014)
		Emirates Advanced Investments Group (2006)	EDGE Group (2019)
		Tawazun Holding (2007)	

Table 2.1: Key Stages and Players in the UAE Defence Manufacturing Industry

2.7 Critical Analysis of the UAE Defence Manufacturing Industry

Despite the rapid growth and strategic importance of the UAE's defence manufacturing sector, ***there is a noticeable shortage of academic publications dedicated to this industry***. This deficiency in scholarly literature hampers comprehensive understanding and analysis of the sector's dynamics, innovations, challenges, and implications. Therefore, the analysis below relies on the limited publications available.

2.7.1 Technological Capability

Limited technology capabilities have posed significant challenges to the UAE's defence manufacturing sector, impacting its growth and competitiveness on the global stage (Abdalla-Alfaki & Ahmed, 2013). The reliance on foreign technology and expertise has often resulted in higher costs and dependency, hindering the development of a self-sustained defence industry. This dependency limited the UAE's ability to innovate and tailor defence solutions to its specific needs.

Limited research and development (R&D) capabilities have been a primary factor hindering the advancement and growth of technological capabilities (Al Hashmi, 2018). Karabchuk et al. (2022) argue that despite significant investments in higher education, universities in the UAE have exhibited relatively slow growth in research output. Given the substantial financial resources allocated to building state-of-the-art educational facilities, attracting top-tier faculty, and creating an environment conducive to academic excellence, this situation is somewhat paradoxical. Karabchuk et al. (2022) propose that the policies should focus on work-attractive long-term conditions for the faculty/researchers, home-based doctoral education system and home-trained human resources.

Recognising the above deficiencies, The Advanced Technology Research Council (ATRC) was established in 2020. ATRC was created to oversee and direct advanced technology research in the UAE, aiming to cultivate a research and development ecosystem that supports innovation and technological advancement across various sectors, including defence (The National, 2020).

The UAE government has also taken steps to strengthen research and development within the higher education sector. In 2017, it created Khalifa University by merging three institutions: the Masdar Institute of Science and Technology, Khalifa University of Science, Technology and Research, and the Petroleum Institute (Mukundan & Narayanan, 2020). These authors argue that Khalifa University leads in research productivity compared to other UAE universities. However, the authors argue *"that to succeed in academic efficiency, the county needs to increase its research investments and diversify research-boosting policies and practices. The policies should focus on work-attractive long-term conditions for the faculty/researchers, home-based doctoral education system and home-trained human resources."*.

As discussed in section 2.6, EDGE Group was established to play a pivotal role in the nation's defence research and development (R&D) landscape. Established to innovate and deliver advanced technology solutions, EDGE focuses on enhancing the UAE's defence capabilities.

Alzaabi (2021) presents robust arguments to support the fact that the above developments have improved the development of research capabilities in the UAE defence sector. However, Shubbar (2023) argues that *"EDGE Group's relative achievements speak to the future capacity of the UAE to address its defence needs and capture market share. However, the Industry still needs development, particularly in terms of human resources and research and development, if it wishes to mimic the economic dynamic observed in other small country defence industries such as Israel".*

2.7.2 Human Capital Development

Human capital development is integral to building a robust and innovative defence manufacturing sector (Siegel et al., 1997). Its role encompasses training and equipping the workforce with the necessary skills and knowledge to operate and innovate within the highly specialised and technologically advanced field of defence production. This development ensures that personnel are proficient in the latest manufacturing techniques, engineering processes, and technological innovations, which are crucial for creating sophisticated defence systems and equipment (Huff et al., 2022). Human resource development in the UAE) faces several challenges despite the country's rapid economic growth and modernisation efforts.

One of the primary issues is the reliance on expatriate labour, which dominates the workforce, leading to a lack of investment in local talent and skills development (De Bel-Air , 2015). This situation has prompted the government to implement Emiratisation policies aimed at increasing the employment of UAE nationals in both the public and private sectors (Albloushi, 2015). However, the mismatch between the educational system and the job market needs is another significant challenge, as it results in a skills gap among Emirati graduates (Ashour, 2020; Khalid & Ahmad, 2021). Developing a domestic defence manufacturing sector requires a skilled Emirati workforce for several strategic and economic reasons. Firstly, involving local talent in defence production enhances national security by reducing reliance on foreign workers and ensuring that the country develops and maintains sensitive military technologies (Al Nehayan,2010). Moreover, the rapid pace of technological advancement and the shift towards a knowledge-based economy demands continuous learning and adaptation (Nusairi, 2021).

Human resource development issues in defence manufacturing are not limited to the UAE. Muravska et al., (2021) discuss the issues faced by the UK defence manufacturing sector. Like their counterparts in other industries and international defence supply chains, UK defence supply chains face ongoing difficulties in securing the necessary volume and quality of skills needed for innovation, preserving existing capabilities, and upholding the UK's position in the global market. It also identifies skills mismatches in the European defence industrial base (Figure 2.3).

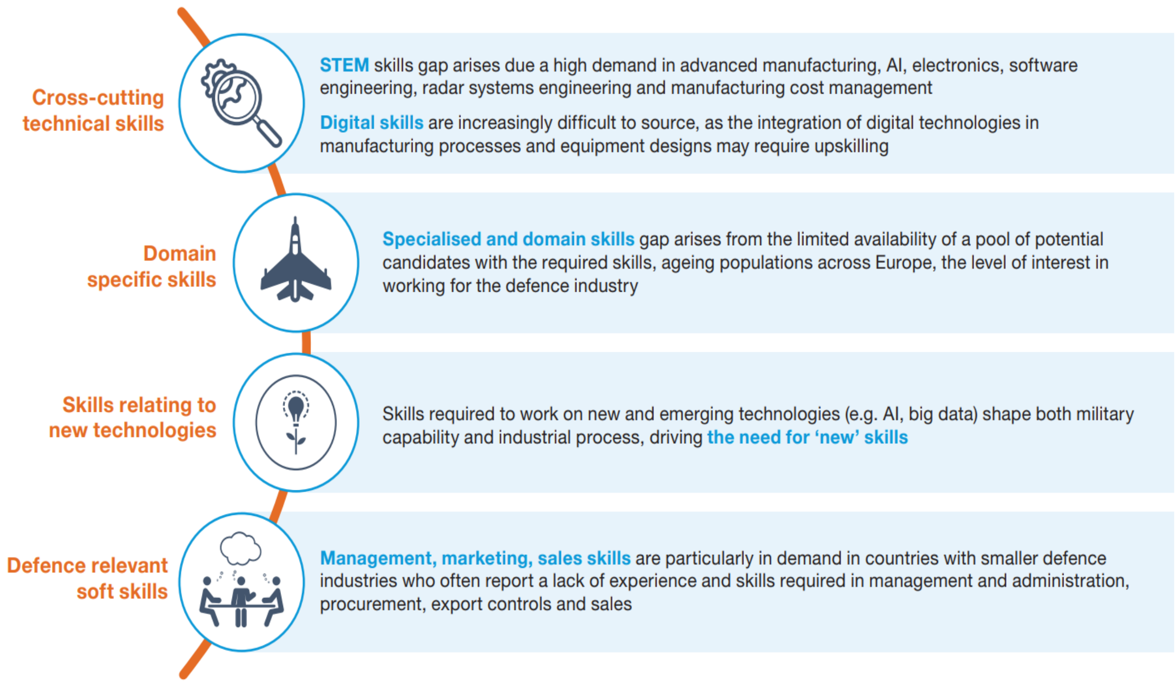

Figure 2.3: Skills mismatches in the European defence industrial base (Muravska et al., 2021)

Therefore, the development of human resources in the defence sector is critical. As technological advancements and strategic complexities continue to evolve, the need for highly skilled and adaptable personnel becomes increasingly critical. Investing in comprehensive training programmes, continuous education, and career development opportunities enhances the capabilities of defence personnel and fosters innovation and resilience within the sector. The UAE has taken steps to educate the Emirati workforce, but further actions are required to create a robust and innovative Emirati workforce.

2.7.3 Supply Chain Integration

Establishing a self-sufficient defence manufacturing sector requires the development of a comprehensive and integrated supply chain. This involves building relationships with domestic and international suppliers, ensuring quality control, managing logistics, and fostering collaboration between various stakeholders. Creating a robust and reliable supply chain is essential to meet production timelines and maintain competitiveness. For example, Matthews & Al-Saadi (2023) discuss the complexities of managing the supply chain for Typhoon fighter aircraft.

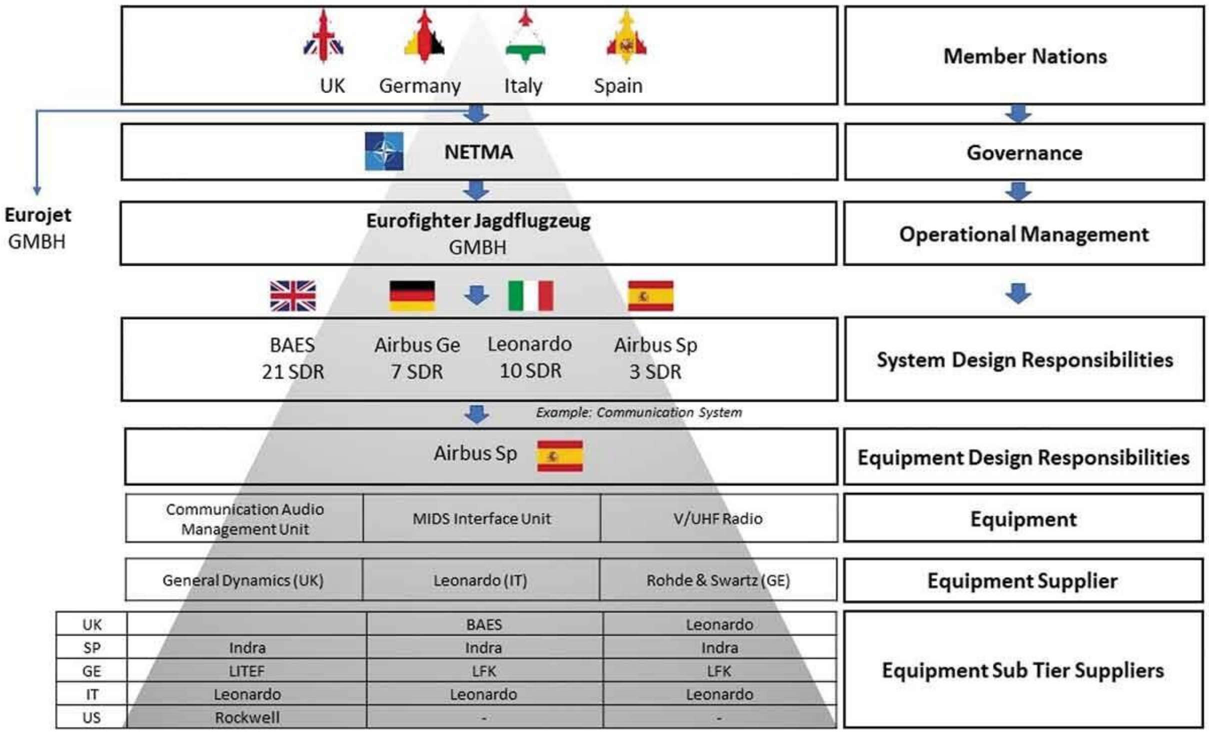

Figure: 2.4: Typhoon Supply Chain (Matthews &and Al-Saadi, 2023)

This complexity is compounded by the need for strict compliance with regulatory and security measures, which can vary significantly across different countries and regions (Muravska et al., 2021). Additionally, the defence sector faces the challenge of managing long lead times and the need for precise synchronisation in the production process to ensure the timely delivery of defence equipment (Bielat, 2010; Özcan et al., 2023). The high level of customisation and the sensitive nature of defence products further necessitate a robust supply chain risk management strategy to mitigate potential disruptions caused by geopolitical tensions, economic instability, or natural disasters (McKendry et al., 2017). Consequently, maintaining a resilient and efficient supply chain is paramount in the defence manufacturing industry.

Alazazi (2017), who conducted a PhD study on "Role of Information Sharing In Supply Chain Management to Enhance the Capabilities of a Defence Firm in the UAE: The Case of Tawazun Subsidiaries" asserts that the dominance of the viewpoints and perceptions of the top managers, whose background is military, seemed to have a heavy impact on the quantity and type of information to be shared across the supply chain. This dominance might have impacted the performance of supply chains, The pervasive influence of this dominance could have had significant repercussions on the efficiency and effectiveness of supply chains. When top managers strongly influence an organisation's operations, their strategic decisions and management style can deeply affect how supply chains are structured and managed. This might lead to a supply chain that is potentially lacking flexibility and adaptability. Such a scenario can impact the supply chain's responsiveness to market changes or unexpected disruptions. Therefore, the dominance of these top managers' perspectives and approaches can shape the performance of supply chains in critical ways, affecting their ability to operate optimally and achieve strategic goals. This research selected "Tawazun Subsidiaries" as the test case due to its prominence as one of the largest conglomerates operating within the UAE's defence manufacturing sector.

During the 2021 International Defence Conference, Tareq Abdulraheem Al Hosani, the CEO of Tawazun Council, discussed the challenges faced by the UAE defence industry. Below are a few extracts from his statements.

"We are very conservative in challenging the normal. In the past, we have identified and addressed the needs of the military domain, but we need to do more than that."

"In conclusion, Al Hosani mentioned that there were three aspects of R&D and innovation affected by the pandemic, and obvious lessons were learned. The first was cost, because a lot of prices had been driven down. The second was an impact on capabilities, and the third was the need to **manage and maintain a secure supply chain**."

Aljeeran (2019) reports that Armoured Vehicle Manufacturers (AVMs) in the Gulf States are grappling with a host of challenges that significantly impact their supply chain management. These AVMs, predominantly Small and Medium Enterprises (SMEs), are often led by entrepreneurs who rely on intuitive management practices. This approach can lead to performance degradation, affecting their output quality and customer satisfaction. The supply chain complexities are further exacerbated by the customers' lack of essential components in the acquisition process, such as the absence of published defence strategy documents, unclearly defined customer needs, fluctuating demand, and inadequate knowledge among customer individuals to aid in developing the intended values. Moreover, the interactions between AVMs and their stakeholders, especially the customers, fail to reflect the critical nature of the products, adding strain to the supply chain dynamics. These internal and external challenges create a volatile environment for supply chain management, necessitating AVMs to navigate through intense global competition, shifts in threats and needs, continuous technological advancements, and political uncertainties. Such a landscape complicates the logistics and operational aspects of the supply chain and places immense pressure on AVMs to maintain supply chain resilience and adaptability. Consequently, these factors collectively impede the AVMs' ability to meet immediate customer satisfaction goals and achieve long-term market sustainability, underscoring the complex link between supply chain management and the broader operational challenges faced by AVMs in the Gulf States.

2.7.4 Defence Export Regulations

The UAE's defence industry, while growing and becoming more prominent in the global arms market, faces specific challenges and considerations due to export regulations.

For example, the United States has stringent export control laws, such as the International Traffic in Arms Regulations (ITAR) (Cook, 2010). and the Export Administration Regulations (EAR) (Gansler & Lucyshyn, 2013), which affect the UAE's defence sector. For instance, when the UAE purchases defence equipment from the US, it must comply with these regulations, which can limit the re-export of US-origin defence articles and services. This compliance is crucial for maintaining the defence trade relationship between the UAE and the US. However, it also imposes restrictions on how the UAE can use and transfer these defence items. McVey (2016) cites an example of a South Carolina company and two of its executives facing charges related to export control violations. These charges stemmed from the sale of armoured vehicles, enhanced with ballistic steel and bulletproof glass, to the United Arab Emirates (UAE) and other countries. The company and its UAE affiliates were accused of illegally transferring these U.S.-origin vehicles on at least nine occasions in breach of U.S. export laws. The violations included exporting the vehicles to Canada, knowing they would be re-exported to other countries without the necessary authorisation, and the unauthorised re-export of these vehicles from the UAE to other destinations.

The UAE also engages in defence trade with European countries, which are governed by the EU's Common Position on arms export (Bonaiuti, 2022). This means that European countries assess export licenses to the UAE based on criteria such as respect for human rights, regional stability, and the risk of diversion. These controls can influence the types of defence equipment the UAE can acquire from European countries and under what conditions.

UAE has its own set of export control regulations, which were updated and strengthened with the Federal Law No. 12 of 2008 (Malkawi, 2019). This law regulates the export, re-export, transit, and transhipment of dual-use items and military goods (Hyde, 2019). The UAE's commitment to non-proliferation and adherence to international export control standards affects how its defence industry operates, particularly in terms of compliance and international cooperation.

2.7.5 Intellectual Property Protection

Defence manufacturing flourishes through the development of advanced technologies and innovations. These encompass sophisticated weaponry and defence systems, cybersecurity measures, and surveillance equipment. For example, the development of stealth technology in aircraft or advanced missile defence systems signifies substantial investments in research and development that defence manufacturers undertake to maintain a competitive advantage (Aslan, 2021)

Protecting intellectual property (IP) rights in this context is essential for several reasons. First, it ensures that companies can recoup their investment in R&D. For example, when a defence manufacturer develops a new drone technology with enhanced surveillance capabilities, securing patents for this innovation prevents other companies from copying the technology without permission, thus safeguarding the original manufacturer's financial and strategic interests. Second, strong IP protection encourages local innovation. In the UAE, for instance, the development of an indigenous defence industry, such as the production of the NIMR armoured vehicles, showcases how local innovation can be fostered when there is confidence that IP rights will be protected. Companies are more likely to invest in developing new products and technologies if they know that their inventions will be legally protected against unauthorised use or replication (Birnhack, & Khoury, 2018).

However, as Kowalski (2018) noted, the UAE needs to enhance its legal and regulatory frameworks to ensure robust intellectual property protection, both domestically and internationally. This involves creating laws that protect patents, copyrights, and trademarks and ensuring that these laws are enforced effectively.

Internationally, the UAE must also work to align its IP protection standards with global norms, such as those set by the World Intellectual Property Organisation (WIPO) (Kapoor, 2022). This alignment can help the UAE's defence manufacturers protect their IP rights when operating in foreign markets and confidently engage in international partnerships and collaborations.

2.7.6 Cost Efficiency and Economies of Scope

Developing a competitive defence manufacturing industry requires achieving economies of scale and cost efficiency. The UAE must balance research, development, and production costs with market demand and pricing considerations. Collaborative ventures, joint production programmes, and strategic partnerships with international defence manufacturers can help the UAE leverage economies of scale and optimise production costs.

There are examples of efforts to improve cost efficiency and economies of scale. The UAE has engaged in collaborative ventures to enhance its defence manufacturing capabilities.

For example, the UAE's EDGE Group and Israel Aerospace Industries (IAI) partnership to develop advanced unmanned surface vessels (USVs) showcases how collaboration can lead to shared R&D costs and access to new markets, thereby achieving economies of scale (Mazzucco & Alexander, 2022). The UAE has participated in joint production programmes to increase its manufacturing scale and reduce costs. A notable example is the collaboration with South Korea to develop the Cheongung II (KM-SAM) air defence missile system (Azad, 2023). This allows the UAE to benefit from the economies of scale and enhances its technological capabilities and self-reliance in defence manufacturing. The UAE has formed strategic partnerships to optimise production costs and access advanced technologies. For instance, the strategic partnership between the Tawazun Economic Council (TEC) and global defence firms facilitates technology transfer and joint ventures, leading to more efficient production processes and cost savings (Dowse et al., 2022).

Al Sheleh (2019) contends that the manufacturing sectors in the United Arab Emirates (UAE) require additional improvements to enhance life cycle cost analysis. It would enable better strategic decision-making by providing clearer insights into the financial implications of manufacturing processes and product lifecycles, thereby optimising resource allocation and investment in the sector.

2.7.7 International Competition

The global defence industry is highly competitive, with many established players and advanced defence technologies. The UAE faces competition from major defence manufacturers from around the world. Building a strong defence manufacturing sector requires the ability to compete in terms of quality, technology, pricing, and timely delivery. To remain competitive, the UAE needs to continuously invest in innovation and stay abreast of emerging trends and advancements (Haglund, 2021).

2.7.8 Integration of SMEs

Small and Medium Enterprises (SMEs) play a critical role in the defence manufacturing sector, serving as the backbone of the industry's supply chain. These entities contribute significantly to innovation, agility, and the diversification of the defence market (Giacomello, & Preka, 2023). SMEs are often more flexible and responsive than larger corporations, enabling them to adapt quickly to changing technologies and requirements. They are pivotal in driving technological advancements and providing specialised services or components that larger companies rely on to complete their projects. Furthermore, SMEs stimulate competition, leading to better quality and cost-effective solutions in defence manufacturing. Their involvement is essential for the development of a resilient and dynamic defence industrial base. By fostering a diverse ecosystem of suppliers, SMEs help to mitigate risks, enhance supply chain security, and ensure the sustainability and self-reliance of the defence sector (Asgary et al., 2020).

In the defence manufacturing sector, SMEs like Hensoldt in Germany, which specialises in sensor technologies (Neumann & Brosch (2020) and Kongsberg Defence & Aerospace in Norway, known for its missile systems (Bovbjerg, 2022) exemplify the innovative capabilities and niche expertise that smaller firms contribute to the industry. In the United States, companies like AeroVironment, which produces unmanned aircraft systems, and Palantir Technologies, known for its data analytics and intelligence solutions, demonstrate how SMEs are at the forefront of technological advancements in defence (Jackman, 2022). These companies often lead research and development within their speciality areas, providing cutting-edge solutions that larger defence contractors incorporate into broader systems.

The United Arab Emirates (UAE) has made significant strides in incorporating Small and Medium Enterprises (SMEs) into its defence manufacturing sector, aligning with its broader economic diversification and industrial development goals. Through strategic initiatives and support mechanisms, such as the Tawazun Economic Council and dedicated offset programmes, the UAE has fostered an environment conducive to SME growth in defence manufacturing.

However, SMEs in the UAE face several key issues that impact their growth and sustainability. Access to financing is a major challenge, as SMEs often struggle to secure loans or investments due to perceived high risks and lack of collateral (Muhammad et al., (2021; Ghak & Zarrouk, 2022).). For example, technology startups find it particularly difficult to attract venture capital (Zarrouk et al., 2020). Regulatory and administrative hurdles also pose significant challenges, with SMEs navigating complex legal requirements and bureaucratic processes, which can be particularly daunting for new entrants (Habbal, 2023).

In summary, the UAE's defence manufacturing sector faces challenges in technological capability, human capital development, supply chain integration, export regulations, intellectual property protection, cost efficiency, international competition, and SME integration. Limited technology and R&D capabilities have hindered the sector's growth, leading to dependency on foreign technology. The Advanced Technology Research Council (ATRC) and Khalifa University's establishment aim to boost local R&D and innovation. Human capital development is crucial, yet the reliance on expatriate labour and the educational system's misalignment with market needs pose challenges. Supply chain integration is vital for self-sufficiency, but it is complicated by regulatory compliance and the need for robust management. Export regulations, particularly from the US and EU, affect the UAE's defence trade, necessitating compliance with international standards. Intellectual property protection is essential for fostering innovation and securing investments in R&D. Cost efficiency and economies of scale are targeted through collaborative ventures and strategic partnerships. The UAE's defence industry faces stiff international competition, requiring continuous innovation and market adaptation. SMEs are integral to the defence sector, offering agility and innovation, but they face challenges like access to financing and regulatory hurdles.

This journey through three decades has enabled the UAE to climb to somewhere between tier two and tier three (Table 2.2), demonstrating that they have developed the capacity to produce, export, and adapt existing technology to meet market and security demands (Saab, 2014)

.

Tier 1	States that innovate at the technological frontier and, therefore, temporarily become the sole or dominant producers of a given arms technology.
Tier 2	States that produce at or near the technological frontier and are capable of adapting existing technology to market and security requirements.

Tier 3	Three States that copy and reproduce (apply) existing technologies but do not capture the underlying process of innovation or adaptation.
Tier 4	States that acquire and use existing technologies but are incapable of Production.
Tier 5	States that acquire technologies and cannot use them or that do not obtain them at all.

Table 2.2. The Hierarchy of Defence Production (Saab, 2014)

2.8 Lessons from the UK Defence Manufacturing Industry.

Certain segments of the UK defence supply chains face productivity issues, affecting their performance and competitiveness. To address this, RAND Europe was engaged by the Ministry of Defence (MOD) to assess and propose policy options to enhance these supply chains (Muravska et al., 2021). A year-long study involving discussions with industry and government stakeholders identified key challenges and barriers within the UK defence supply chains (Figure 2.4).

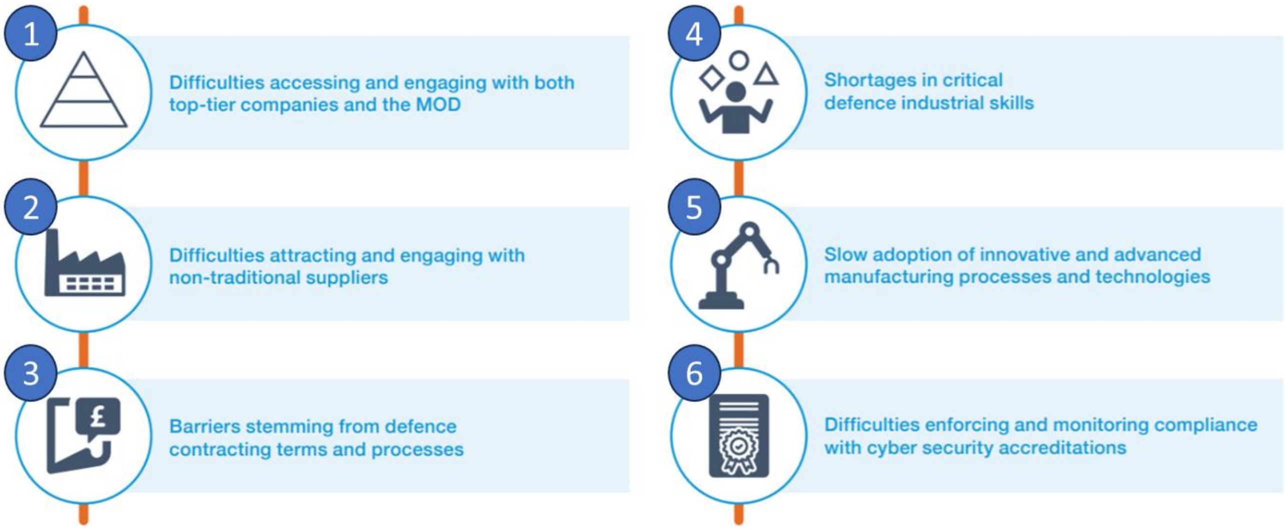

Figure 2.5: Key challenges to defence supply chain productivity (Muravska et al., (2021)

The numbers in Figure 2.5 are used below to describe each issue briefly.

(a) The most commonly identified barrier to productivity within supply chains was the challenge that Small and Medium Enterprises (SMEs) and mid-tier suppliers face in engaging with prime contractors and the Ministry of Defence (MOD). This encompasses difficulties in marketing their businesses and product offerings to prime contractors and the restricted opportunities to interact with the MOD directly. Often, prime contractors act as intermediaries, managing the interactions between lower-tier suppliers and the government, which can limit the visibility and direct communication channels for these smaller entities. This situation hinders their ability to effectively present their capabilities and innovations, thereby affecting their potential contributions to the UK's defence sector and supply chain dynamics.

(b) Although there are growing opportunities for interaction across different sectors, UK defence supply chains continue to face challenges in drawing investors and partners from outside the traditional defence industry. This difficulty in attracting non-traditional stakeholders can curtail the potential for innovation within the sector. Stakeholders have indicated that the defence sector is perceived negatively due to its slow, rigid, and highly bureaucratic procurement processes and the cumbersome sub-contracting practices of Tier 1 companies. This reputation makes it less appealing for entities from other sectors to engage and collaborate, thus limiting the infusion of fresh ideas and innovative solutions in the UK defence supply chains.

(c) The operational culture and methodologies within the defence sector have not been optimally adjusted to effectively acknowledge and integrate innovation from lower-tier suppliers. Primarily, the structure of defence contracts is uniform for both Tier 1 and lower-tier suppliers, with contract terms that are not always suitably tailored for Small and Medium Enterprises (SMEs). This lack of flexibility and adaptation in contract terms can hinder the contribution of smaller entities to the sector's innovation landscape.

(d) Comparable to various sectors and defence supply chains outside the UK, the British defence supply chains consistently face difficulties in acquiring the necessary skills in both volume and quality. These skills are essential for driving innovation, preserving existing capabilities, and maintaining the UK's competitive stance in the global market.

(e) The defence sector as a whole has been slower than commercial industries in taking up new manufacturing processes and technologies commonly associated with Industry 4.0, which loosely refers to increased ‘connectivity, communication and digitisation’ in manufacturing. One major reason for this lag is security concerns and regulations related to the digitalisation of manufacturing,

(f) A significant challenge faced by UK defence supply chains lies in enforcing and monitoring cybersecurity standards. A considerable proportion of defence suppliers lack 'Cyber Essentials' accreditation, and among those who have obtained it, many fail to comply with all the required standards, thereby heightening the cybersecurity threat across the supply chains. Although some prime contractors are not fully compliant with cyber requirements, the lower-tier suppliers predominantly constitute the bulk of defence companies lacking this essential accreditation.

While the above-mentioned six challenges are specifically relevant to the UK defence manufacturing sector, it is reasonable to infer that the UAE defence manufacturing industry might encounter comparable difficulties. Given the global nature of defence manufacturing, which often involves complex supply chains, stringent regulatory requirements, and the need for advanced technological integration, it is likely that the UAE's defence sector faces similar hurdles. These could include adapting to rapid technological changes, managing supply chain vulnerabilities, ensuring cybersecurity compliance, and fostering innovation amidst bureaucratic constraints. Therefore, the issues identified in the UK context could very well mirror the challenges within the UAE's defence manufacturing landscape, reflecting broader industry-wide trends and obstacles.

2.9 Lessons from China’s Defence Manufacturing Industry

The transformation of China's defence industries offers several critical lessons relevant for policymakers, analysts, and scholars studying defence manufacturing industries.

(a) The Importance of Self-Reliance and Indigenous Innovation

One of the most salient lessons from China's military modernisation is the emphasis on self-reliance and indigenous innovation (Abas, 2015). Historical events, such as the Sino-Soviet split and the Tiananmen Square sanctions, have significantly influenced China's strategy to develop its domestic defence capabilities. These incidents underscored the vulnerabilities associated with reliance on foreign military supplies and technologies. Consequently, China has prioritised building a robust domestic defence industry to ensure that external political pressures do not compromise its military capabilities.

The pursuit of self-reliance is evident in China's substantial investments in research and development (R&D) and the promotion of indigenous innovations (Bitzinger, 2011). Despite facing significant technological barriers and limitations, China has made considerable progress in developing sophisticated weapon systems and military technologies. The lesson here is clear: for a nation to achieve strategic autonomy and enhance its security, it must invest in building and nurturing its domestic technological capabilities.

(b) The Role of Strategic Modernisation Programmes

China's strategic modernisation programmes highlight the importance of having a coherent and long-term vision for military development (Patil, 2022). The re-initiated and focused modernisation programmes aimed to meet the requirements of 21st-century warfare, addressing both contextual and direct drivers such as national security threats and technological denial. By aligning its military modernisation efforts with broader strategic goals, China has been able to upgrade its military capabilities systematically.

(c) The Benefits and Challenges of Civil-Military Integration (CMI)

Civil-Military Integration (CMI) has been a key component of China's strategy to modernise its defence industries (Yang et al., 2024). By leveraging dual-use technologies and fostering collaboration between military and civilian sectors, China has aimed to accelerate technological advancements and reduce costs. The integration with the civilian economy, particularly in sectors like information and communications technology (ICT), has facilitated the transfer of advanced technologies to the military.

However, implementing CMI has also faced significant challenges, including structural and operational reforms needed to adapt to market-oriented practices (Lin, 2022). The lesson here is twofold: while CMI can offer substantial benefits in terms of technological innovation and cost efficiency, it requires significant adjustments in organisational culture and practices. Other nations considering CMI must be prepared to address these challenges to fully realise the potential of integrating civilian and military industries.

(d) Economic Considerations and the Defence Industry
China's military modernisation efforts also underscore the intricate relationship between economic factors and defence capabilities. The establishment and growth of domestic defence industries have enhanced China's military capabilities and contributed to its economic development by creating jobs and stimulating industrial growth. However, the focus on self-reliance has sometimes led to inefficiencies and resource wastage due to replicating existing technologies (Kania & Laskai, 2021).

(e) Conclusion
China's military modernisation and the development of its defence industries provide valuable lessons for other nations. The emphasis on self-reliance, strategic planning, civil-military integration, and the careful navigation of technological denial offer a roadmap for countries aiming to enhance their defence manufacturing capabilities. While China's approach has its unique challenges and limitations, the overarching principles of fostering Indigenous innovation, strategic coherence, and economic integration are universally applicable and can guide other nations in their defence manufacturing modernisation

2.10 Lessons from Russia's Defence Manufacturing Industry
There are several lessons that other nations might learn from Russia's efforts to improve its defence manufacturing industries:

(a) Emphasis on Breakthrough Technologies
Russia has focused on developing breakthrough technologies to close capability gaps with rivals. This includes pursuing hypersonics, artificial intelligence (AI), and other advanced technologies under the 4th Industrial Revolution (4IR) umbrella. Countries can benefit from prioritising innovative technologies to advance their defence capabilities rapidly (Zysk, 2022).

(b) State-Driven Innovation Models
The establishment of state-driven innovation centres such as the Advanced Research Foundation (FPI) and the Era Technopolis demonstrates a strategic approach to fostering defence innovation. These centres focus on creating conditions conducive to innovation and drawing on both military and civilian expertise (Kozyulin, 2023).

(c) Public-Private Partnerships
Russia's approach includes fostering collaboration between state institutions, private companies, and academic institutions (Pukhova et al., 2021). This model leverages the strengths of various sectors to drive innovation and technological advancements.

(d) Military-Civilian Collaborative Platforms
Integrating military and civilian sectors through collaborative platforms helps in the generation and exchange of ideas, expertise, and talent. This integration is essential for dual-use technologies that can benefit both defence and civilian markets (Bendett et al., 2021)

(e) Strategic Use of AI and Autonomous Systems
AI and autonomous systems are pivotal in modern warfare. Russia's development of AI technologies for both military and civilian applications showcases the importance of integrating AI into defence strategies to enhance operational capabilities and decision-making processes (Carlo, 2023).

(f) Importance of Asymmetric Warfare Capabilities
Russia has emphasised the development of asymmetric warfare capabilities, such as AI-enabled unmanned systems and hypersonic weapons, to offset traditional military disadvantages. This highlights the value of investing in technologies that can provide strategic advantages without direct confrontation (Zysk, 2022).

(g) Government Support and Funding
Sustained government support and funding are critical for the success of defence innovation programmes. Despite economic challenges, Russia has prioritised funding for key defence projects and innovation centres, ensuring continued progress in its defence capabilities. By adopting these practices, other nations can enhance their defence manufacturing industries, ensuring they remain competitive and capable of addressing modern security challenges (Romanova & Kuzmin, 2020).

(h) Conclusions

In conclusion, Russia's efforts to improve its defence manufacturing industries offer several key lessons for other nations. By prioritising breakthrough technologies, leveraging state-driven innovation models, and fostering public-private partnerships, Russia has demonstrated the importance of a strategic and integrated approach to defence innovation. The emphasis on military-civilian collaboration, the strategic use of AI and autonomous systems, and the development of asymmetric warfare capabilities further underscore the need for adaptable and forward-thinking defence strategies. Finally, sustained government support and funding are crucial to ensuring the success and competitiveness of defence initiatives. By adopting these practices, other nations can enhance their defence manufacturing capabilities and address the evolving security landscape better.

2.11 Lessons from US Defence Manufacturing Industry

The transformation of the U.S. defence manufacturing sector offers several critical lessons for policymakers, analysts, and scholars studying defence industries.

(a) Government Support and Funding

Substantial government support and funding significantly bolster the success of the U.S. defence manufacturing industry. Continuous financial backing from the U.S. government, particularly through the Department of Defense (Amara, 2021), provides the necessary resources for research and development, procurement, and innovation. Long-term defence contracts offer stability and predictability, allowing manufacturers to invest confidently in advanced technologies and infrastructure, ensuring sustained growth and technological superiority.

(b) Advanced Research and Development

A key driver of the U.S. defence manufacturing industry's success is its commitment to advanced research and development. Organisations like the Defense Advanced Research Projects Agency (DARPA) spearhead groundbreaking innovations, fostering technological advancements that keep the industry at the forefront of global defence capabilities (Shapiro et al., 2020). Strong partnerships with universities and research institutions further nurture a culture of innovation, facilitating the continuous evolution of defence technologies.

(c) Robust Industrial Base

The U.S. defence manufacturing industry benefits from a robust and diverse industrial base. This ecosystem includes large defence contractors, medium-sized firms, and small businesses, creating a competitive and collaborative environment. Well-integrated and resilient supply chains ensure the availability of essential materials and components, contributing to the industry's overall efficiency and capability to meet diverse defence needs (Kotila et al., 2023).

(d) Technological Innovation

Technological innovation is at the heart of the U.S. defence manufacturing industry's success. The industry places a strong emphasis on developing and integrating emerging technologies such as artificial intelligence, robotics, cyber defence, and advanced materials. A culture of innovation is fostered through robust R&D initiatives, public-private partnerships, and support for startups and tech incubators, ensuring that the industry remains a global leader in defense technology.

(e) Strategic Policy and Regulation

The U.S. defence manufacturing industry thrives within a framework of strategic policy and regulation. Well-defined national defence policies and strategies provide clear direction, while a balanced regulatory framework ensures security needs are met without stifling industry growth. This includes robust export controls and intellectual property protections, which are essential for maintaining the industry's competitive edge.

(f) Global Leadership and Influence

Global leadership and influence are critical to the U.S. defence manufacturing industry's success. Strong alliances and partnerships with other countries enhance the industry's global reach and impact. Access to international markets through foreign military sales (FMS) and direct commercial sales (DCS) programmes further expands the industry's footprint, reinforcing its position as a dominant player in global defence.

(g) Economic Scale and Infrastructure

The economic scale and advanced infrastructure of the U.S. contribute significantly to the success of its defence manufacturing industry. Large-scale defence spending enables economies of scale in production and procurement, reducing costs and improving efficiency.

State-of-the-art manufacturing facilities, testing ranges, and logistics infrastructure support high-quality production and rapid deployment capabilities, ensuring the industry can meet the demands of modern defence.

(h) Innovation and Adaptation to Threats
The U.S. defence manufacturing industry excels in innovation and adaptation to emerging threats. Continuous threat assessment and proactive strategies ensure that the industry can rapidly respond to new challenges. Agile manufacturing processes allow for quick adjustments in production, facilitating the development of new technologies and solutions that address evolving defence needs.

(i) Political and Economic Stability
Political and economic stability in the U.S. provides a conducive environment for the success of the defence manufacturing industry. A stable political environment and consistent defence policies enable long-term planning and investment. Additionally, a robust economy supports defence spending, providing the financial resources necessary for sustained investment in defence capabilities.

(j) Intellectual Property and Innovation Protection
Effective intellectual property (IP) management is a cornerstone of the U.S. defence manufacturing industry's success. Strong IP laws and enforcement mechanisms protect innovations, encouraging continuous investment in research and development. Government policies that support and safeguard intellectual property in defence technologies further enhance the industry's ability to innovate and compete globally.

(k) Cultural Commitment to National Security
A cultural commitment to national security underpins the success of the U.S. defense manufacturing industry. Broad societal and political support for maintaining national security ensures consistent backing for defence initiatives and funding. The alignment between public sentiment, political will, and industry goals creates a supportive environment, fostering growth and sustainability.

(l) Conclusions
The success of the U.S. defence manufacturing industry is underpinned by substantial government support, robust research and development efforts, and a diverse industrial base. Technological innovation and strategic policy frameworks ensure the industry remains

globally competitive, while political and economic stability provide a conducive environment for sustained growth. Additionally, the U.S. defence sector benefits from strong intellectual property protections, global influence, and a cultural commitment to national security, all of which drive continuous advancements and maintain its leadership in defence capabilities.

2.9 Industry 4.0 in Defence Manufacturing

In the context of modernising defence manufacturing to meet the evolving challenges, Industry 4.0 technologies can play a pivotal role. The integration of these advanced technologies can significantly enhance the capabilities of defence manufacturing, making it more agile, efficient, and responsive to the demands of contemporary military operations.

2.9.1 General Manufacturing vs Defence Manufacturing

Manufacturing and defence manufacturing differ significantly in their purpose, regulatory environment, and operational focus. While general manufacturing encompasses the production of a broad range of consumer and industrial products, defence manufacturing is specifically tailored to developing and producing military equipment and technologies. This specialisation in defence manufacturing requires adherence to strict government regulations, higher security measures, and handling of classified information, distinguishing it from the more commercially driven and less regulated general manufacturing sector (Markowski, et al., 2021). Additionally, the procurement processes in defence manufacturing are heavily influenced by national security considerations and often involve long-term government contracts, contrasting with the market-driven dynamics of general manufacturing, where consumer demand and competitive pricing play crucial roles (Meershoek, 2021). These factors collectively highlight the defence manufacturing sector's unique complexities and stringent requirements compared to its general manufacturing counterpart.

2.9.2 Industry 4.0

The emergence of Industry 4.0 technologies (Figure 2.5) has significantly transformed general manufacturing, introducing higher levels of automation, efficiency, and data integration. These technologies have enabled smart factories where machines and systems communicate seamlessly, optimising production processes and enhancing product quality (Xu, et al., 2021).

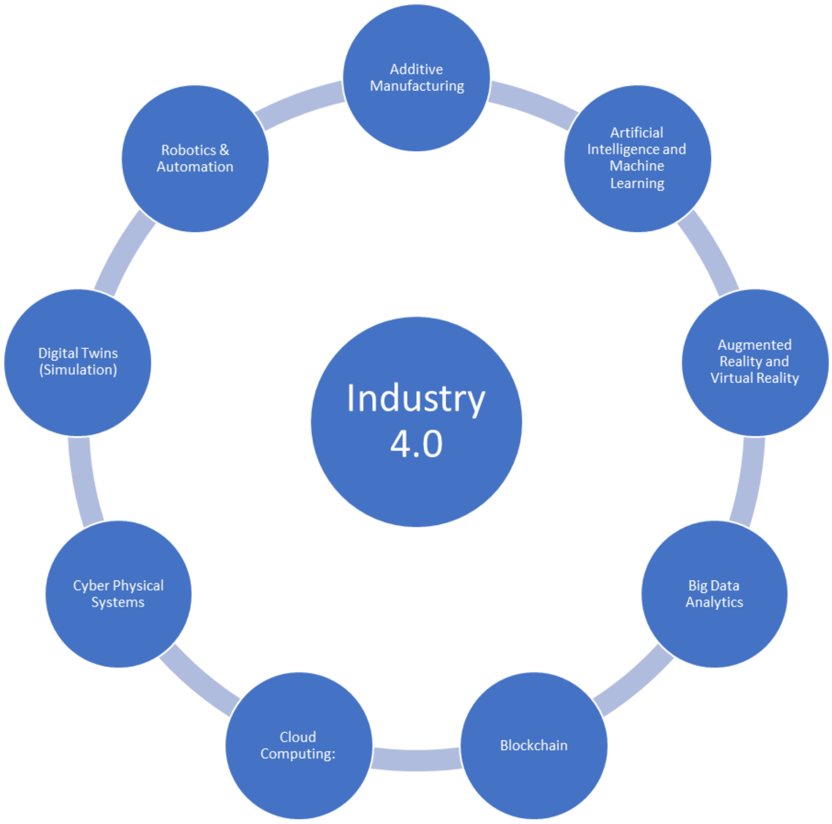

Figure 2.6: Industry 4.0 Technologies

Additive Manufacturing: 3D printing allows for the layer-by-layer creation of objects from digital models, enabling rapid prototyping, customisation and on-demand production.

Artificial Intelligence and Machine Learning: These technologies analyse data, predict trends, and make decisions, enhancing the automation and intelligence of manufacturing processes.

Augmented Reality (AR) and Virtual Reality (VR): AR and VR are used for training and simulation and to provide workers with real-time information and guidance, enhancing the interaction between humans and machines.

Big Data Analytics: This technology processes and analyses large volumes of data generated by connected devices and systems to improve decision-making and operational efficiency.

Blockchain: Blockchain provides secure and transparent record-keeping and transaction processes, enhancing trust and traceability in the supply chain.

Cloud Computing: Cloud technology offers scalable and flexible resources for data storage and computing power, facilitating the integration and analysis of data across the global supply chain.

Cyber-Physical Systems: These systems integrate computation, networking, and physical processes. Embedded computers and networks monitor and control the physical processes, with feedback loops in which physical processes affect computations and vice versa.

Digital Twins: A digital twin is a virtual model of a process, product, or service. This pairing of the virtual and physical worlds allows data analysis and system monitoring to prevent problems before they occur.

Robotics and Automation: Advanced robotics and automation technologies are used to perform tasks with high precision and efficiency, often in hazardous or unsuitable environments for human workers.

The potential impact of Industry 4.0 technologies is **even more profound** in the context of defence manufacturing. The defence sector, with its unique precision, reliability, and security requirements, stands to benefit greatly from these advanced technologies. While all these technologies can make significant contributions to the development of the defensive manufacturing industry, the following three (3) technologies can make a wider impact.

Blockchain technology offers transformative potential for defence manufacturing by enhancing security, traceability, and efficiency. In this sector, where supply chains' integrity and sensitive data protection are paramount, blockchain provides a decentralised and immutable ledger that can securely record transactions and data exchanges (Krichen et al., 2022). This capability ensures that components and materials are traceable from origin to delivery, reducing the risk of counterfeit parts and ensuring compliance with strict defence standards. Furthermore, blockchain's smart contract functionality can automate and streamline procurement processes, enforce compliance with regulatory requirements, and facilitate secure collaboration between various stakeholders, including government entities, manufacturers, and suppliers (Krichen, 2023). By integrating blockchain, defence manufacturing can achieve higher transparency, security, and operational efficiency, thereby enhancing the overall reliability and trustworthiness of defence products and services. Ahmad et al. (2021) provide a comprehensive analysis of the critical areas in the defence sector where blockchain technology can have a significant impact (Figure 2.7). They discuss how blockchain's inherent features, such as decentralisation, transparency, and security, can revolutionise various aspects of defence operations, enhancing efficiency and trust in the processes.

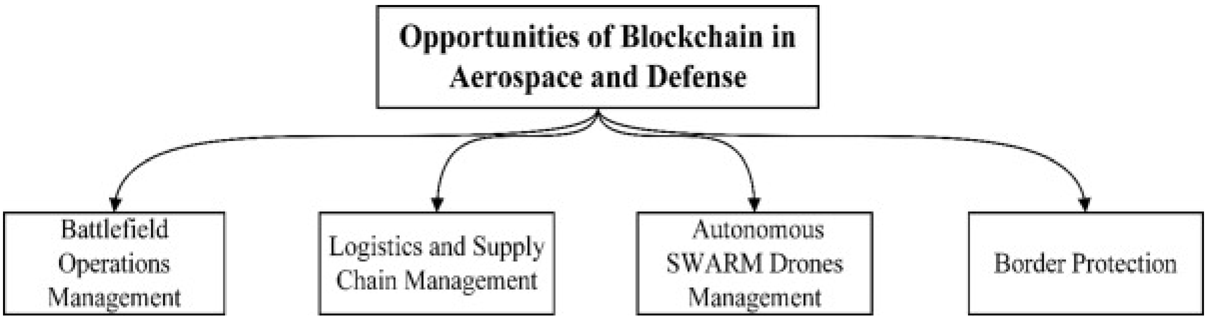

Figure 2.7: Blockchain opportunities in aerospace and defence Industries (Ahmad et al. ,2021)

Artificial Intelligence (AI) and Machine Learning (ML) are transforming defence manufacturing by streamlining production processes, enhancing quality control, and accelerating innovation. AI can optimise supply chain management in this sector, predicting and mitigating potential disruptions and ensuring a steady flow of materials and components (Singh et al., 2022). ML algorithms analyse vast datasets to identify patterns and insights, leading to more efficient manufacturing methods and the reduction of waste and errors (Ding et al., 2020). These technologies also play a crucial role in predictive maintenance, where AI-driven systems monitor equipment health in real-time, predicting failures before they occur and significantly reducing downtime (Dalzochio et al., 2023). Moreover, AI and ML facilitate the rapid design and testing of new defence products (Arenander, 2023)

Digital twins significantly enhance defence manufacturing by providing a comprehensive and dynamic virtual model of physical defence systems and processes (Council, 2021). This technology enables manufacturers to simulate, predict, and optimise the performance and maintenance of defence equipment before it is physically built or deployed. Digital twins facilitate advanced analytics, machine learning, and simulation capabilities by creating a real-time digital counterpart of physical assets. This leads to improved design accuracy, operational efficiency, and predictive maintenance, reducing costs and increasing the reliability and readiness of defence systems (Madni & Madni, 2022). Digital twins in defence manufacturing streamline development, enhance lifecycle management, and contribute to more effective and resilient defence capabilities.

In summary, while Industry 4.0 technologies have already revolutionised general manufacturing, their application in defence manufacturing could be even more transformative. They could address the sector's specific challenges and contribute to the development of more advanced, reliable, and secure defence capabilities.

2.10 Defence Manufacturing Ecosystems

Section 2.6 outlines the UAE government's initiative to merge defence manufacturing organisations to establish a cohesive and effective national defence sector. This move is intended to boost self-sufficiency in defence mechanisms and foster technological advancements. Despite these efforts, there is a lack of documented evidence in scholarly works regarding the extensive integration of stakeholders to form a comprehensive defence manufacturing ecosystem. Although the researcher acknowledges the existence of cooperative projects with various entities like universities and research institutes, these collaborations are not prominent and visible within the industry.

Publications that are somewhat relevant to ecosystems primarily focus on national economic innovations (Al-Khalifa et al., 2021; Alkhanbouli, 2022). However, Sharafi (2022) argues that “the UAE must learn from its own experiences and those of other nations to further improve its innovation ecosystem, such as by tackling legacy rentier institutions and laws that prevent it from transforming into a fully modern sustainable economy”.

The UAE's defence manufacturing sector stands at a critical juncture where the establishment of a robust ecosystem is imperative for its evolution and sustainability. A well-integrated ecosystem would streamline operations and enhance efficiency and foster innovation by facilitating collaboration among industry players, academic institutions, and research bodies.. Moreover, a dynamic defence manufacturing ecosystem would attract investment, spur economic growth, and position the UAE as a global leader in the defence industry. Therefore, the development of a strong and interconnected ecosystem is not just beneficial but necessary for the UAE's defence manufacturing sector to thrive and compete on the international stage.

2.11 Industry 5.0

Industry 5.0 marks the next significant evolution in industrial development, where the focus shifts from purely automated processes to a harmonious collaboration between humans and advanced technologies. Unlike its predecessor, Industry 4.0, which emphasised the power of disruptive technologies, Industry 5.0 reintroduces the human element into manufacturing, prioritising human-centric values alongside technological innovation (Xu et al., 2021). This new paradigm envisions a future where machines and humans work together in synergy, leveraging their strengths to create more personalised, sustainable, and ethical production processes. Industry 5.0 seeks to enhance the role of human creativity and ingenuity, ensuring that technological progress is aligned with societal needs and well-being (Golovianko et al., 2023). The human-centric approach of Industry 5.0 ensures that ethical considerations and sustainability are integral to the design and production of defence technologies, leading to effective and responsible innovations.

2.12 Conclusions

This chapter offers a comprehensive review of the UAE's defence manufacturing industry, exploring its evolution, challenges, and strategic importance. It starts by tracing the history of global defence manufacturing, highlighting key developments from ancient times to the present, and emphasising the evolution of military technologies and strategies.The UAE's defence sector is analysed in the context of its geopolitical importance, regional instability, and economic considerations. The review highlights the transition of the UAE's defence manufacturing from reliance on imports to developing indigenous capabilities through strategic alliances, technology transfers, and initiatives like the Tawazun Economic Council and EDGE Group.

Critical analysis reveals challenges such as limited technological capabilities, human capital development, supply chain integration, and the impact of export regulations. It stresses the need for enhanced research and development, investment in local talent, robust supply chain management, adherence to international export controls, and intellectual property protection.

The UAE's defence manufacturing sector, as it seeks to become a global leader, requires an integrated ecosystem to ensure sustainable growth, innovation, and competitiveness. An integrated ecosystem fosters collaboration among key stakeholders, including government agencies, private companies, research institutions, and international partners, enabling the seamless exchange of knowledge, resources, and technologies. This interconnected environment enhances efficiency, reduces costs, and accelerates developing and deploying advanced defence solutions. Moreover, it strengthens supply chain resilience and ensures the sector can rapidly adapt to emerging threats and technological advancements. By integrating various components of the defence industry, the UAE can build a robust and self-reliant defence manufacturing capability that supports national security and economic diversification. This study, hence, aims to develop an integrated ecosystem for defence manufacturing, recognising the critical need for a cohesive and collaborative framework that brings together all elements of the industry.

Chapter 3: Research Methodology

3.1 Introduction

The research methodology is the foundational framework for any well-organised and methodical research project. Its significance cannot be overstated, as it involves carefully selecting and applying various approaches, tools, and methods to ensure the research process is coherent and effective, ultimately leading to meaningful results. This chapter provides insights into the formulation of the research methodology, laying out structured steps for its development.

This work draws upon the Research Onion model proposed by Sanders to construct a robust methodology. This model offers a comprehensive guide to the layers of decision-making processes involved in formulating a research strategy. It encompasses the choice of methods, data collection and analysis approaches, and the philosophical stances underpinning the research. By adopting this framework, the chapter aims to present a clear and systematic approach to developing the research methodology, ensuring that every aspect is meticulously planned and aligned with the overall research objectives.

3.2 Saunders Research Onion

The research onion (Saunders et al., 2012) is a conceptual framework used in academic research to outline the stages of methodology in a structured and coherent manner. Developed by Saunders, Lewis, and Thornhill, the onion metaphorically represents the layers researchers must peel away to define the core elements of their research design (Figure 3.1). It begins with the outermost layer, the philosophical stance (positivism, interpretivism, etc.), which influences the subsequent layer, the approach to research (deductive or inductive) (Table 3.1). Next, the strategy (experimental, survey, case study, etc.) and choices (quantitative, qualitative, or mixed methods) layers follow, detailing how the research will be conducted. The onion continues with the time horizon (cross-sectional or longitudinal) and, finally, the data collection and analysis methods (interviews, questionnaires, statistical analysis, etc.). This model helps systematically organise and understand the complex decision-making process in research methodology.

Layer	Description
1. Research Philosophy	Refers to the belief about the way in which data about a phenomenon should be gathered, analysed, and used. Common philosophies include positivism, interpretivism, realism, and pragmatism.
2. Research Approaches	Indicates the approach to research, whether deductive (testing a hypothesis), inductive (building theory through observations), or abductive (combining both).
3. Research Strategies	Encompasses the plan and procedure for the research, such as experiments, surveys, case studies, action research, grounded theory, ethnography, etc.
4. Research Choices	Relates to the nature of the research, whether it is mono-method (quantitative or qualitative), mixed-method, or multi-method.
5.Time Horizons	Refers to the timeframe of the research, which can be cross-sectional (at a single point in time) or longitudinal (over an extended period).
6. Data Collection Methods	Involves the techniques and procedures used to gather data, which could include surveys, interviews, observation, archival research, etc.

Table 3.1: Description of Layers

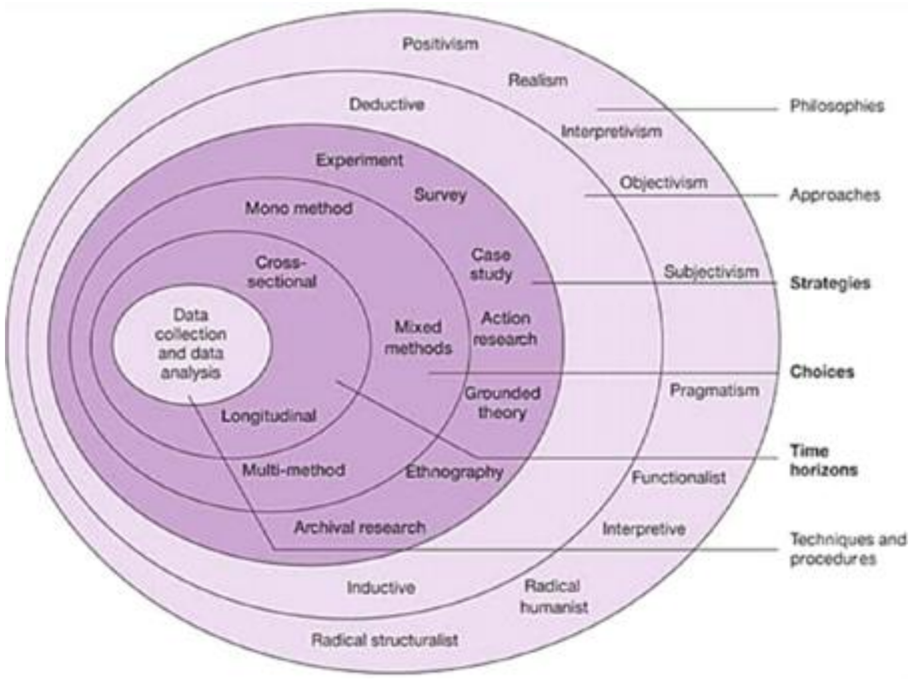

Figure 3.1: The Research Onion (Saunders et al., 2012)

3.3 Layer 1 – Philosophies

Research philosophy is a fundamental aspect of research methodology, acting as the backbone that shapes the direction and approach of a study. It encompasses the researcher's worldview, influencing how they perceive and interpret the research subject. This philosophy is not monolithic but is composed of various layers, with the first layer consisting of ten distinct philosophical approaches. Each of these approaches offers a different lens through which to view the research topic, grounded in specific ontological, epistemological, and axiological assumptions.

Ontological assumptions concern the nature of reality and what is considered truth in the research context, dictating whether the focus is on objective facts or subjective experiences. Epistemological assumptions deal with the nature and scope of knowledge, influencing how researchers gather and interpret data. On the other hand, Axiological assumptions relate to the role of values in research, guiding ethical considerations and the importance placed on objectivity or subjectivity.

Ontological assumptions investigate the fundamental nature of reality, presenting two distinct viewpoints: objectivism and subjectivism. Objectivism asserts that an external reality exists independently of individual perceptions, suggesting that the world has an objective structure that can be understood through empirical observation and logical analysis. On the other hand, subjectivism contends that reality is not a standalone entity but is instead constructed and influenced by individual perspectives and experiences, indicating that our understanding of the world is inherently subjective and shaped by personal, cultural, and societal influences. In conducting this research, a comprehensive approach was adopted, incorporating best practices from various relevant disciplines, considering the insights and opinions of stakeholders, and examining the theoretical models proposed by other scholars. This holistic integration of knowledge and perspectives led to adopting a subjectivist approach, which emphasises the importance of understanding key stakeholders' unique viewpoints and experiences. By centring the research on these perspectives, the study aims to capture the subjective nature of reality as experienced and interpreted by those directly involved; thereby providing a more in-depth and contextually rich understanding of the subject matter.

Epistemological assumptions are introductory beliefs about the nature and origin of knowledge, exploring how we come to understand and categorise the world. These assumptions are crucial in the research, guiding the knowledge-creation process. In the field of epistemology, there are primarily two divergent perspectives: positivism and interpretivism. Positivism is an approach that emphasises the importance of objective knowledge and often relies on quantifiable data that can be empirically verified. It supports the concept that knowledge should be based on natural phenomena and their properties and relations, as established through scientific methods. For instance, the law of gravity is a product of positivist research grounded in observable and measurable facts. Conversely, Interpretivism argues that knowledge is subjective and constructed through social constructs and interactions. This perspective holds that understanding the context in which knowledge is created is essential and that individuals' perceptions and experiences play a critical role in shaping what is considered knowledge. Interpretivism suggests that reality is interpreted through the lens of cultural, historical, and personal perspectives, making it a more fluid and dynamic process. Given the objective of this research, which is to develop a new framework or to contribute new knowledge to the field, the interpretive approach appears more suitable. This is because the creation of new frameworks often involves understanding and interpreting complex social interactions and phenomena, which are better suited to the context-sensitive nature of interpretivism. By adopting an interpretive stance, the research can delve deeper into the subjective meanings and experiences that underlie the phenomenon being studied, thereby facilitating a more comprehensive and insightful understanding of the new knowledge it aims to generate.

Axiological assumptions play a crucial role in shaping the research process by guiding the determination of what information is deemed valuable and significant. These assumptions underpin the researcher's decisions on which data should be prioritised and how its worth should be assessed within the context of the study. According to Sekaran & Bougie (2016), axiology significantly influences both the selection and valuation of data and its collection methods. This involves a critical evaluation of the nature and sources of data to ensure alignment with the research's axiological stance. Saunders further elaborates on this concept by outlining various approaches to axiological assumptions, specifically in the context of data collection. These approaches provide a framework for researchers to understand and articulate the value judgments underpinning their methodological choices, ensuring that the data collected is relevant and resonates with the research's underlying values and objectives.

Positivism, Realism, Interpretivism, and Pragmatism are four principal philosophical stances that influence research methodologies and axiological outlooks. Positivism is founded on the notion that reality is objective and can be uncovered through empirical observation and logical reasoning, emphasising quantifiable data and statistical techniques. Realism, conversely, recognises an objective reality but contends that our comprehension of it is filtered through human senses and scientific apparatus, thus blending elements of objective and subjective viewpoints. Interpretivism advocates for understanding human behaviour and social phenomena through the subjective interpretation of participants' experiences, emphasising qualitative methods to grasp the complexity of social realities. Pragmatism rejects the binary between objective and subjective realities, focusing instead on the practical application of research and the employment of mixed methods to address real-world problems. It values the utility and action-oriented nature of knowledge, proposing that the merit of research lies in its capacity to tackle practical issues.

Considering that this research integrates objective and subjective viewpoints, pragmatism emerges as the optimal axiological philosophy for guiding this research study. This approach allows for a flexible and practical framework that acknowledges the value of empirical evidence and individual experiences. By adopting pragmatism, the research can effectively navigate the complexities of analysing factual data while also appreciating the nuances of personal perceptions and beliefs, thereby ensuring a comprehensive and balanced exploration of the subject matter.

3.4 Layer 2 – Approaches

This layer of research methodology encompasses two distinct approaches: deductive and inductive, also called top-down and bottom-up approaches. Deductive research is theory-driven, starting with an established theory or hypothesis and testing it against empirical data. This approach is systematic and structured, often used in quantitative research to validate or refute theoretical propositions through observation and experimentation. In contrast, inductive research is data-driven, beginning with data collection and analysis to form theories or hypotheses. This method is exploratory in nature, commonly employed in qualitative research to understand patterns, behaviours, and phenomena, leading to the generation of new theoretical insights. Collis and Hussey (2003) highlights these methodologies, emphasising their fundamental differences in the process of theory and hypothesis development. Table XX systematically outlines these differences, providing a comparative overview of the two approaches and their respective methodologies in the research process.

This research will adopt a hybrid methodology, incorporating deductive and inductive approaches to analyse the subject matter comprehensively. In the initial phases, a deductive approach will be employed to systematically identify and analyse issues, models, and challenges within the field of emergency management. This will involve applying existing theoretical frameworks and principles to the collected data to understand the underlying structures and recurring patterns in emergency management practices. As the study progresses, it will shift towards an inductive approach, especially in the later stages. This transition is crucial for deriving specific, context-driven insights from the data. The research will focus on collating and interpreting data through the inductive method to develop a robust framework and detailed recommendations organically. This process is essential for generating a theory that is not only grounded in empirical evidence but also tailored to address the unique complexities and dynamics observed in defence manufacturing.

3.5 Layer 3 – Strategies

The third layer of Saunders' Research Onion model deals with research strategy, offering a range of options that researchers can adopt based on the nature and objectives of their study. This layer encompasses various strategies such as experiments, surveys, case studies, action research, grounded theory, ethnography, and archival research. Each strategy has its unique focus and methodology. Experiments are suitable for testing hypotheses under controlled conditions, while surveys are ideal for collecting large amounts of data from a significant population sample. Case studies provide an in-depth analysis of a particular context or situation, and action research involves solving a problem through iterative cycles of planning, acting, observing, and reflecting. Grounded theory is used to generate theory from systematically collected and analysed data, and ethnography offers a deep understanding of people's behaviours and cultures through immersive observation. Archival research involves analysing existing historical records and documents. The choice of research strategy is crucial as it directly influences how the research will be conducted, the type of data collected, and the overall direction of the study.

This research study aims to use the following approaches.

(a) Case studies

Case studies are employed in research to conduct an in-depth investigation of a particular individual, group, organisation, or event. This method allows researchers to explore complex issues within their real-life context, gaining a comprehensive understanding of the subject matter. Case studies are particularly useful for generating detailed, qualitative insights, enabling researchers to uncover specific phenomena' dynamics and underlying mechanisms.

They often involve the collection of data through various means, such as interviews, observations, and document analysis, providing a multifaceted perspective on the research question. In this research, case studies of newly industrialised countries are utilised to examine the strategies and methods these nations employ to rapidly develop their defence manufacturing sectors. The focus is on understanding the key factors and policies that facilitated such swift industrial growth in the defence sector, drawing from the experiences and practices of these countries.

(b) Comparative analysis of case studies

Comparative analysis in case study research involves systematically comparing and contrasting different cases to identify patterns, similarities, and differences. This method is used to deepen understanding of a phenomenon across different contexts, enhancing the robustness of the findings. By examining multiple case studies, researchers can uncover how varying conditions or approaches lead to different outcomes, thereby gaining insights into the factors that influence the success or failure of a particular phenomenon.

(c) Surveys

Surveys are employed as a key methodological tool to gather the current viewpoints of stakeholders in the UAE's defence manufacturing sector. This approach involves designing structured questionnaires to collect data from industry experts systematically. Surveys are particularly effective in this context as they allow for the efficient collection of data on a large scale, providing a broad perspective on the perceptions, attitudes, and opinions of those directly involved in or affected by the defence manufacturing industry. The standardised format of surveys ensures consistency in responses, facilitating the analysis and comparison of data across different groups of stakeholders. By capturing the contemporary insights of these stakeholders, surveys help in identifying trends, challenges, and opportunities within the UAE's defence manufacturing landscape, contributing to a comprehensive understanding of the sector's dynamics.

3.6 Layer 4 – Choices

This layer offers three distinct methodological approaches: mono methods, mixed methods, and multi-methods.

(a) Mono Method Study: This approach employs a singular methodological framework, focusing exclusively on either quantitative or qualitative research techniques. In a mono-method study, the researcher selects one type of data collection and analysis method, which could be either quantitative, involving numerical data and statistical analysis, or qualitative, focusing on descriptive data and thematic analysis.

(b) Mixed Method Study: This approach integrates both qualitative and quantitative methodologies to provide a more comprehensive understanding of the research topic. By combining these methods, the researcher can leverage the strengths of both quantitative and qualitative approaches, allowing for a complete analysis of the data. This method is particularly useful in addressing complex research questions that require multiple perspectives to understand the phenomena being studied.

(c) Multi-Method Research: Unlike the mixed method, which integrates qualitative and quantitative approaches within a single study, multi-method research involves the use of multiple data sources or research techniques, which may all be qualitative, all quantitative, or a combination of both. This approach allows for a more in-depth exploration of the research topic from various angles, enhancing the robustness and validity of the findings.

For this research, the adoption of both qualitative and quantitative data signifies the selection of the Mixed Method approach. This choice is driven by the need to capture a holistic view of the research subject, combining statistical analysis of survey results with in-depth qualitative insights to achieve a balanced and comprehensive analysis.

3.7 Layer 5 – Time Horizons

This fifth layer outlines the temporal structure within which the research is conducted. The time horizon for research can be categorised into two distinct types: cross-sectional and longitudinal.

Cross-Sectional Studies - According to Flick (2015), cross-sectional research is characterised by the collection of data at a specific, singular point in time. This approach provides a snapshot of the phenomena under investigation, allowing researchers to analyse and infer relationships or conditions that exist within a particular time frame. Cross-sectional studies are often used to assess the prevalence of features or to establish associations between variables within a defined population at a single moment.

Longitudinal Studies - On the other hand, Goddard & Melville (2004) describe longitudinal studies as those that gather data repeatedly over an extended period. This method is designed to observe changes and developments in the subject matter over time, facilitating a deeper understanding of dynamics, trends, and causal relationships. Longitudinal research is particularly valuable for studying progression, evolution, or long-term effects within a given population or phenomenon.

In the context of this study, data collection was conducted in a short period of time, employing both primary and secondary methods. Primary data was obtained through surveys, while secondary data was gathered from existing literature. This approach indicates that the research adhered to a cross-sectional time horizon, involving a snapshot of data collection and analysis at a specific moment.

3.8 Layer 6 – Techniques and Procedures

In the context of this work, the methodology for data collection is twofold, encompassing both primary and secondary data sources:

Primary Data Collection: - The study employs surveys as the primary means of data gathering. Surveys are utilised to obtain quantitative data, offering a broad perspective on the research questions by capturing responses from a large sample of participants. This method is particularly effective in gauging prevalent trends, attitudes, or behaviours within the target population.

Secondary Data Collection - Alongside primary data, the research incorporates a literature survey as a method for collecting secondary data. This involves a systematic review of existing scholarly works, including articles, books, and reports, to gather relevant information and theoretical perspectives related to the study's subject matter. The literature survey helps establish a solid theoretical foundation for the research, identify gaps in the current knowledge, and situate the new research within the broader academic discourse.

3.9 Summary - Selected Options from the Research Onion

The table presented below provides a comprehensive summary of the methodological choices made for this research project, structured according to the Research Onion model. This model, a systematic framework for conducting academic research, guides the selection of various methodological layers, each contributing to the overall design and approach of the study.

Layer	Chosen Options
Layer 1 – Philosophies	Ontological assumptions - Subjectivist Epistemological assumptions – Interpretivism Axiological assumptions – Pragmatism
Layer 2 - Approaches	Both deductive and inductive
Layer 3 – Strategies	Surveys, Case studies
Layer 4 - Choices	Mixed Method
Layer 5- Time Horizons	Cross-Sectional
Layer 6 Techniques and Procedures	Questionnaires, Surveys, Comparative Analysis

Table 3.2: Choices for the research study

3.10 Research Study

Figure 3.2 illustrates the implementation of the tools and techniques previously identified within this study. The corresponding chapters thoroughly examine and detail each step of this process A brief explanation of some of the steps is provided here..

Questionnaire Survey - The survey's primary objective was to gather and understand stakeholders' perspectives regarding the ongoing developments within the sector. The survey specifically targeted a homogeneous sample from the UAE defence manufacturing sector, By capturing a wide range of views, the survey sought to highlight key areas of concern, opportunities for growth, and emerging trends that could influence the sector's evolution in the coming years.

Comparative Analysis—Comparative analysis of defence industries from other nations offers significant benefits in building a framework for an integrated defence ecosystem. By examining the strategies, technologies, and operational models employed by leading defence sectors worldwide, valuable insights can be gained into best practices and innovative approaches that have proven effective in diverse environments.

Validation - To ensure the robustness and relevance of the proposed framework for integrated ecosystems, industry experts will play a crucial role in its validation. These experts, with extensive experience across various sectors within the ecosystem, will provide critical insights and feedback to refine the framework.

3.11 Validity and Reliability

Several key factors underpin the validity and reliability of the questionnaire survey and comparative analysis. The questionnaire survey, which targeted a homogeneous sample from the UAE defence manufacturing sector, is meticulously designed to capture a broad spectrum of stakeholder perspectives. By focusing on this specific group, the survey ensured that the data collected was directly relevant to the sector, thus enhancing its validity. Furthermore, using a homogeneous sample increases the reliability of the results, as the respondents share similar backgrounds and industry experiences, reducing the variability in responses.

The comparative analysis adds another layer of validity by incorporating proven strategies and operational models from leading global defence industries. This approach ensures that the framework is grounded in real-world applications and best practices, making it more likely to be effective in the UAE context. The involvement of industry experts in the validation process further strengthens the reliability of the proposed framework. Their expertise and critical feedback help refine the framework, ensuring it is robust and applicable across various scenarios within the integrated defence ecosystem. These methodologies provide a comprehensive and credible foundation for developing a framework.

3.12 Ethical Considerations

This study has been conducted in strict accordance with the ethical guidelines and regulations mandated by Sheffield Hallam University. All procedures involving human participants have been reviewed and approved by the appropriate ethics committee, Informed consent was obtained from all participants prior to their involvement, and their privacy and confidentiality were rigorously protected throughout the study. The commitment to ethical integrity was maintained at all stages of the research process, aligning with the ethical framework established by Sheffield Hallam University.

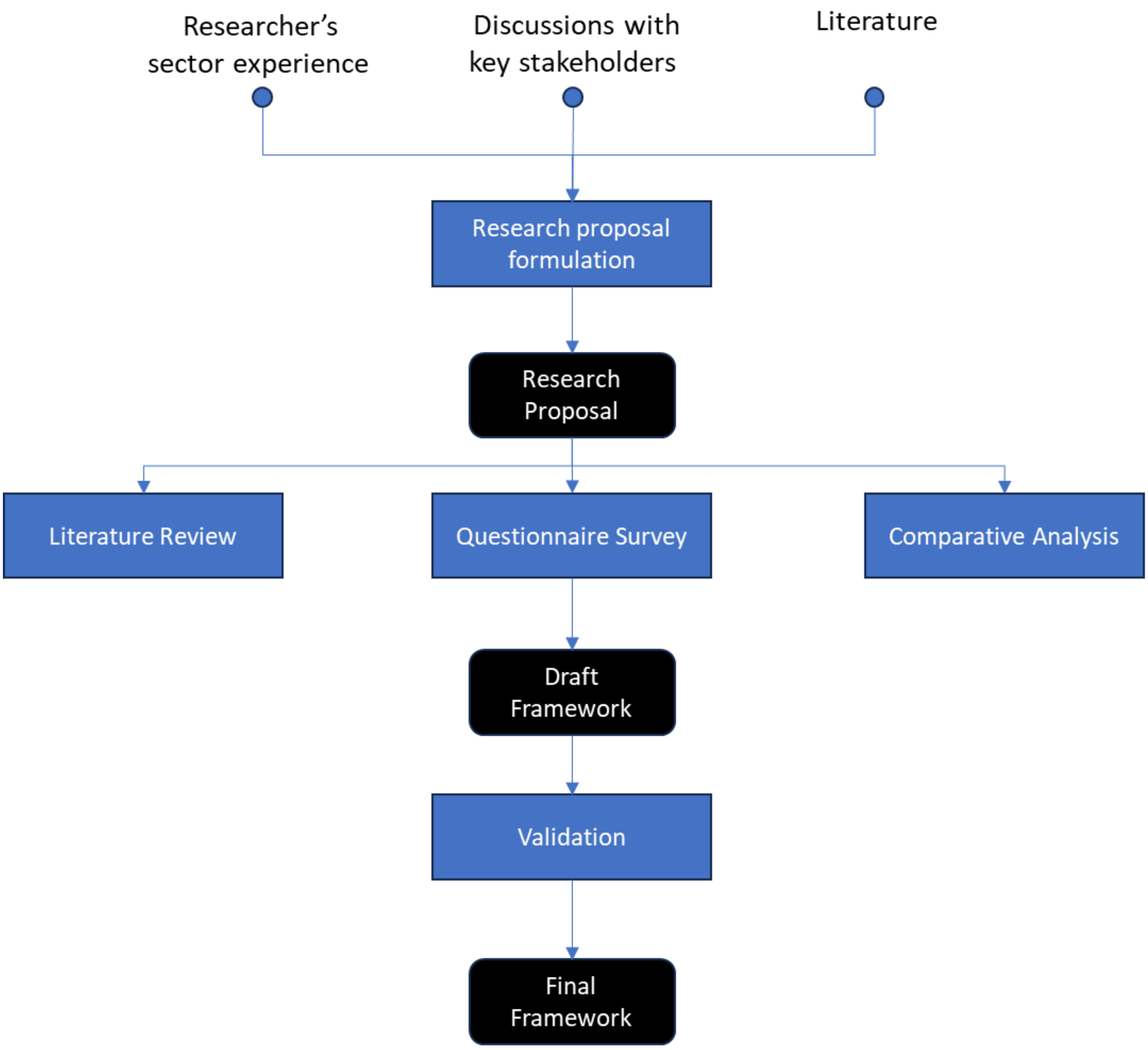

Figure 3.2: Key steps in the research study

3.13 Summary

The principal objective of this chapter is to systematically outline the selection of research philosophies and methodologies that underpin this research study. In doing so, it employs Saunder's Research Onion Model as a guiding framework, through which appropriate choices were selected for each layer, ensuring a robust and coherent research design. Table 3.2 provides a concise summary of these selections, encapsulating the core elements of the research approach adopted.

Furthermore, Figure 3.2 visually demonstrates how the selected tools and techniques have been effectively implemented within the scope of this research study, offering a clear and structured overview of the methodological application. Subsequent chapters explain their relevance and contribution to the research process to provide a deeper understanding and insight into these methodologies.

Chapter 4: Questionnaire Survey & Viewpoints from Industry Research

4.1 Introduction

As this research aims to find ways to transform the defence manufacturing industry in the UAE, it is critically important to recognise the stakeholder views on the current state of the industry and ascertain further perspectives from industry sources. The collated information would strengthen the need for this research and influence the formulation of the framework.

The first part of this chapter focuses on the development and conduct of the survey and the analysis of the collated data. The second part presents perspectives gathered from industry sources.

4.2 Questionnaire Survey

Questionnaire surveys are a well-established method of gathering data from primary sources (McLafferty, 2016). This section presents all the key phases of the design of the questionnaire survey and the analysis of collated data.

4.2.1 The Need

Research study of this nature requires a holistic understanding of the sector under consideration. At present, the primary sources of information are (a) government websites, (b) policy documents, (c) news feeds and (d) evidence from sector-specific research by consultancy organisations. Whilst these sources provide useful information on the developments and trends, none of the publicly available publications, including research papers, refers to results from sector surveys. There is evidence of surveys conducted elsewhere but not in the UAE (Caruso & Locatelli, 2013, Uttley & Wilkinson 2016). It is difficult to ascertain why no surveys have been conducted in the UAE defence industry, but it may be due to the fact that the sector has been in a state of flux for many years. The researcher's extensive interactions with the industry gave him the opportunity to conduct a first-ever survey.

4.2.2 The Purpose

The main purpose of the survey was to capture the stakeholder views on the ongoing developments, needs, and future directions of the sector.

4.2.3. The Design of The Survey and Pilot Testing

Given the purpose outlined above, the questionnaire survey focused on the following four (4) elements.

(a) Respondent's experience and the type of organisation

(b) The development journey of the UAE defence manufacturing industry

(c) Models for a new defence manufacturing industry

(d) Development Needs

The initial questionnaire was pilot-tested with six (6) experts from the industry. They broadly agreed with the structure of the questionnaire but advised that it should include questions on (a) the role of SMEs in the defence manufacturing industry and (b) the interactions with higher education and research organisations.

The final version of the questionnaire is presented in Appendix 1.

4.2.4 The Survey

The following sections outline the operational aspects of the survey.

(a) The Format

For efficient distribution and collation of data, the questionnaire was produced using Google Forms. The survey participants were sent the link to the questionnaire.

(b) The Sample

Given the researcher's extensive interactions with the industry, it was possible to identify a significant number of potential participants from a variety of organisations.

(c) The Period

The questionnaire survey was launched on 18-07-2018 and kept active for nearly four months. The survey results may exhibit some variations in 2024 compared to those observed in 2018, as they were collected when circumstances, opinions, and external factors could have differed. Therefore, while the 2018 data provides valuable insights, it is important to consider these potential shifts when interpreting the findings in 2024.

(d)The number of useful responses

A total of useful responses were identified, as some of the responses had to be rejected due to partial completion. Hence, the response rate is 29%, which is an acceptable response rate.

4.3 The Analysis of Survey Data

In the following sections, a detailed analysis of the data collected from the survey is presented.

4.3.1 Respondent's Experience and The Types of Organisations

Two (2) questions under this section aim to establish the length of the respondents' work experience and the type of organisations they belong to.

4.3.1.1 Length of working experience

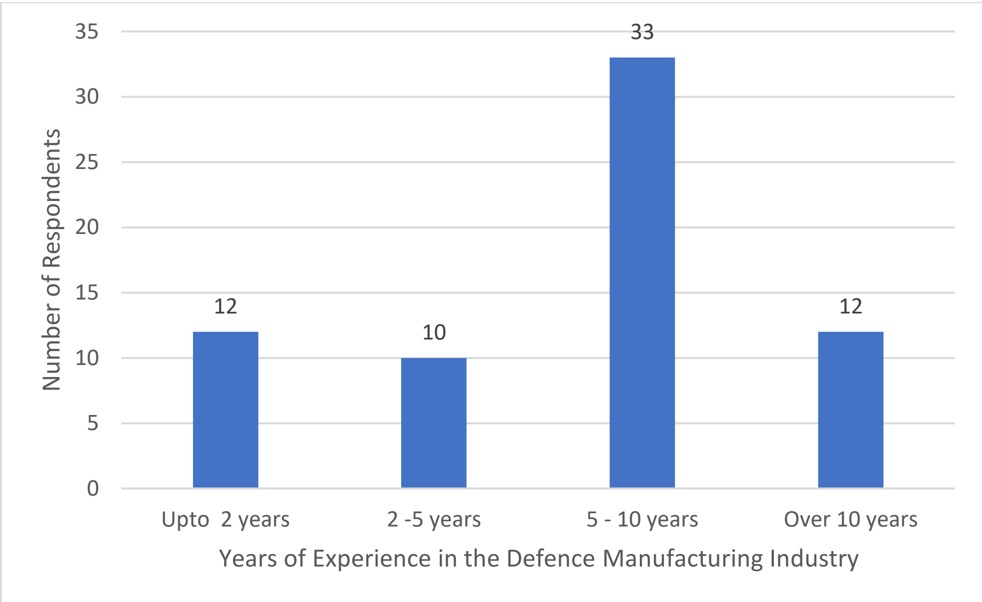

Figure 4.1: The length of working experience of the respondents

Nearly 50% of the respondents have 5-10 years of working experience in the industry, and a further 15% with more than ten (10) years of experience. Given that the majority of respondents have more than five (5) years of experience, it is safe to assume that their views reflect a true picture of the industry.

4.3.1.2 Respondent's industry association

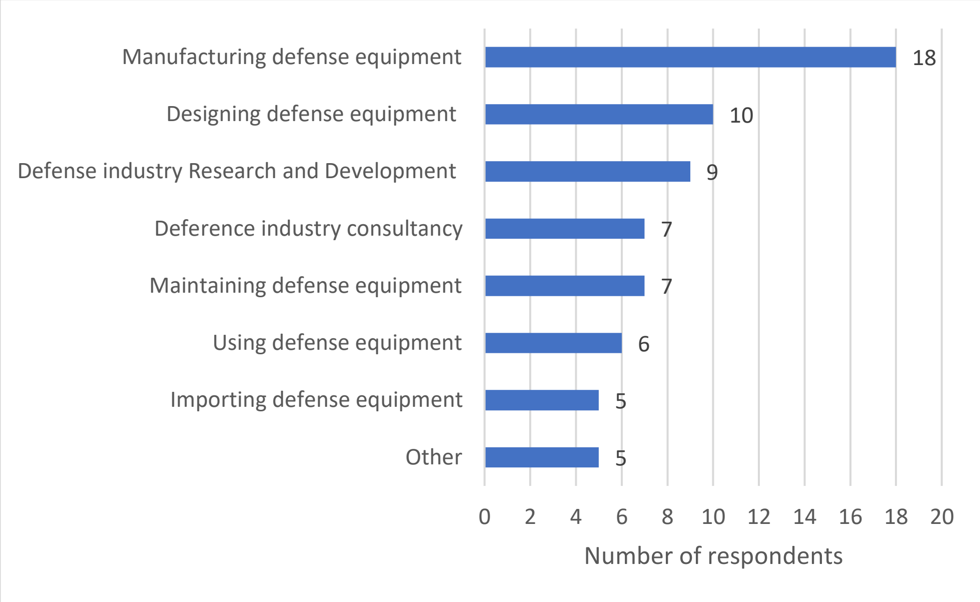

Figure 4.2: Industrial associations of the respondents

The sample includes respondents from a range of industry associations. The largest group, just over 25%, is from the defence manufacturing sector. It is important to note that the "Defence Industry Research and Development" group does not include any respondents from the higher education sector in the UAE. It was decided not to approach the higher education sector as there is no strong evidence of active research on the defence sector.

4.3.2 Development journey of the UAE defence manufacturing industry

This section of the survey focuses on the aspects relating to the UAE defence manufacturing industry.

4.3.2.1 UAE Defence Strategy

Survey statement: UAE has a clear and coherent strategy for developing its own defence manufacturing industry

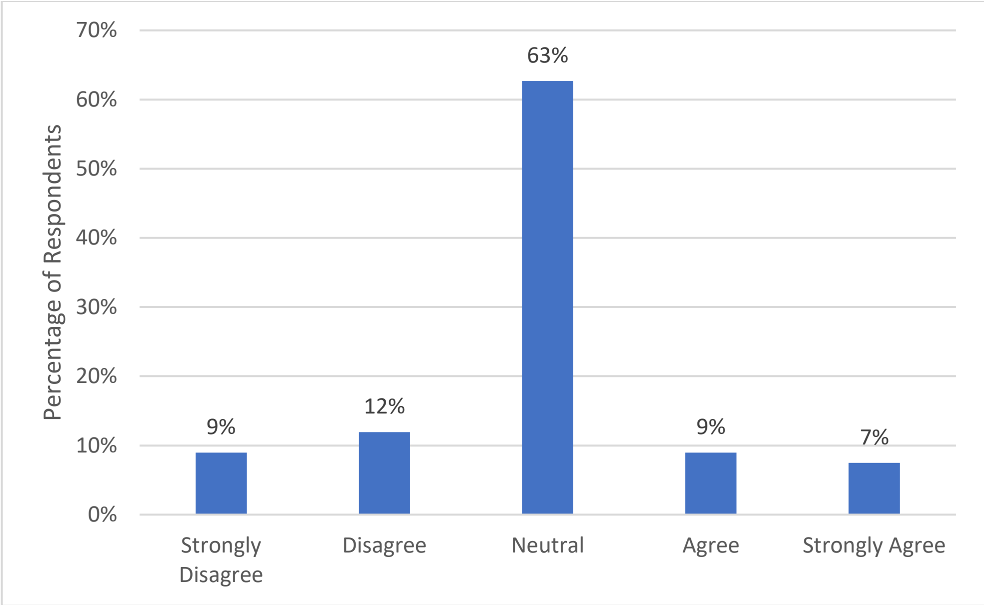

Figure 4.3: *Survey Statement* - UAE has a clear and coherent strategy for developing its own defence manufacturing industry

There is no strong support for this statement, as a significant proportion of respondents have taken a neutral stand. This may be due to the fact that the UAE defence manufacturing sector has gone through a number of transformations in recent years. In 2016, the government of the UAE launched.

4.3.2.2 Investment

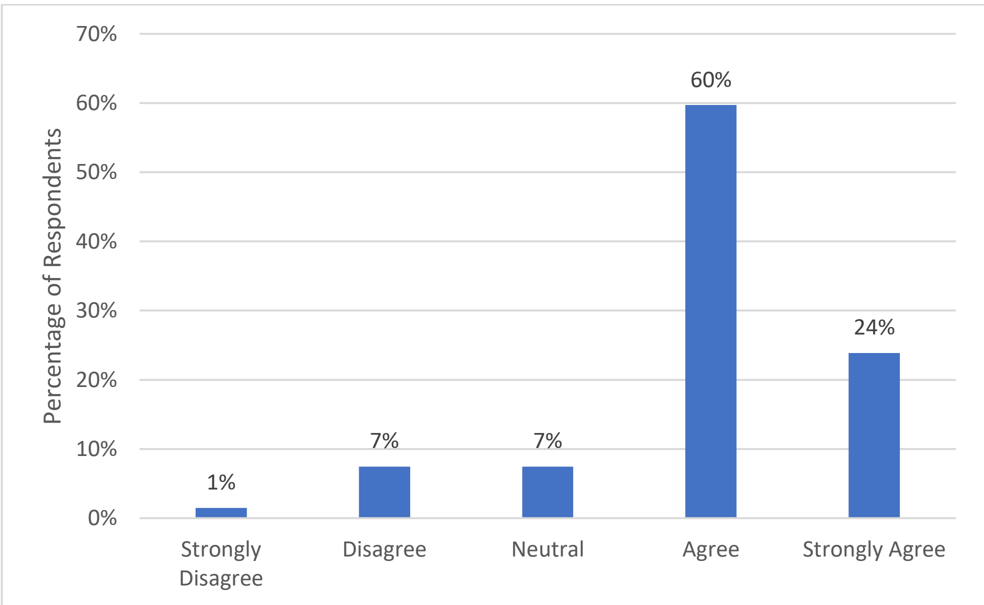

Figure 4.4: Survey Statement - The government has made the necessary investment to simulate the growth of a local defence manufacturing industry

The results suggest that there is overwhelming agreement on using investment to stimulate the growth of the defence sector. In 2014, the government of the UAE took steps to consolidate the defence sector by establishing EDIC (Emirates Defence Industries Company), which acts as an umbrella body for the sector. This transformation appears to have had a positive impact by channelling the necessary investment into the sector.
<u>Note:</u> in 2019, the government of the UAE took further steps to consolidate the sector by establishing the EDGE Group. It is important to note that this survey was conducted prior to the establishment of the EDGE Group.

4.3.2.3 Support for SMEs

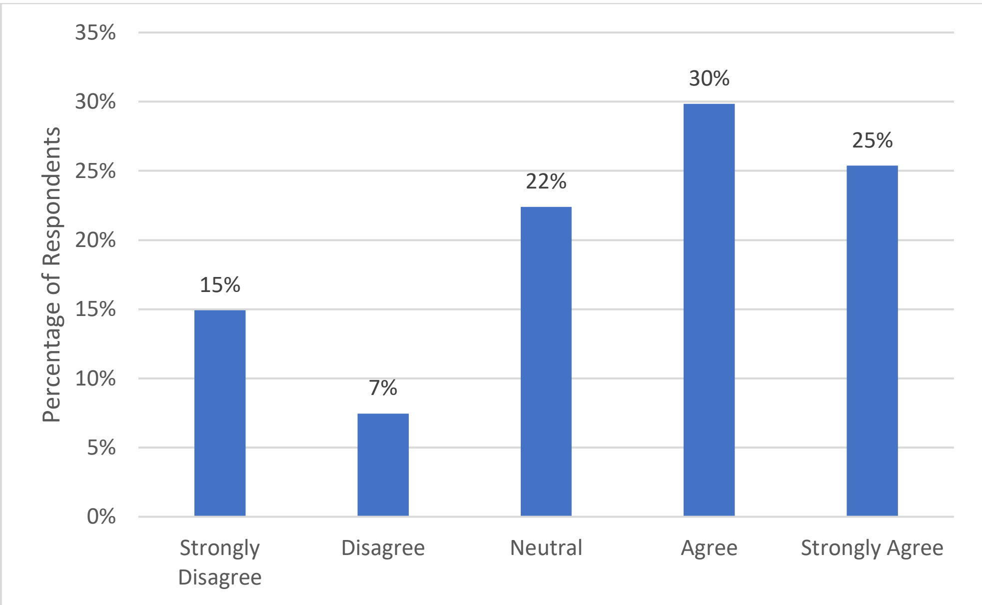

Figure 4.5: *Survey Statement* - Government investment mainly supports only very large companies

As only 22% strongly disagree or disagree with the statement, it may be asserted that SMEs are not benefiting from the consolidation with respect to the investment required to stimulate growth. A study by Mohammed (2019), identified the lack of investment in SMEs in the UAE as a key barrier to innovation. As SMEs play a major role in modern economies (Savlovschi & Robu, 2011) it is critically important to integrate SMEs into the defence industry ecosystem. For example, Holder (2015) argues that developing key industrial capabilities for Canadian defence small and medium enterprises is vital to creating a competitive defence industrial base.

4.3.2.4 Emirati workforce

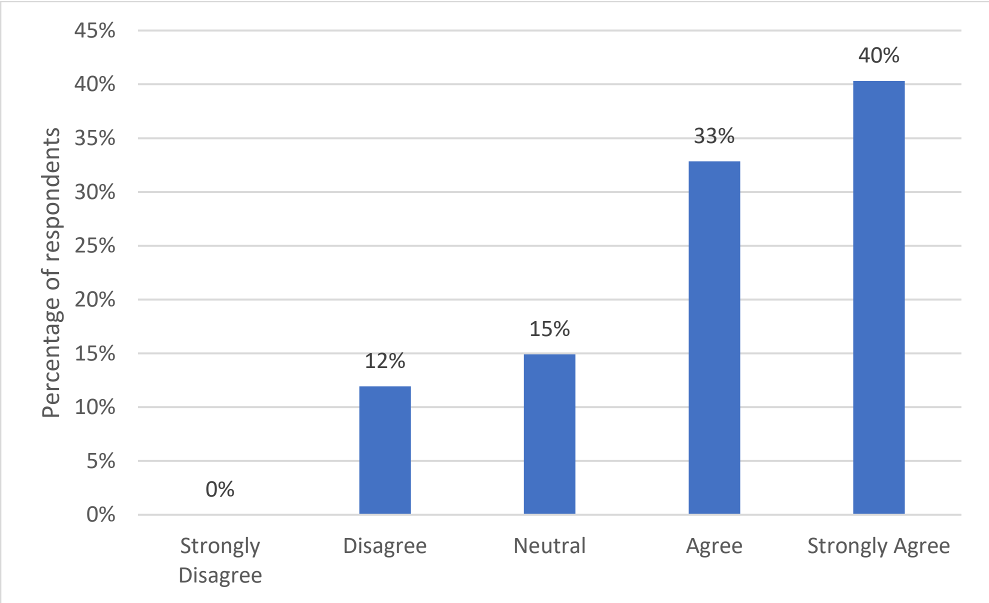

Figure 4.6: *Survey Statement* - There is a shortage of Emirati workforce to support the development of defence manufacturing industry

Nearly three-quarters of respondents agree with the fact that there is a shortage of Emirati professionals to support the development of the local defence industry. Given the sensitivities involved and geo-political tensions, naturally, the defence industry prefers to engage local talent. In 2006, the UAE Ministry of Labour issued a ruling that required all private sector organisations with 50 or more employees to appoint an Emirati human resource manager (Abdusheikh, 2012); the primary motive behind this decree was to ensure that every effort was taken to employ Emiratis. However, there is no evidence that there is a clear strategy for developing the Emirati workforce for the defence industry.

4.3.2.5 Research & Development

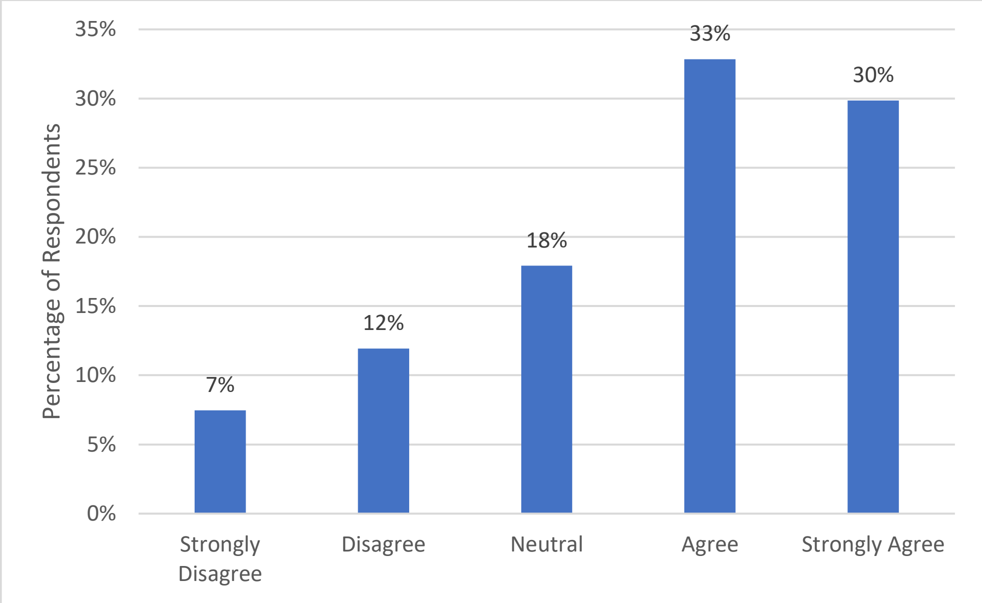

Figure 4.7: *Survey Statement* - There are no significant research and development capabilities within the UAE to support the development of the defence manufacturing sector

In early 2000, the UN Arab Human Development Reports (UNDP, 2002; UNDP 2003) highlighted the lack of progress towards the development of knowledge economies in the Arab States. Two key factors cited were (a) the poor quality of higher education and (b) the low level of research productivity in higher education. With the view to address this gap, each emirate developed their own strategies (McGlennon,2006). In addition to developing federal universities and the UAE adopted an open-door policy which enabled overseas universities to set up their own campuses in the UAE. By 2010, the leading universities in the UAE were demonstrating their abilities to produce high-quality, world-class research (Wilkins,2010). However, a recent analysis (Karabchuk et al., 2022) argues that universities are still mainly seen as teaching instruments rather than research centres. The authors conclude that further investments into national research programmes for public and private– public universities and the establishment of a National Research University would boost research. The UAE government has already taken steps to achieve this transformation. The National Strategy for Higher Education 2030 states that.

"the Investment in Knowledge initiative aims to increase the number of Ph.D. students by increasing support for postgraduate funding and creating incentives to pursue higher education by ensuring attractive job opportunities."

“The Competitive Research Funding initiative will create a platform to provide funding for research in vital sectors and stimulate the collaboration between higher education institutions and the private sector.”.

The respondents have clearly identified the need to develop further R&D capabilities for the defence manufacturing sector.

4.3.2.6 Supply Chain

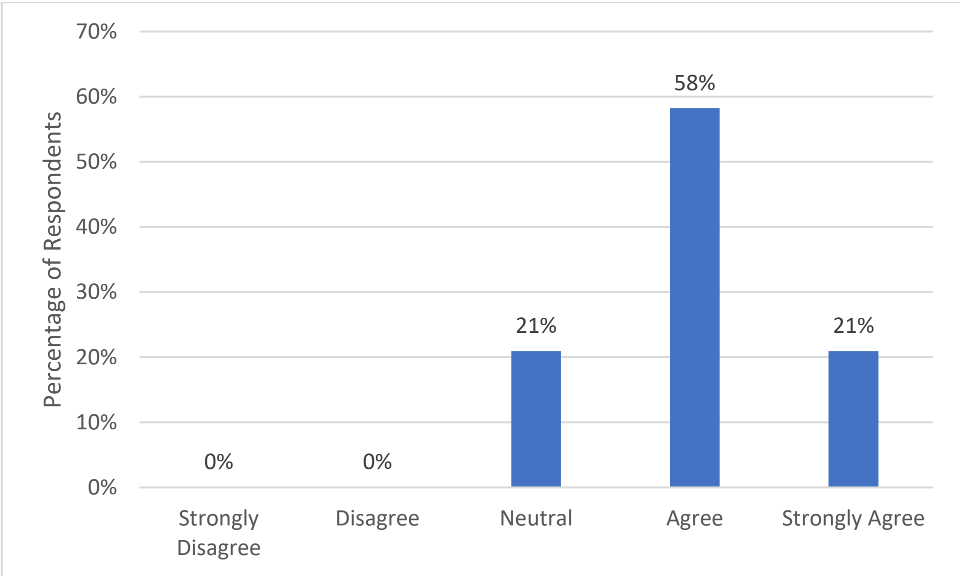

Figure 4.8: Survey Statement - Current defence manufacturing capabilities within the UAE are fragmented hence, a clear path is required to develop robust supply chains within the UAE

Current defence manufacturing capabilities within UAE are fragmented hence a clear path is required to develop robust supply chains within the UAE (Mangan & Lalwani 2016), the crucial role of the effective and efficient supply chain in the manufacturing sector. Supply chains are the backbone of any industry. The respondents agree that further efforts are required to build a coherent supply chain for the defence manufacturing sector. Alazazi (2017), who conducted a series of interviews and a questionnaire survey in the UAE defence manufacturing sector, concluded that manufacturing organisations understand the importance of supply chain management. Nevertheless, the sector has yet to reach the full potential of supply chain integration and information sharing.

4.3.2.7 Small and Medium-Sized Enterprises

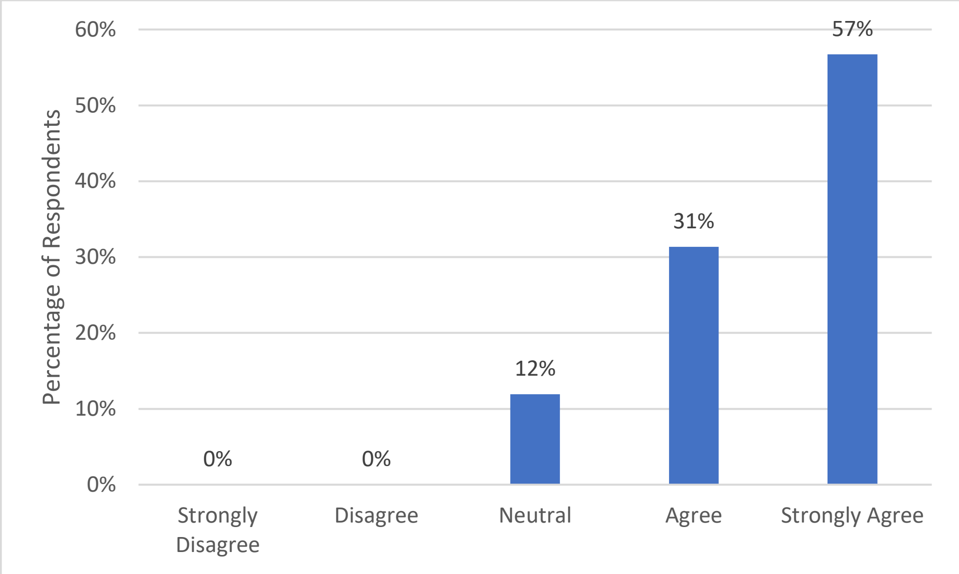

Figure 4.9: Survey Statement - Small and medium-sized companies require more support from the government to engage in defence manufacturing supply chain

The critical role that SMEs play in economic growth is universally recognised (Savlovschi & Robu, (2011), Floyd & McManus, (2005). For example, The Federation of Small Businesses in the UK claims that SMEs account for 99.9% of the business population and 61% of the employed population (UK Small Business Statistics, 2023). According to the UAE government's statistics, SMEs represent 94% of the business population, employ over 86% of the labour force and generate over 60% of the GDP (The Government of UAE, 2024). These statistics confirm SMEs' vital role; hence, SMEs should be an integral element of any industry. Bakhouche et al. (2020) discuss the challenges faced by SMEs in the UAE and propose that SMEs require systematic and targeted support from the government to achieve sustainable growth. This survey also strongly supported the view that SMEs require support from the government for active engagement in the defence manufacturing sector. Having recognised this need, in 2023, the UAE government launched a new initiative to provide targeted support for SMEs in the defence manufacturing sector (ZAWYA. 2023).

4.3.3 Models for a new defence manufacturing industry

This part of the survey focused on the operating models for the UAE defence manufacturing sector.

4.3.3.1 Collaboration

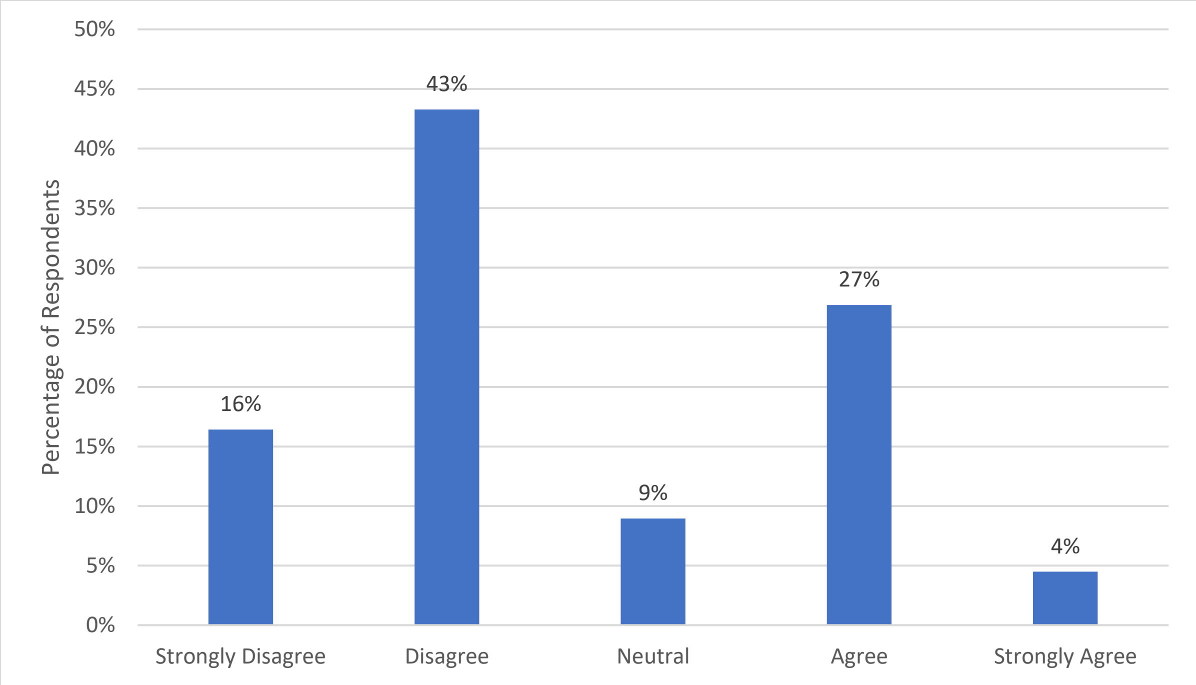

Figure 4.10: *Survey Statement*: UAE should develop its own defence manufacturing industry with minimal collaboration with overseas companies

Nearly 60% of the respondents agree that collaborations with overseas companies are required to develop the local defence manufacturing industry. Given the limited homegrown technologies, collaborations with overseas companies are required to develop and manufacture highly sophisticated products. The academic and industry literature point to examples of existing collaborations between the UAE and leading defence manufacturing nations (Gaub & Stanley-Lockman, (2017), Louth et.al (2013).

4.3.4 Product Range

Defence industry covers a wide range of products, from small arms to naval vessels. With the exception of superpowers, it is unlikely that defence industries in other nations would consider manufacturing a full range of defence products due to cost constraints, and technology know-how limitations. Therefore, nations developing their own defence manufacturing sectors need to identify the most appropriate defence products for local manufacturing. Three statements were included in the survey to capture the respondents' views.

(a) UAE defence manufacturing industry should focus on niche products so that UAE can become the world leader for those products in the future (Niche Products)

(b) UAE defence manufacturing industry should focus on a limited product range of those products that are strategically important to the UAE (Strategically Important Products).

(c) UAE defence manufacturing industry should focus on high-value products (High-Value Products). Figure 4.11 below shows the results.

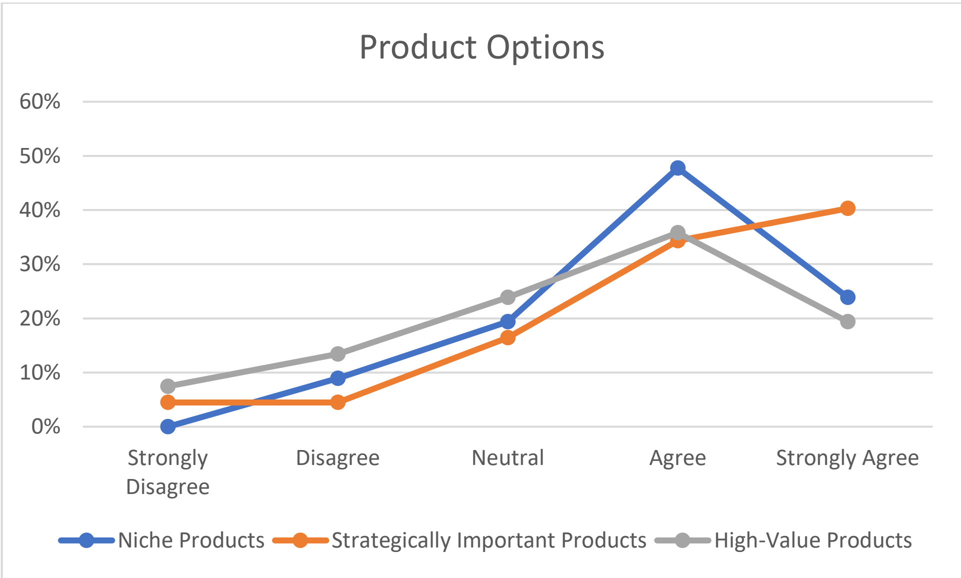

Figure 4.11: Product Range

Most respondents tend to agree or strongly agree with all three (3) statements. Selecting the right product range is highly complex problem and a wide range of factors need to be considered in the decision-making process. As shown in table 4.1, the UAE defence manufacturing sector manufactures a range of products, from pistols to advanced naval vessels.

Caracal pistols: used by military and law enforcement agencies.

NIMR armoured vehicles: a range of wheeled armoured vehicles, including the NIMR Ajban and NIMR Hafeet, used for various purposes such as troop transport, reconnaissance, and border patrol.
Al Fahd armoured personnel carriers: provides mobility and protection for troops during operations
ADASI unmanned systems: including aerial drones and ground robots, for surveillance, reconnaissance, and other military applications.
Calidus B-250 light attack aircraft: designed for counterinsurgency, close air support, and reconnaissance missions.
Al Tariq-class patrol boats: fast, highly manoeuvrable vessels used for coastal patrol and maritime security operations.
Baynunah-class corvettes: advanced naval vessels equipped with modern sensors, weapon systems, and communication capabilities.

Table 4.1: A selection of defence products manufactured in the UAE

4.4 Critiques of survey results

The survey pointed out that the lack of a clear and coherent strategy has impeded the development of the UAE defence manufacturing sector. The government of UAE has recognised that gap and has taken a range of actions in recent years to provide strategic leadership, such as establishing EDGE Group as the focal point for the industry. The survey also pointed out that three major areas need to be considered to develop the sector further.

- Enhancing R&D capabilities in the higher education sector
- Addressing the human capital shortage
- Integrating SMEs.

The above requirements indicate that the defence manufacturing ecosystem is fragmented, and a holistic approach is required to grow the industry.

4.5 Viewpoints from Industry Research

Industry Research Reports provide valuable assessments of specific industries, including challenges, opportunities and trends. Professional bodies and consultancy organisations produce industry research reports, and often high premiums are applied for full access. However, some industry research organisations make executive summaries available. After initial scanning, the following reports/summaries (table 4.2) were selected for further analysis.

Year	Publisher	Report Title
2023	Al-Bayan Centre for Planning and Studies	The Political Economy of The United Arab Emirates Defence Industry
2023	The Geneva Centre for Security Policy	The Business of War: IDEX 2023 Reveals the Latest Military Acquisitions Trends in the Middle East
2020	Malcom H. Kerr Carnegie Middle East Centre	Evolving UAE Military and Foreign Security Cooperation: Path Toward Military Professionalism
2017	EU Institute for Security Studies	Defence Industries in Arab States: Players and Strategies
2013	The Royal United Services Institute	Deference Industry and the Reinvigorated UK-UAE Security Relationship
Not known	Strategy& (part of the PwC network)	The Emerging GCC Defence market

Table 4.2: Reports/Summaries on the UAE Defence Manufacturing Sector

The review of the above reports/summaries identified the following challenges and trends in the UAE defence manufacturing sector.

(a) Technological Dependence: The UAE defence manufacturing sector has faced challenges related to technological dependence on foreign suppliers for critical components and systems. This dependence can impact the country's ability to develop Indigenous capabilities and maintain self-sufficiency.

(b) Skilled Workforce: Developing a skilled and specialised workforce for the defence manufacturing industry has been challenging. The sector requires engineers, technicians, and other professionals with expertise in defence-specific technologies and manufacturing processes.

(c) Research and Development: Enhancing research and development capabilities in the defence manufacturing sector has been challenging. Investing in research and development is crucial for innovation, technological advancement, and developing cutting-edge defence systems.

(d) Global Competition: The UAE defence manufacturing sector faces competition from established global manufacturers. Building a competitive edge regarding cost, quality, and technology can be challenging when competing with well-established defence industries.

(e) Export Control Regulations: Compliance with international export control regulations can present challenges for the UAE defence manufacturing sector. Strict regulations on the export of defence technologies and products can impact international collaboration and limit market access.

(f) Defence Budget Constraints: Budget constraints and fluctuations in defence spending can influence the growth and development of the defence manufacturing sector. Economic factors and changing geopolitical dynamics can affect defence budgets and investment in the sector.

4.6 Conclusions

This chapter presents the results from the survey and analysis of industry research reports. Both approaches identified some inherent challenges in the UAE defence manufacturing industry. Among them are human capital development, integration of SMEs and R&D capabilities. The government of UAE is making strides to develop a defence industry ecosystem, but currently, it is fragmented. This research, therefore, needs to consider Industry 4.0 as an integral element of a defence industry ecosystem.

Chapter 5: Comparative Analysis of Defence Manufacturing Bases

5.1 Introduction

As detailed in preceding chapters, the United Arab Emirates (UAE) has been striving to position itself as a dominant force in defence manufacturing within the region for approximately the last thirty (30) years. Initially, these endeavours faced significant challenges due to the absence of a unified strategy and limitations in human resources. Concurrently, several other nations have successfully created and developed their defence industries. This chapter examines and outlines the key success factors employed by a select group of countries that have successfully developed their indigenous defence manufacturing capabilities. This analysis will explore the strategic, operational, and policy frameworks underpinning their achievements, to draw lessons that could inform the UAE's ongoing efforts to enhance its defence manufacturing sector.

5.2 The Critical Role of a Robust Manufacturing Sector

A country lacking a strong manufacturing sector may struggle to establish and grow its defence production capabilities. A strong manufacturing base is a fundamental prerequisite for developing a defence manufacturing base for several critical reasons (Naudé & Szirmai, 2012; Haraguchi et al., 2017; Halkos et al., 2021).

Firstly, a well-established manufacturing sector lays the foundation by offering the essential technological framework and industrial expertise needed for the complex manufacturing processes involved in the production of defence equipment. The shift from producing civilian goods to military hardware requires exceptional precision, stringent quality control measures, and advanced technological capabilities. These attributes are inherently developed and refined within a mature manufacturing landscape. This environment fosters the technical skills necessary for defence production. It encourages innovation and the development of cutting-edge technologies, which are critical for maintaining a competitive edge in defence capabilities.

Secondly, having a robust manufacturing foundation guarantees access to a skilled and proficient workforce that can manage the intricate responsibilities of defence manufacturing. This includes a wide range of expertise in engineering, design, and the integration of complex systems. Such a workforce is essential for the successful execution of specialised tasks that are critical to the production and maintenance of defence equipment, ensuring that the sector remains at the forefront of technological advancements and operational readiness.

Thirdly, a varied and comprehensive industrial ecosystem plays a crucial role in bolstering the development of the necessary supply chains for defence manufacturing. This diversity within the industrial landscape enables the streamlined procurement of materials and components, ensuring an efficient and effective manufacturing process. By accessing a wide range of industries, defence manufacturers can easily source the required parts, materials, and technologies, enhancing overall production capabilities and facilitating a more robust and resilient supply chain infrastructure. This, in turn, contributes to the timely and cost-effective production of defence equipment, underscoring the importance of a diversified industrial base in supporting national defence objectives.

Lastly, a robust manufacturing sector is pivotal in enhancing a country's economic resilience, creating the essential financial resources required for investing in research and development activities that are critical for fostering innovation in defence technologies. This infusion of financial resources into R&D not only propels advancements in defence capabilities but also ensures that a nation remains at the forefront of technological innovation, essential for maintaining a competitive edge in defence. Consequently, the strength of a nation's manufacturing base is directly correlated with its ability to develop, support, and sustain an indigenous defence manufacturing industry.

Although superpowers largely dominate the global defence manufacturing industry, many other nations have also carved out their niches within the defence sector. As previously mentioned, a strong manufacturing base has empowered various countries, especially those classified as newly industrialised countries (NICs), to develop their defence industries. This development underlines the importance of a solid industrial foundation in enabling nations to achieve self-sufficiency in defence production.

5.3 Newly Industrialised Countries (NICs)

Bożyk (2006) categorises newly industrialised nations as those whose economic development falls between developing and highly developed nations. These nations have undergone significant economic growth and industrialisation, usually within the last few decades. This growth is often marked by increased industrial production, a visible shift from agricultural-based economies to manufacturing and service industries, and a higher Gross Domestic Product (GDP) per capita than other developing countries. NICs typically exhibit rapid economic growth, increased social and economic stability, and a more significant role in the global economy. Characteristics of NICs include (Haraguchi et al., 2019):

(a) Economic Diversification: Moving from traditional agriculture to more diverse economic activities, particularly manufacturing and services.

(b) Export-oriented Industrialisation: A focus on producing goods for export to global markets, often supported by government policies.

(c) Technological Advancement: Adoption and innovation in technology to improve productivity and compete internationally.

(d) Improvements in Infrastructure: Transportation, communication, and energy infrastructure development to support industrial and economic growth.

(e) Increased Foreign Direct Investment (FDI): Attracting foreign capital to invest in local industries and infrastructure projects.

(f(Rising Standards of Living: Improvements in income, education, and healthcare, leading to higher living standards for the population.

5.4 Newly Industrialised Countries & Defence Manufacturing Industries

The emergence of defence manufacturing in newly industrialised countries (NICs) marks a pivotal shift in the global defence landscape, reflecting these nations' growing economic capabilities and strategic ambitions. This development is driven by a desire to achieve self-reliance in defence capabilities, stimulate economic growth, and assert a more significant presence on the international stage. NICs have embarked on this path through strategic investments in technology, fostering public-private partnerships and international collaborations to acquire, develop, and manufacture advanced defence systems.

Exploring the distinct factors contributing to the successful transition of newly industrialised countries (NICs) into defence manufacturing offers valuable insights. This exploration entails a thorough analysis of industrial policies, investments in research and development (R&D), strategic partnerships, and the pivotal role of government support in enabling this shift. Understanding the approaches adopted by these NICs provides a framework for other countries at comparable stages of economic development to harness their industrial potential for establishing and expanding their defence manufacturing sectors.

5.5 Selecting Newly Industrialised Countries for comparative analysis

Although there is no universally accepted list of newly industrialised countries, Boddin (2016) and various online sources have identified a group of nations as Newly Industrialised Countries (NICs).

- Asia: India, Indonesia, Malaysia, Philippines, Thailand
- Americas: Mexico, Brazil
- Europe: Turkey
- Africa: South Africa

It is important to note that the classification of NICs can change over time as countries continue to develop and their economies evolve.

The ten (10) Newly Industrialised Countries above represent four different continents with varying industrial strengths and development histories. The first step is to choose countries comparable with the UAE in terms of development history. Table 5.1 presents key economic strength and history indicators based on data collected from different sources.

Country	Continent	GDP (Billion US$)	Manufacturing, value added (%) Average 2009-2019 (Pre-Covid)	Defence Industry Policy/operations launched in	Arms Exports (2020) – Million US$
Brazil	South America	2,760	-1.08%	2005	170

China	Asia	27,490	Data not available	1964	760
India	Asia	5,580	6.46%	1960	151
Indonesia	Asia	2,050	4.40%	Early 1980	N/A
Malaysia	Asia	634	3.78%	Late 1980	N/A
Mexico	South America	2,000	1.77%	1976	N/A
Philippines	Asia	640	4.99%	1974	N/A
South Africa	Africa	468	0.13%	1964	37
Thailand	Asia	767	1.94%	1960	N/A
Turkey	Europe	1,330	5.09%	Mid-1980	141
UAE	Asia	639	4.05%	2007	191

Table 5.1: Performance of Newly Industrialised Countries

(1) https://www.imf.org/external/datamapper/NGDPD@WEO/WEOWORLD

(2) https://data.worldbank.org/indicator/NV.IND.MANF.KD.ZG

(3) https://www.theglobaleconomy.com/rankings/arms_exports/

Considering the advanced stage and scale of their defence industries, excluding China and India from this analysis is reasonable. Their capability to export military equipment indicates that these countries have surpassed the phase of merely satisfying domestic defence needs, indicating a mature defence manufacturing sector. Among the other eight countries, only Brazil, South Africa, and Turkey have managed to penetrate global markets, suggesting that the focus of the analysis should be narrowed to these three nations.

Despite the exclusion of other Asian countries (apart from China and India), South Korea presents a notable exception with its well-established defence manufacturing industry. South Korea, which achieved developed nation status in 1996, began to cultivate its defence manufacturing capabilities in the 1970s, a timeline that aligns with the developmental trajectory observed in the UAE. Given its comparable development history and significant advancements in defence manufacturing, it is proposed that South Korea should also be considered in this analysis.

5.6 Key Factors in Assessing NICs' Defence Manufacturing Development

Several critical factors must be considered when assessing the development of the defence manufacturing industry in newly industrialised countries (NICs) to fully understand their progress and challenges (Chowdhury & Islam, 2005; Osei-Kyei & Chan, 2017).

These factors include:

Figure 5.1: Key Factors in Assessing NICs' Defence Manufacturing Development

(F1) Government Policy and Support: The role of government policies in providing support through subsidies, incentives, and regulatory frameworks that encourage the growth of the defence industry.

(F2) Investment in Research and Development (R&D): The extent of investment in R&D to foster innovation, develop indigenous technologies, and reduce dependence on foreign technology.

(F3) Strategic Partnerships and Collaboration: The establishment of partnerships with foreign defence firms and governments for technology transfer, joint ventures, and collaborative projects that enhance technological capabilities and market access.

(F4) Industrial Base and Infrastructure: The development of a robust industrial base and infrastructure capable of supporting the complex processes involved in defence manufacturing, including production facilities, supply chains, and logistics.

(F5) Human Capital and Skills Development: The availability of skilled labour and the focus on education and training programmes to develop the necessary technical expertise for the defence manufacturing sector.

(F6) Market Access and Export Capabilities: The ability to access domestic and international markets, including the development of export capabilities that indicate a competitive and mature defence industry.

(F7) Regulatory Compliance and Standards: Adherence to international standards and regulatory compliance is crucial for participating in the global defence market.

(F8) Technological Innovation and Adaptation: The capacity for technological innovation and the adaptation of emerging technologies in areas such as cyber defence, artificial intelligence, and unmanned systems.

(F9) Economic Stability and Funding: The overall economic stability of the country and the availability of funding and financial resources to support the capital-intensive nature of defence manufacturing.

(F10) Security and Strategic Needs: Aligning defence manufacturing capabilities with the country's security and strategic needs ensures that the development of the defence industry supports national objectives.

(F11) International Relations and Geopolitical Considerations: How international relations and geopolitical strategies influence the development of defence manufacturing, including access to technology and markets, as well as participation in international defence collaborations.

Assessing these factors provides a multidimensional view of the development of the defence manufacturing industry in NICs, highlighting the complexities and strategic considerations involved in establishing and advancing the sector. Among these (eleven) 11 factors, the first five (5) factors are considered primary as they form the foundation for any industrial base. Other factors can be considered secondary, i.e., contingent upon the first five (5) factors. The following presents the first five factors used to build indigenous defence manufacturing for each shortlisted country.

The following analysis is grounded in the comparative study conducted by Kurç & Neuman (2017) and is further supported by evidence from additional sources.

5.7 (F1) Government Policy and Support

The development of defence industries in newly industrialised countries (NICs) shows the pivotal role of government support and policy frameworks. These nations have strategically leveraged government interventions to strengthen their defence capabilities and stimulate economic growth and technological innovation.

(a) Turkey

Turkey's defence industry has witnessed remarkable growth over the past few decades, driven by comprehensive government support and strategic policy implementation. The Undersecretariat for Defence Industries (SSM), established in 1985, and its successor, the Presidency of Defence Industries (SSB), have been instrumental in coordinating and overseeing Turkey's defence procurement and development projects. The government's strategic vision, outlined in various five-year development plans, emphasises self-reliance in defence technology and the promotion of exports. Key policies include incentives for research and development (R&D), investment in defence startups, and partnerships with domestic and international firms. The Defence Industry Support Fund, financed through a levy on alcohol, tobacco, and gambling, provides crucial financial resources for these initiatives (Mevlutoglu, 2017; Feridüddin, 2020; Egeli et al., 2024).

(b) South Korea

South Korea's transformation into a major defence manufacturer is a testament to its focused government policies and support mechanisms. The Defence Acquisition Program Administration (DAPA), established in 2006, plays a critical role in defence procurement and R&D efforts, aiming to enhance the country's self-reliance in defence technology. South Korea's approach includes significant investment in R&D, encouragement of public-private partnerships, and a strong emphasis on exporting defence products. The government has also facilitated the development of a robust defence industrial base through strategic investments in key technologies and industries, demonstrating a commitment to becoming a global leader in defence technology (Nolan, 1986; Bitzinger, 2019; Hartley & Belin, 2019; Bellais, 2024).

(c) South Africa

The South African defence industry's development has been closely tied to government support and strategic policy interventions. The Armaments Corporation of South Africa (Armscor), established in 1968, has been pivotal in developing and procuring defence equipment. Post-apartheid, the government's Defence Review outlined a vision for revitalising the defence industry, focusing on innovation, sustainability, and export potential. Policies have emphasised the importance of technology transfer, black economic empowerment (BEE) initiatives, and international collaboration. The National Defence Industry Council (NDIC), established to advise on defence industry matters, underlines the strategic importance of government-industry collaboration (Fine, 2018; Sutherland,2020).

(d) Brazil

Brazil's defence industry benefits from strong government support and strategic policy-making. The Brazilian Defence Strategy, unveiled in 2008, emphasises the development of a strong national defence industry as a pillar of national security. The government has fostered the growth of the defence sector through the Brazilian Development Bank (BNDES), which provides financial support for defence projects. Additionally, the Ministry of Defence's Strategic Defence Company Program identifies and supports key companies in the defence sector. Brazil's focus on technology transfer agreements, strategic partnerships, and export promotion has been crucial in positioning its defence industry on the global stage (Leske & Santos, 2020; Franko & Herz, 2021; Gouvea, 2021).

The experiences of Turkey, South Korea, South Africa, and Brazil highlight the critical role of government support and policy in the development of defence industries. While each country has adopted unique strategies tailored to its specific needs and contexts, common themes include the emphasis on R&D, strategic partnerships, and exports. They demonstrate that proactive government policies and support mechanisms are indispensable for cultivating robust defence industries.

5.8 (F2) Investment in Research and Development (R&D)

The strategic investment in Research and Development (R&D) is a cornerstone for advancing and competitiveness in the defence industries in newly industrialised countries. These nations have recognised the pivotal role of R&D in fostering innovation and gaining a foothold in the global defence market.

(a) Turkey

Turkey has embarked on a transformative journey to become self-reliant in defence production, significantly increasing its investment in R&D. The Turkish government, through the Presidency of Defence Industries (SSB), has been instrumental in steering R&D initiatives towards critical technology areas such as unmanned aerial vehicles (UAVs), missile systems, and electronic warfare. The establishment of the Defence Industry Research and Development Institute (SAGE) underlines Turkey's commitment to indigenous technology development. Furthermore, Turkey encourages collaboration between universities, research institutions, and defence companies to bolster innovation. The result has been a notable increase in domestically produced defence products and a growing presence in the international defence market (Mevlutoglu, 2017; Feridüddin, 2020; Egeli et al., 2024).

(b) South Korea

South Korea's defence industry is a testament to the country's strategic investment in R&D, driven by the goal of technological independence and global competitiveness. Through the Defence Acquisition Program Administration (DAPA), the government allocates significant resources to R&D projects, focusing on advanced technologies such as smart weaponry, cyber defence, and space systems. South Korea's approach includes fostering public-private partnerships, with major conglomerates like Hyundai and Samsung participating in defence projects. The government's commitment is reflected in the Defence Reform 2020 plan, which emphasises the importance of R&D for future defence capabilities. South Korea's investment in R&D has enhanced its defence capabilities and positioned it as a leading exporter of defence technology Nolan, 1986; Bitzinger, 2019; Hartley & Belin, 2019; Bellais, 2024)..

(c) South Africa

In South Africa, investment in R&D within the defence sector has been a key driver for maintaining a competitive edge in technology and innovation. The Armaments Corporation of South Africa (Armscor) plays a crucial role in managing defence R&D investments, focusing on areas such as advanced materials, electronic warfare, and vehicle technology. The government supports R&D through various programmes and initiatives to revitalise the defence industry and promote exports. Collaboration between the Defence Science and Technology Institute (DSTI) and universities has been pivotal in nurturing innovation. South Africa's strategic R&D investments have enabled it to maintain a unique position in the global defence market, particularly in areas like mine-protected vehicles Fine, 2018; Sutherland,2020).

(d) Brazil

Brazil's defence industry benefits from a strategic approach to R&D investment, focusing on developing indigenous technologies and enhancing military capabilities. Through the Ministry of Defence and the Brazilian Development Bank (BNDES), the Brazilian government provides substantial funding for defence R&D. Key focus areas include aerospace, naval systems, and cyber defence. The establishment of the Brazilian Innovation Agency (FINEP) further highlights s the commitment to leveraging R&D for defence industry growth. Brazil's emphasis on technology transfer agreements and international partnerships has facilitated the development of advanced defence systems, contributing to the country's growing presence in the global defence market (Leske & Santos, 2020; Franko & Herz, 2021; Gouvea, 2021).

The investment in R&D is crucial for the development and competitiveness of the defence industries in Turkey, South Korea, South Africa, and Brazil. Each country has adopted tailored strategies to enhance its technological capabilities and meet both domestic and international defence needs. The success stories of these countries underline the importance of sustained investment in R&D as a fundamental pillar for building resilient and innovative defence industries.

5.9 (F3) Strategic Partnerships and Collaboration

Strategic partnerships and collaboration play a crucial role in the development of the defence industries. These collaborations can take various forms, including joint ventures, technology-sharing agreements, and participation in international defence projects.

(a) Turkey

Turkey's defence industry has seen significant growth through strategic partnerships and collaborations, both with NATO allies and other international partners. These collaborations have enabled Turkey to advance its technological capabilities, particularly in areas such as drone technology, armoured vehicles, and missile systems. For instance, Turkey's collaboration with international firms has facilitated technology transfer, helping the country to develop its indigenous defence products like the Altay main battle tank and the Bayraktar TB2 drone. Furthermore, Turkey's involvement in the F-35 Joint Strike Fighter programme despite subsequent issues, initially provided access to cutting-edge aerospace technology and manufacturing processes (Mevlutoglu, 2017; Feridüddin, 2020; Egeli et al., 2024).

(b) South Korea

South Korea's defence industry benefits greatly from strategic partnerships, especially with the United States and other allies. These partnerships have been instrumental in the development of advanced military technologies, including fighter jets, submarines, and missile defence systems. For example, the collaboration between South Korea and the U.S. in the development and production of the KF-21 Boramae fighter jet showcases how technology sharing and joint development projects can enhance a nation's defence capabilities. Additionally, South Korea's defence exports have grown, supported by international collaborations that have opened new markets and facilitated the sharing of technology and expertise Nolan, 1986; Bitzinger, 2019; Hartley & Belin, 2019; Bellais, 2024).

(c) South Africa

South Africa's defence industry is known for innovating in certain niche areas, such as armoured vehicles and mine-resistant ambush-protected (MRAP) vehicles. Strategic partnerships and international collaboration have been key to this success. Collaboration with countries and private entities has enabled South Africa to develop and export its defence products, contributing to the global defence market. For instance, the success of the Paramount Group in exporting armoured vehicles worldwide is a testament to the benefits of strategic international partnerships. These collaborations boost the local defence industry and contribute to technological advancements and job creation (Fine, 2018; Sutherland,2020).

(d) Brazil

Brazil has leveraged strategic partnerships to develop its defence industry, focusing on areas such as aerospace, naval, and land systems. The collaboration between Brazil and Sweden in developing and producing the Gripen fighter jet under the FX2 programme is a prime example. This partnership involves the transfer of technology and the development of local manufacturing capabilities, enhancing Brazil's aerospace industry. Brazil's Embraer has also formed significant partnerships with international firms, bolstering its position in the global aerospace market. These collaborations help Brazil modernise its military forces and increase its defence exports (Leske & Santos, 2020; Franko & Herz, 2021; Gouvea, 2021).)

Strategic partnerships and collaboration are essential for countries to develop their defence industries. These collaborations enable the transfer of technology, development of indigenous capabilities, access to new markets, and participation in global defence projects. By working with international partners, these countries can enhance their defence capabilities and stimulate economic growth through their defence sectors.

5.10 (F4) Industrial Base and Infrastructure

The development of a robust defence industry is significantly influenced by the strength of its industrial base and infrastructure. These elements provide the foundation necessary for the growth and sustainability of defence capabilities.

(a) Turkey

A strong industrial base and significant investments in infrastructure support Turkey's rapidly growing defence industry. The country has focused on developing domestic production capabilities across a wide range of defence sectors, including land systems, aerospace, and naval technologies. The establishment of technologically advanced facilities and research centres, such as the Defence Industry Research and Development Institute, has been crucial. Turkey's strategic location, bridging Europe and Asia, enhances its logistical capabilities, enabling efficient supply chains and export routes for defence products. The government's support, through incentives and investments, further strengthens the industrial base, making Turkey a significant player in the global defence market (Mevlutoglu, 2017; Feridüddin, 2020; Egeli et al., 2024).

(b) South Korea

South Korea's advanced industrial base and state-of-the-art infrastructure are key drivers behind its successful defence industry. The country has made substantial investments in research and development (R&D), particularly in areas like electronics, shipbuilding, and aerospace, which directly benefit defence production. South Korea's robust manufacturing capabilities, supported by a highly skilled workforce and cutting-edge technology, allow for the domestic production of a wide range of sophisticated defence systems. The government's strategic focus on the defence sector, coupled with close collaborations with the United States and other allies, has facilitated the development of an infrastructure capable of supporting complex defence projects and innovations Nolan, 1986; Bitzinger, 2019; (Hartley & Belin, 2019; Bellais, 2024).

(c) South Africa

South Africa's defence industry benefits from a unique industrial base known for innovating in certain niche areas, such as armoured vehicles and electronic warfare systems. The country's infrastructure, including well-established manufacturing facilities and a network of suppliers and service providers, supports the defence sector's needs. South Africa's historical focus on self-reliance during the apartheid era laid the groundwork for a capable defence industry, which has continued to evolve. The government and private sector's investment in R&D has spurred advancements in technology and product development, enabling South Africa to maintain a competitive edge in the global defence market, particularly in areas where it has specialised expertise (Fine, 2018; Sutherland,2020)..

(d) Brazil

Brazil's defence industry is underpinned by a diverse industrial base and a strategic focus on developing infrastructure to support defence needs. The country has made significant strides in aerospace, naval, and land systems through investments in technology parks and innovation centres. Brazil's Embraer is a testament to the success of these efforts, becoming a global leader in the aerospace sector. The development of the São José dos Campos technology cluster, where Embraer is located, highlights the importance of concentrated infrastructure in fostering innovation and growth in the defence sector. Additionally, Brazil's vast size and strategic location facilitate access to both the Atlantic and Pacific markets, enhancing its export potential (Leske & Santos, 2020; Franko & Herz, 2021; Gouvea, 2021).

The industrial base and infrastructure play a pivotal role in the development of the defence industries. Investments in R&D, manufacturing capabilities, and technological innovation, supported by strategic government policies, have enabled these countries to advance their defence sectors.

5.11 (F5) Human Capital and Skills Development

Human capital and skills development are crucial components in the advancement and sustainability of the defence industries. The ability of countries to develop, innovate, and compete on the global stage is significantly influenced by their investment in education, training, and workforce development within the defence sector.

(a) Turkey

Turkey has placed a strong emphasis on developing its human capital to support its growing defence industry. The country has established several universities and institutions that specialise in defence technologies and engineering, such as the Defence Sciences Institute. These institutions collaborate closely with defence companies and the government to ensure that the curriculum is aligned with the industry's needs, producing graduates who are well-equipped to contribute to R&D and manufacturing. Additionally, Turkey has implemented vocational training programmes and apprenticeships to enhance the skills of technicians and workers, ensuring a skilled labour force capable of operating advanced manufacturing equipment and technologies (Mevlutoglu, 2017; Feridüddin, 2020; Egeli et al., 2024).

(b) South Korea

South Korea's defence industry benefits from the country's overall high level of education and emphasis on science, technology, engineering, and mathematics (STEM) disciplines. The government and private sector invest heavily in education and training programmes specifically tailored to the defence sector's needs. South Korea's approach includes partnerships between universities, research institutions, and defence companies to foster innovation and develop cutting-edge technologies. The country's workforce is highly skilled, with a strong focus on continuous learning and adaptation to new technologies, essential for maintaining a competitive edge in the rapidly evolving defence industry (Nolan, 1986; Bitzinger, 2019; Hartley & Belin, 2019; Bellais, 2024)..

(c) South Africa

South Africa's defence industry leverages its human capital through specialised education and training programmes aimed at developing skills in areas such as engineering, manufacturing, and information technology. The Council for Scientific and Industrial Research (CSIR) plays a significant role in conducting research and development that supports the defence sector. South Africa also benefits from a history of innovation in defence-related technologies, which has cultivated a culture of technical expertise and problem-solving. However, the country faces challenges in retaining its skilled workforce, prompting initiatives to enhance career opportunities within the defence industry and related sectors (Fine, 2018; Sutherland,2020).

(d) Brazil

Brazil recognises the importance of human capital development in sustaining and growing its defence industry. The country has several universities and technical institutes offering specialised programmes in aerospace, naval engineering, and other defence-related fields. Brazil's strategy includes fostering partnerships between these educational institutions and defence companies, such as Embraer, to ensure students receive practical, hands-on experience. Additionally, Brazil has invested in professional development and training programmes to upgrade the skills of its existing workforce, focusing on areas critical to the defence sector's needs, such as advanced manufacturing and systems engineering (Leske & Santos, 2020; Franko & Herz, 2021; Gouvea, 2021).

The development of human capital and skills is fundamental to the success of the defence industries in Turkey, South Korea, South Africa, and Brazil. By investing in education, training, and workforce development, these countries are able to innovate, improve their competitive advantage, and meet the complex demands of the global defence market. Skilled human capital drives technological advancements and production efficiency and ensures that these countries can maintain and enhance their strategic capabilities. As the defence sector continues to evolve, the focus on developing a highly skilled and educated workforce will remain a key factor in achieving sustainable growth and technological superiority. Table 5.2 below highlights the similarities and differences between them.

Factor	**Turkey**	**South Korea**	**South Africa**	**Brazil**
Government Policy and Support (F1)	Comprehensive support through SSM/SSB; focus on self-reliance and exports; Defence Industry Support Fund; strategic vision in five-year plans.	DAPA's role in procurement and R&D; focus on self-reliance and global competitiveness; strategic investment in key technologies and industries.	Armscor's role in procurement, post-apartheid revitalisation focus, emphasis on innovation, BEE initiatives, and international collaboration.	Strong government support through BNDES and Strategic Defence Company Program; focus on technology transfer, strategic

Factor	Turkey	South Korea	South Africa	Brazil
				partnerships, and export promotion.
Investment in R&D (F2)	Significant increase in R&D investment; focus on UAVs, missile systems, electronic warfare; collaboration between universities, research institutions, and industry.	Major investment in advanced technologies (smart weaponry, cyber defence); public-private partnerships; Defence Reform 2020 plan emphasising R&D.	R&D focus on advanced materials, electronic warfare; collaboration between DSTI and universities; investment in technology and innovation.	Strategic R&D focuses on aerospace, naval, and cyber defence; funding from BNDES and FINEP; and emphasis on technology transfer agreements and international partnerships.
Strategic Partnerships (F3)	Collaborations with NATO allies; technology transfer; development of indigenous products like Altay tank and Bayraktar TB2; involvement in F-35 program.	Partnerships with the U.S. and allies; joint development of KF-21 Boramae fighter jet; strong growth in defence exports supported by international collaborations.	Innovation in niche areas like MRAP vehicles; international partnerships and collaborations; Paramount Group's success in exporting armoured vehicles.	Collaboration with Sweden in developing Gripen fighter jet; significant partnerships in aerospace sector (e.g., Embraer); focus on modernising military and exports.
Industrial Base and Infrastructure (F4)	Strong domestic production capabilities in land, aerospace, and naval sectors; technologically advanced facilities; strategic location enhances logistical capabilities.	Advanced industrial base in electronics, shipbuilding, aerospace; strong manufacturing capabilities supported by a skilled workforce and cutting-edge technology.	Well-established manufacturing facilities; unique industrial base with a focus on niche areas; investments in R&D and technology spur competitiveness.	Diverse industrial base with a focus on aerospace and naval systems; development of technology parks and innovation centres; strategic location for export potential.
Human Capital and Skills Development (F5)	Emphasis on education in defence technologies; Defence Sciences Institute; vocational	High level of education with a focus on STEM; strong partnerships between universities and defence	Specialised education and training programs in engineering and IT; CSIR's role in R&D; challenges in	Focus on education in aerospace, naval engineering; partnerships between

Factor	Turkey	South Korea	South Africa	Brazil
	training and apprenticeships to enhance skills.	companies; skilled workforce adept at new technologies.	retaining skilled workforce addressed through career initiatives.	educational institutions and companies like Embraer; investment in professional development.

Table 5.2: Comparison of factors (Turkey, South Korea, South Africa and Brazil)

5.12 China, Russia and USA

In the context of addressing the challenges faced by the UAE's defence manufacturing sector, it may not be entirely sensible to draw direct comparisons with the well-established defence manufacturing bases of China, Russia, and the United States. These countries possess decades of experience, extensive infrastructure, and a robust ecosystem that has enabled them to reach their current levels of excellence. Nevertheless, such comparisons can still serve as a valuable exercise in identifying the key factors that have contributed to their success. By understanding these factors—such as advanced technological capabilities, substantial investment in research and development, and strong government-industry collaboration—the UAE can gain insights into the strategies and practices that could be adapted to bolster its own defence manufacturing industry. In doing so, the UAE might accelerate its progress towards becoming a more self-reliant and competitive player on the global stage.

Factor	China	Russia	USA
Government Policy and Support (F1)	Centralised government control; strong state support through the Military-Civil Fusion (MCF) strategy; focus on self-reliance and reducing dependence on foreign technologies (Can & Vieira, 2022).	Government-driven through state-owned enterprises like Rostec; emphasis on restoring military capabilities post-Soviet era; national security is a key focus (Ergashev & Maslennikova, 2020). .	Extensive support through the Department of Defense (DoD) and related agencies; long-term military spending; focus on maintaining global military superiority and innovation (Mahoney, 2020)

Investment in R&D (F2)	Significant investment in R&D, particularly in AI, quantum computing, and hypersonic weapons; MCF promotes integration of civilian and military sectors for technological advancement (Wortzel, 2022)	Strong focus on advanced military technology (hypersonic weapons, missile systems); R&D primarily state-funded; historical legacy in aerospace and nuclear technologies (Williamson, & Wirtz, 2021).	Highest global R&D spending; focus on advanced technologies like AI, cyber defense, space systems; significant investments in DARPA projects; close ties between industry and academia (Cheung, 2021)
Strategic Partnerships (F3)	Limited formal alliances, a focus on strategic partnerships with countries like Pakistan and North Korea, participation in technology-sharing with select nations, and the Belt and Road Initiative (BRI) influence global defence ties (Wübbeke, et al., 2016)	Strategic partnerships with China, India, and CIS countries; arms export agreements; technology-sharing initiatives with selected nations; involvement in joint military exercises (Giles et al., 2015)	Extensive global alliances (NATO); key defence partnerships with countries like the UK, Israel, and Japan; strategic collaborations on technology and intelligence sharing; leading global arms exporter (Bustinza et al., 2019)
Industrial Base and Infrastructure (F4)	Rapidly expanding industrial base with a focus on self-reliance; significant investment in manufacturing capabilities for advanced technologies (aerospace, naval, AI); strategic infrastructure projects under MCF (Can & Vieira, 2022).	Legacy industrial base from Soviet era; focus on upgrading and modernizing existing infrastructure; challenges include outdated facilities and economic sanctions impact (Ergashev & Maslennikova, 2020).	Advanced and diverse industrial base; robust infrastructure with cutting-edge facilities; strong private sector involvement (Boeing, Lockheed Martin); well-developed supply chain and export capabilities (Mahoney, 2020).
Human Capital and Skills Development (F5)	Strong emphasis on STEM education; government-driven initiatives to boost skills in critical technologies; significant military recruitment; focus on indigenous talent development (Fravel, 2020)	Historically strong in STEM education; focus on maintaining technical expertise in aerospace, engineering; challenges in retaining talent due to economic factors and brain drain (Gurkov, 2016).	World-class education system with a focus on STEM; strong ties between military and academic institutions; extensive training programs and continuous learning initiatives; leading in innovation and technology development (Bibby & Dehe, 2018).

Table 5.3: Comparison of Factors (China, Russia and the USA)

5.13 UAE vs NICs

Comparing the UAE's defence industry development with that of Turkey, South Africa, South Korea, and Brazil reveals a distinct landscape influenced by historical, geopolitical, economic, and strategic factors unique to each country. The relatively slower pace at which the UAE developed its defence manufacturing base compared to these countries are attributed to several key factors:

(a) Historical and Geopolitical Context

Turkey, South Africa, South Korea, and Brazil have longer histories of political and military engagement that necessitated the development of their defence industries. For instance, Turkey's strategic NATO membership and its regional security challenges, South Africa's apartheid-era isolation, South Korea's proximity to North Korea, and Brazil's role as a regional power in Latin America have all driven the indigenous development of military capabilities.

The UAE, by contrast, is a relatively young federation established in 1971, with a different set of security dynamics and initially less immediate pressure to develop an indigenous defence industry, relying instead on partnerships and defence procurement from established global powers.

(b) Economic Development and Industrial Base

Turkey, South Africa, South Korea, and Brazil had more diversified industrial bases earlier on, which provided a foundation for the development of defence industries. These countries had significant manufacturing, engineering, and technological sectors that could be adapted or expanded to include defence manufacturing.

The UAE historically focused on developing its oil and gas sector, tourism, and real estate. While it achieved remarkable economic success, the diversification into industrial manufacturing, including defence, started more prominently only in recent decades.

(c) Human Capital and Technical Expertise

The aforementioned countries have had longer to develop educational systems and technical training programmes to support complex industries, including defence. They have established universities, technical institutes, and research centres that contribute to a skilled workforce capable of supporting defence manufacturing.

The UAE has made significant investments in education and human capital development in recent years but is still in the process of building the depth of technical expertise and specialised skills required for a comprehensive defence industry.

(d) Strategic Partnerships and Technology Transfer

Turkey, South Africa, South Korea, and Brazil have engaged in strategic partnerships that facilitated technology transfer and helped develop their defence industries over several decades. These partnerships often included licensing agreements to produce foreign military equipment locally, serving as a catalyst for the development of indigenous capabilities.

The UAE has also pursued strategic partnerships but started this process later. Its approach has increasingly focused on joint ventures and technology transfers with leading global defence firms, aiming to leapfrog to advanced defence manufacturing capabilities.

(e) Government Policy and Investment

Other countries have longer-standing government policies that explicitly support the development of their defence industries through investment, subsidies, and strategic planning. A combination of national security concerns and economic development goals often drives these policies.

The UAE has recently been formulating and implementing policies to support the growth of its defence industry. The establishment of entities like the Emirates Defence Industries Company (EDIC) and Tawazun Economic Council reflects a strategic push to develop the defence sector as part of broader economic diversification efforts.

The UAE's slower development of its defence manufacturing base compared with Turkey, South Africa, South Korea, and Brazil can be attributed to its different historical, geopolitical, and economic starting points. However, the UAE is rapidly catching up, leveraging its significant financial resources, strategic partnerships, and policy initiatives to establish a modern, innovative defence industry.

The slower development of UAE defence manufacturing is also attributed to the lack of a comprehensive defence manufacturing ecosystem. Ecosystems play a crucial role in defence manufacturing, encompassing a broad network of participants and resources that collectively contribute to developing, producing, and maintaining defence capabilities. These ecosystems are not just about the manufacturing entities but include a wide array of stakeholders such as government agencies, defence contractors, research institutions, technology providers, supply chain partners, and policymakers. While there are many reviews about how defence ecosystems for the above sample of NICs, there are no academic or non-academic publications on the UAE defence manufacturing ecosystem. This lack of information implies that there is no well-established defence manufacturing ecosystem in the UAE.

5.13 Conclusions

The analysis of the defence manufacturing industry in newly industrialised countries (NICs) such as Turkey, South Korea, South Africa, and Brazil reveals several key conclusions about the factors contributing to the development and success of their defence sectors. These conclusions emphasise the importance of a multifaceted approach to building a robust defence industry, highlighting the critical roles of government policy and support, investment in research and development (R&D), strategic partnerships and collaboration, a strong industrial base and infrastructure, and the development of human capital and skills. The comparative analysis of the defence industry development in the UAE versus Turkey, South Africa, South Korea, and Brazil underlines a compelling argument for the UAE to establish a comprehensive defence manufacturing ecosystem. The experiences of these countries highlight the transformative impact such an ecosystem can have on national security, technological independence, and economic diversification.

Chapter 6: Defence Manufacturing Ecosystems

6.1 Introduction

As concluded in Chapter 5, ecosystems are vital for the success of defence manufacturing. Ecosystems constitute complex networks involving a broad spectrum of participants, including government agencies, private enterprises, research institutions, and suppliers, all collaborating to achieve national defence objectives. In relation to defence manufacturing, there are four critical ecosystems.

This chapter examines the essential characteristics of defence manufacturing ecosystems to inform the development of a defence manufacturing ecosystem for the UAE. This analysis includes the defence manufacturing ecosystems of four countries discussed in the preceding chapter and four other nations with well-established defence manufacturing industries.

6.2 The Origin of the Phrase Defence Manufacturing Ecosystem

In 2006, Mr Quek Tong Boon, serving as Singapore's Deputy Defence Secretary for Technology and Transformation, is credited with introducing the term “defence ecosystem,” according to Karniol (2006). In his definition, the defence ecosystem was described as embodying the mutual dependence and joint evolution among the nation's *users*, *developers*, and *defence equipment manufacturers*. This conceptualisation highlighted the complex relationships and collaborative dynamics essential for developing, producing, and utilising defence technologies and equipment. Since this initial introduction, various countries have increasingly adopted the concept of an “ecosystem” to characterise their defence manufacturing sectors.

The sections below highlight the main characteristics of defence industrial ecosystems across eight countries. It is essential to acknowledge that visuals depicting the defence industrial ecosystems have not been obtainable for some countries, as not every country has created such visuals. Regarding the USA, although a visual exists, its graphical complexity prevents its inclusion in this presentation.

6.3 Defence Ecosystems in Newly Industrialised Countries (NICs)

In Chapter 5, four (4) NICs were chosen to analyse critical success factors behind their defence manufacturing industries. In this section, key features of their defence manufacturing ecosystems are presented.

6.3.1 Brazil's Defence Manufacturing Ecosystem

Brazil's defence manufacturing ecosystem is characterised by a blend of historical strengths in certain sectors, strategic government support, and an increasing focus on innovation and international collaboration. The following analysis used three key publications (Fernandes et al., 2020; Hartley & Belin, 2019; Gouvea, R. 2021).

(a) Government Support and Strategic Direction: The Brazilian government plays a pivotal role in shaping the defence industry through strategic programmes and policies. The Ministry of Defence and related agencies, such as the Brazilian Defence Company (Embraer), have been instrumental in directing investments towards research and development and fostering an environment favourable to growth in the defence sector (Hirata, 2017).

(b) Focus on Technology and Innovation: Innovation is a cornerstone of Brazil's defence strategy, with significant investments in developing indigenous technologies and capabilities. This includes advancements in unmanned aerial vehicles (UAVs), satellite technology, and cyber defence. The Brazilian government encourages collaboration between universities, research institutions, and the defence industry to foster innovation.

(c) International Partnerships and Exports: Brazil's defence industry has actively sought international partnerships to enhance its technological capabilities and expand market access. These collaborations often involve technology transfer agreements, joint ventures, and participation in international defence projects. Brazil is also focused on increasing its defence exports, with Latin America, Africa, and the Middle East being key markets.

(d) Regulatory Framework and Support for Small and Medium Enterprises (SMEs): The Brazilian government has implemented a regulatory framework that supports the growth of the defence industry, including measures to protect national interests and promote exports.

Additionally, the framework focuses on supporting SMEs within the defence sector to encourage innovation and diversification of the industrial base.

6.3.2 South Africa’s Defence Manufacturing Ecosystem

South Africa's defence manufacturing ecosystem is notable for its advanced technological capabilities, innovation, and a strong focus on domestic and international markets. This analysis used four key publications (Beri, 2001; Dunne & Haines, 2006; Van Rensburg, 2016; Drab, 2018).

(a) Innovation and R&D: The South African defence industry is characterised by its strong emphasis on research and development (R&D), driving innovation, particularly in areas such as electronic warfare, radar systems, and armoured vehicle technology. Institutions like the Council for Scientific and Industrial Research (CSIR) play a crucial role in defence technology R&D.

(b) Strategic Partnerships and International Collaboration: South African defence firms actively seek and engage in strategic partnerships and collaborations with international defence companies. These partnerships often focus on technology transfer, joint ventures, and co-production agreements, enhancing the global competitiveness of the South African defence sector.

(c) Regulatory Framework and Government Support: Through the Department of Defence and the Armaments Corporation of South Africa (ARMSCOR), the South African government provides strategic direction and support to the defence industry. Policies and regulations promote the sector's development, ensure compliance with international arms control agreements, and support exports.

6.3.3 South Korea’s Defence Manufacturing Ecosystem

South Korea's defence manufacturing ecosystem is a dynamic and rapidly evolving sector, characterised by significant investment in research and development (R&D), a focus on indigenous capabilities, and an expanding global footprint. This analysis used four key publications (Moon & Lee, 2008; Choi et al., 2018; Bitzinger, 2019; Hartley & Belin, 2019).

(a) Government Support and Strategic Planning: The South Korean government plays a crucial role in the development of the defence industry through strategic planning, funding, and policy support. Agencies such as the Defence Acquisition Program Administration (DAPA) are instrumental in setting procurement priorities, fostering R&D, and promoting exports.

(b) Advanced Research and Development (R&D): South Korea invests heavily in R&D to develop cutting-edge defence technologies. These include advanced missile systems, unmanned aerial vehicles (UAVs), cyber warfare capabilities, and next-generation combat vehicles. The government collaborates with research institutions, universities, and private companies to drive innovation.

(c) Indigenous Defence Capabilities: A key goal of South Korea's defence strategy is to achieve self-reliance in defence technology and production. This has led to the development of indigenous platforms such as the K2 Black Panther main battle tank, the K9 Thunder self-propelled howitzer, the KF-21 Boramae fighter jet, and the Dosan Ahn Changho-class submarines.

(d) Collaboration with International Partners: South Korea also engages in strategic partnerships and technology exchanges with international defence companies and governments while focusing on indigenous development. These collaborations help South Korea access advanced technologies and open up opportunities for joint ventures and co-production agreements.

Highly Skilled Workforce: South Korea's highly educated and skilled workforce benefits the defence industry. The country's strong emphasis on science, technology, engineering, and mathematics (STEM) education provides a solid foundation for innovation and technological advancement in the defence sector.

6.3.4 Turkey's Defence Manufacturing Ecosystem

Turkey's defence manufacturing ecosystem has evolved significantly over the past few decades, transforming the country into an increasingly self-reliant and innovative player in the global defence industry. This analysis included evidence from three publications (Bağcı & Kurç 2017; Mevlutoglu, 2017; Pinto, 2017; Egeli et al., 2024).

(a) Government Support and Strategic Vision: The Turkish government has been instrumental in fostering the growth of the defence sector through strategic planning, investment, and policies aimed at increasing self-sufficiency in defence production. The Undersecretariat for Defence Industries (SSB), now known as the Presidency of Defence Industries, plays a pivotal role in setting priorities, facilitating research and development (R&D), and overseeing procurement processes.

(b) Domestic and International Partnerships: Turkish defence companies engage in both domestic collaborations and international partnerships to enhance their technological capabilities and expand their market reach. These partnerships often involve technology transfer agreements, joint ventures, and participation in international defence projects.

(c) Focus on Research and Development (R&D): The Turkish defence sector strongly emphasises R&D, with investments aimed at developing indigenous capabilities in areas such as unmanned aerial vehicles (UAVs), missile systems, electronic warfare, and naval ships. The government encourages innovation through funding and incentives for defence companies and research institutions.

(d) Human Capital and Workforce Development: The defence sector benefits from a skilled workforce, including engineers, technicians, and scientists. Turkish universities and technical institutes collaborate with defence companies to ensure a steady pipeline of talent. The sector also invests in training and development to keep pace with technological advancements.

(e) Regulatory Framework and Export Controls: Turkey has established a regulatory framework to support the development of its defence industry while adhering to international standards and commitments. This includes regulations on export controls, industrial security, and intellectual property rights to facilitate responsible growth and international cooperation.

6.4 Analysis of Defence Manufacturing Ecosystems of NICs

The four ecosystems outlined above share multiple foundational elements crucial for the thriving defence manufacturing sector.

Brazil	South Africa	South Korea	Turkey
Government Support and Strategic Direction	Innovation and R&D	Government Support and Strategic Planning	Government Support and Strategic Vision
Focus on Technology and Innovation	Strategic Partnerships and International Collaboration:	Advanced Research and Development (R&D):	Domestic and International Partnerships
International Partnerships and Exports	Regulatory Framework and Government Support	Collaboration with International Partners	Focus on Research and Development (R&D)
			Human Capital and Workforce Development:
			Regulatory Framework and Export Controls

Table 6.1: Key Features of Defence Manufacturing Ecosystem

Firstly, each ecosystem relies on a robust network of resources and collaborations, whether the raw materials from natural ecosystems or the technological innovations and supply chain synergies from industrial ecosystems.

Secondly, each ecosystem benefits from a culture of innovation and continuous improvement. In defence manufacturing, this means developing new technologies and materials and improving processes and methodologies to enhance product quality, reduce costs, and increase manufacturing efficiency. Collaboration between research institutions, private companies, and government agencies is pivotal in pushing the boundaries of what is possible in defence technology and production.

Thirdly, strategic partnerships and alliances underline the interconnectedness of these ecosystems. Collaborative efforts, whether through joint ventures, research collaborations, or international defence agreements, amplify the sector's capabilities, enabling the sharing of knowledge, resources, and technologies.

Fourthly, human capital and workforce development are pivotal to the defence manufacturing industry, serving as the bedrock for innovation, production efficiency, and technological advancement. Investing in skilled labour, continuous training, and education ensures that the workforce remains adept at handling the complexities of modern defence technologies and manufacturing processes.

Lastly, regulatory and policy frameworks play a significant role across these ecosystems, setting quality, safety, and environmental stewardship standards. These frameworks ensure that defence manufacturing practices comply with national and international laws, ethical considerations, and best practices, thereby maintaining the sector's integrity and public trust.

6.5 Defence Ecosystems in Developed Nations

Defence ecosystems in developed nations represent complex and multifaceted networks that encompass a wide range of stakeholders, including government bodies, military forces, private sector companies, research institutions, and non-governmental organisations. These ecosystems are designed to foster innovation and maintain a technological edge in the global arena. They operate within a framework that encourages collaboration and knowledge sharing, aiming to develop cutting-edge defence technologies and capabilities. Understanding the dynamics of defence ecosystems in developed countries is crucial for the development of the framework.

6.5.1 Singapore’s Defence Industrial Ecosystem

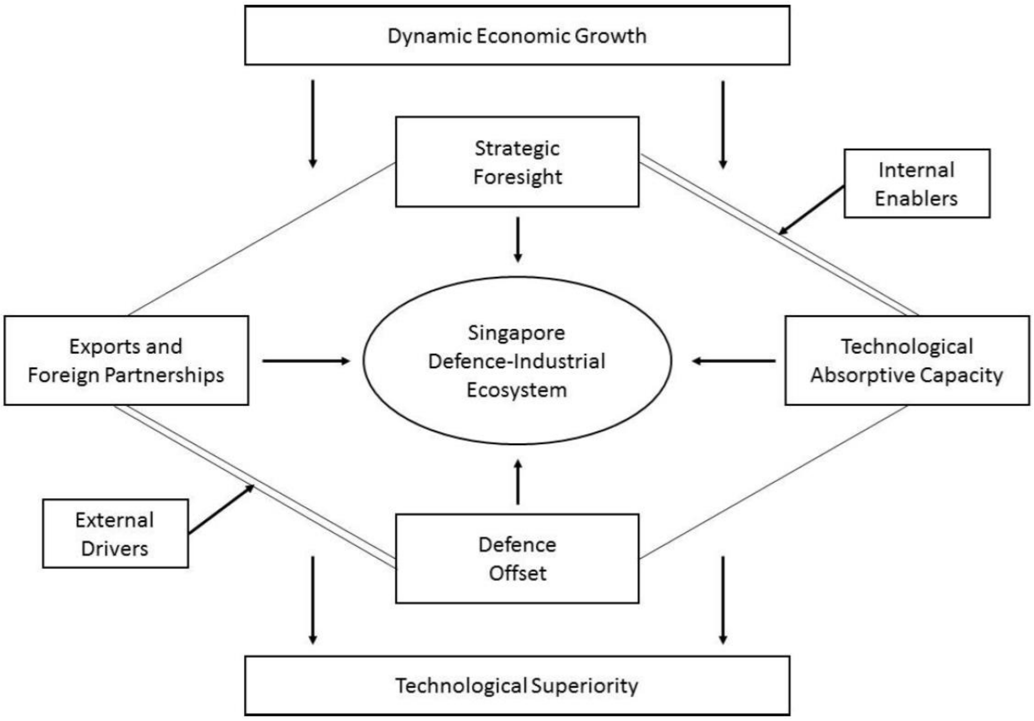

Figure 6.1: Constituent components of Singapore's defence-industrial ecosystem (Matthews & Koh 2019)

(a) Strategic Foresight: The Singapore government has been actively involved in fostering the growth of strategic industries within its economy, a practice that dates back to the early post-independence era and was significantly boosted in 1991 with the launch of a Strategic Economic Plan. This plan outlined eight key areas of focus, including human resource development, international partnerships, investment, and the promotion of R&D along with industrial and technological clusters (Hughes, 2019). A complementary Science and Technology Plan aimed to bolster R&D capabilities and increase the number of researchers, with significant investments in civil and defence sectors. Defence and aerospace emerged as key strategic industries, benefiting from technological synergies across the civil-military divide.

The Economic Development Board (EDB) played a pivotal role in identifying and nurturing strategic industrial sectors, similar to Japan's post-WWII MITI. An example of EDB's success is the development of an advanced industrial aerospace cluster at the former Seletar airfield, which attracted major global companies and created thousands of skilled jobs. The

EDB's proactive approach has also extended to horizon scanning for emerging strategic sectors, such as the space industry.

The country has developed a range of small satellites, involving *local university students in the R&*D process, and currently boasts a space industry that employs 1,000 people across 30 companies. The EDB established the Office for Space Technology and Industry (OSTIn) in 2013 to further support this sector (Gray, 2012). Notable achievements include the development of a significantly smaller and more efficient radar camera chip by NTU scientists and the launch of the Satellite Technology and Research Centre (STAR) by DSO National Laboratories and NUS to advance distributed satellite systems capabilities. Additionally, early 2018 saw a partnership between DSTA and ST Egg to acquire a new earth observation satellite, showcasing Singapore's commitment to advancing its position in high-tech industries through strategic planning and investment (Goswami, et al., 2019).

(b) Technological absorptive capacity: The concept of technological absorptive capacity in Singapore highlights the nation's focus on developing local innovation through a robust ecosystem of highly skilled professionals, knowledge institutions, and specialised institutes. Since gaining independence, Singapore has heavily invested in human capital, establishing world-class universities, and promoting the growth of small and medium-sized enterprises (SMEs) to enhance innovative supply chains and R&D capabilities. Despite its small size, Singapore ambitiously aims to be a leader in technology, particularly in defence science and technology, supported by a 5,000-strong community of defence engineers and scientists. The Defence Science and Technology Agency (DSTA) and DSO National Laboratories play pivotal roles in advancing defence technologies, working alongside local universities and government agencies like A*STAR and GovTech. Additionally, companies like ST Engg invest in R&D, with a portion of their revenue dedicated to customer-funded and internal research projects. The government also allocates R&D funds to universities and polytechnics, with significant investments made to foster collaboration between local and international research institutions (Matthews & Koh, 2019).

Singapore's R&D programmess are pragmatic, focusing on long-term national security and market opportunities, emphasising emerging technologies such as AI, robotics, and unmanned systems. Initiatives like the seed grant for DSTA and DSO National Laboratories for AI and robotics R&D aim to leverage local expertise and achieve early successes in niche areas. Collaborations between DSTA, ST Engg, and local universities have led to innovations in unmanned vehicles and systems, showcasing Singapore's capabilities in developing and producing advanced technologies for both domestic use and potential export.

(c) Defence Offset: Starting in the 1970s, Singapore began developing a strong and diverse domestic defence industry, recognising the benefits of defence offsets in building capacity and improving worker skills. Unlike typical approaches, Singapore's Ministry of Defence (MINDEF) did not publish a prescriptive offset policy but kept it for internal use, negotiating each procurement programmes from scratch. This approach allowed for rigorous bargaining but also opportunities for compromise, depending on the procurement scale. Singapore's defence offset programmes have grown significantly, making it one of the most successful globally (Chinworth & Matthews, 2014).

Singapore's strategic approach to acquiring and integrating foreign technologies into local defence capabilities is also evident in submarine procurements. The initial acquisition of A12 Sjöormen class submarines from the Royal Swedish Navy served as training platforms, leading to the acquisition and modernisation of A18 Västergotland class submarines. This experience, particularly in modern electronic systems integration, prepared Singapore to acquire customised Type-218SG submarines from German shipbuilder TKMS, marking a progression in submarine technology expertise.

(d) Export and Foreign Partnerships: Singapore, while not a major global defence exporter, has navigated the complexities of overseas arms sales with caution, prioritising its diplomatic goal of maintaining neutrality over the economic gains from such exports. This approach has led to mixed results in its export performance. In the Maintenance, Repair, and Overhaul (MRO) sector, particularly in aerospace, Singapore stands out as a leading provider worldwide. However, its broader military export achievements have been less remarkable.

6.5.2 United States Defence Industrial Ecosystem

The United States boasts one of the most advanced and comprehensive defence manufacturing ecosystems in the world, characterised by its significant investment in research and development (R&D), a strong base of defence contractors (such as Lockheed Martin, Boeing, Raytheon Technologies, and Northrop Grumman), and extensive collaboration with research universities and institutions. The Department of Defence (DoD) plays a central role through entities like the Defence Advanced Research Projects Agency (DARPA), which drives innovation in technology and defence. The ecosystem is supported by a vast network of suppliers and small businesses across the country, facilitated by policies and programmes that encourage defence innovation and manufacturing. The U.S. defence manufacturing ecosystem is characterised by several key features that distinguish it as a global leader in defence technology and production. This analysis used four key publications (Heidenkamp, et al., 2011; Sköns, 2014; Barbaroux, 2019, Merindol, & Versailles, 2020).

(a) Public-Private Partnerships: The U.S. Department of Defence (DoD) collaborates closely with private sector companies, leveraging their innovation, agility, and production capabilities. This partnership is facilitated through contracts, grants, and research and development agreements. For example, the Defence Advanced Research Projects Agency (DARPA) is crucial in funding and developing emerging technologies.

(b) Advanced Technology and Innovation: The U.S. defence sector is at the forefront of technological innovation, focusing on areas such as artificial intelligence (AI), unmanned systems, cyber defence, and space technology. The U.S. government invests heavily in research and development (R&D) to maintain its technological edge.

(c) Complex Supply Chains: The U.S. defence manufacturing ecosystem involves a complex network of suppliers, including prime contractors, subcontractors, and smaller companies across multiple tiers. This complexity ensures the production of highly sophisticated military systems but also poses challenges in terms of supply chain security and resilience.

(d) Regulatory Environment: The U.S. defence sector is governed by a comprehensive regulatory framework that includes the International Traffic in Arms Regulations (ITAR) and the Defence Federal Acquisition Regulation Supplement (DFARS). These regulations ensure that defence technologies are protected and that the defence industrial base operates in the national interest.

(e) Workforce and Skills: The defence manufacturing ecosystem relies on a highly skilled workforce, including engineers, scientists, technicians, and production workers. The sector faces workforce development and retention challenges, particularly in competing with the private sector for talent in emerging technology areas.

(f) Defence Budget and Funding: The U.S. defence budget is the largest in the world, providing significant funding for procurement, R&D, and operations and maintenance. This funding supports the development and production of cutting-edge military capabilities.

(g) Export Controls and International Cooperation: The U.S. is a major exporter of defence equipment, subject to strict export controls to protect national security and support foreign policy objectives. At the same time, the U.S. engages in international defence cooperation, including foreign military sales (FMS) and direct commercial sales (DCS), to strengthen alliances and partnerships.

(h) Industrial Base Policies: The U.S. government implements policies to support and protect the defence industrial base, addressing issues such as market competition, technological superiority, and supply chain vulnerabilities. The Executive Order on America's Supply Chains (EO 14017) is an example of recent efforts to assess and strengthen supply chain resilience in key sectors, including defence.

6.5.3 United Kingdom Defence Industrial Ecosystem

The UK's defence ecosystem features key players such as BAE Systems, Rolls-Royce, and MBDA, supported by the Ministry of Defence (MoD) and its procurement arm, the Defence Equipment and Support (DE&S). The UK focuses on fostering innovation through initiatives like the Defence Science and Technology Laboratory (Dstl) and the Defence and Security Accelerator (DASA), which aim to connect the MoD with industry and academia to develop cutting-edge defence technologies (Carr, 2020). The ecosystem is characterised by strong international collaborations, particularly with NATO allies, and a deep commitment to research and technological advancement.

(a) Advanced Technology and Innovation: The UK has a strong reputation for innovation and technological advancement in defence manufacturing. It is home to some of the world's leading defence companies, such as BAE Systems, Rolls-Royce, and MBDA, which are known for their cutting-edge research and development capabilities.

(b) Collaboration and Partnerships: The UK defence sector is characterised by strong government, industry, and academia collaboration. This collaborative approach helps in the development of innovative defence solutions and technologies. The UK also actively participates in international defence projects and partnerships, such as the F-35 Joint Strike Fighter programme and the Eurofighter Typhoon consortium.

(c) Focus on Cybersecurity and Intelligence: Given the evolving nature of threats, the UK defence manufacturing sector places a significant emphasis on cybersecurity and intelligence. This includes the development of advanced cyber defence technologies and systems to protect against cyber threats and ensure national security.

(d) Export-Oriented: The UK defence sector is one of the world's leading defence exporters. It has a strong global presence and exports a wide range of defence products and services, including aircraft, naval ships, and military equipment, to various countries around the world.

(e) Sustainable and Ethical Practices: The UK defence manufacturing sector is increasingly focused on sustainability and ethical practices. Companies are investing in green technologies and adopting sustainable practices to reduce their environmental impact and ensure ethical business operations.

(f) Skilled Workforce: The UK has a highly skilled workforce in the field of defence manufacturing, with expertise in various areas such as engineering, design, and project management. This skilled workforce is a key asset for the UK defence industry and contributes to its global competitiveness.

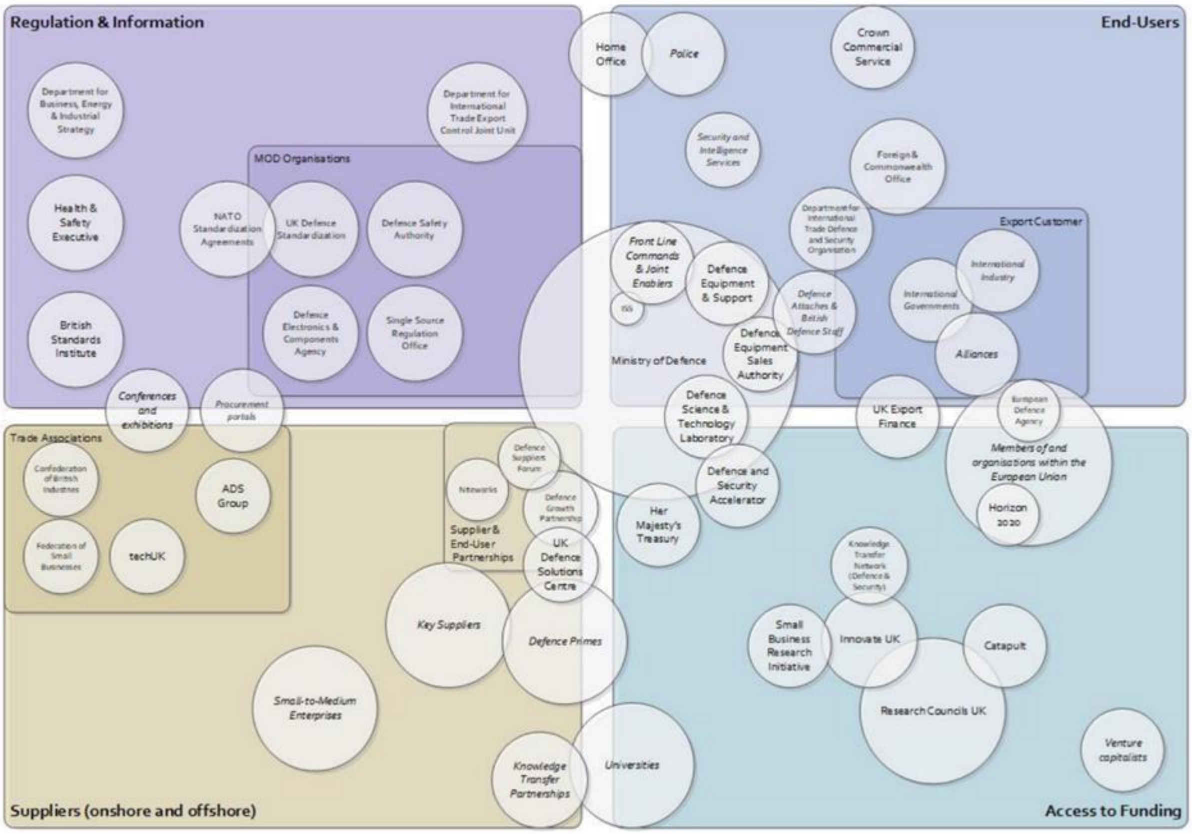

Figure 6.2: The UK Defence Industry Ecosystem (Fisher, 2017)

6.5 China, Russia and USA Defence Manufacturing Ecosystems

Analysing the defence manufacturing ecosystems in China, Russia, and the United States is an exceptionally complex task, primarily due to the extensive and deeply entrenched legacies that each of these nations has developed over time. These countries have built their defence industries over decades, with roots often stretching back over a century, resulting in highly intricate systems and frequently shrouded in secrecy. In China, the defence industry is heavily integrated with state-owned enterprises and operates under the tight control of a centralised government (Joske, 2019).This structure not only ensures a high degree of confidentiality but also complicates any external attempts to scrutinise the true scale and capabilities of China's military-industrial complex. The situation in Russia is similarly opaque, where the defence manufacturing sector is a direct descendant of the Soviet-era military-industrial complex (Kuo, 2020). Russia’s defence industry remains largely state-controlled, with a strong emphasis on maintaining secrecy and nationalistic fervour, making it difficult for external observers to gain accurate insights into its operations and strategic priorities.

In contrast, the United States has developed a vast and multifaceted defence ecosystem that, while more transparent in some respects due to its significant private sector involvement, is still challenging to comprehend (Heidenkamp et al., 2015) fully. A complex web of collaborations between government entities, private corporations, and international partners characterises the U.S. defence industry. This ecosystem is further complicated by the sheer size and diversity of the U.S. military's procurement needs and its history of pioneering technological innovations. Additionally, the interplay between public policy, corporate interests, and global geopolitics adds layers of complexity that are difficult to untangle. The long-standing nature of these defence ecosystems, deeply embedded in each country's historical, political, and economic contexts, creates an environment where transparency is often limited, and understanding the full scope of their capabilities and operations is a formidable challenge. Consequently, any analysis of these defence manufacturing ecosystems must navigate a maze of historical legacies, institutional secrecy, and strategic ambiguity, making it an arduous and intricate endeavour.

Collins (2021) has attempted to generalise the key players and components of defence manufacturing innovation ecosystems (Figure 6.3).

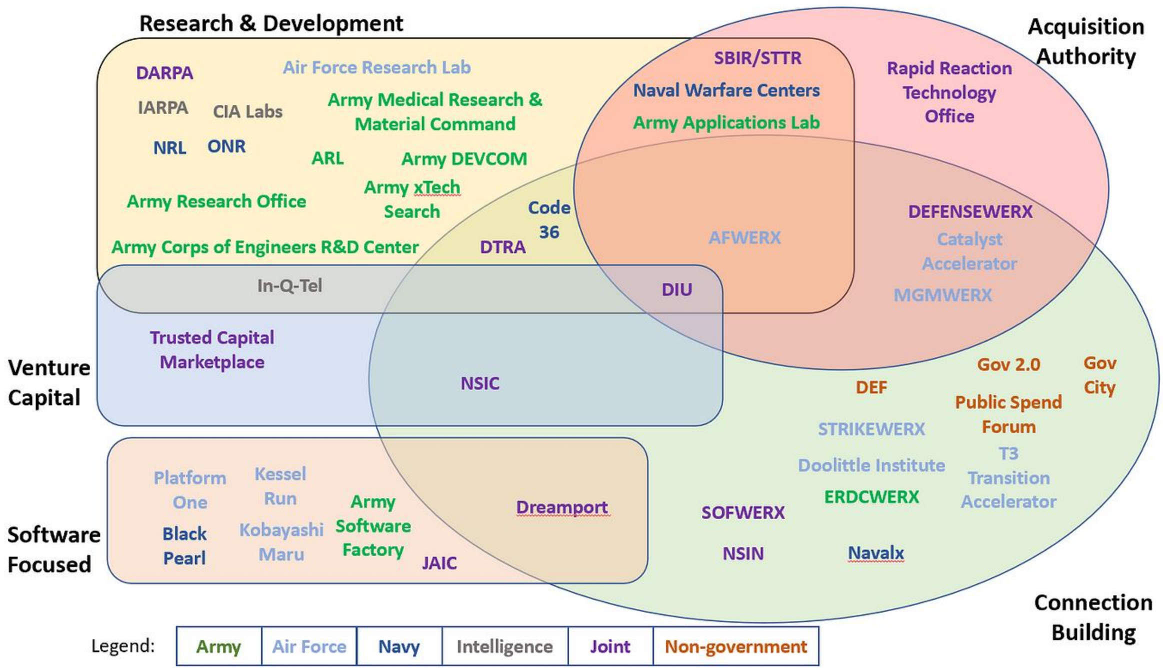

Figure 6.3: Generic Structure of Defence Innovation Ecosystems (Collins, 2021)

6.6 Conclusions

These examples illustrate the diversity and complexity of defence manufacturing ecosystems around the world. Each ecosystem is shaped by its country's strategic priorities, technological capabilities, and industrial base, demonstrating the critical role these networks play in supporting national defence and contributing to global security.

Chapter 7: Integrated Defence Manufacturing Ecosystem Approach for the UAE – (IDEA-UAE)

7.1 Introduction

Chapter 6 emphasised the vital role of robust ecosystems in the success of defence manufacturing systems, highlighting a significant gap in the literature regarding the United Arab Emirates (UAE). Specifically, there is a lack of evidence demonstrating a visible and established ecosystem for defence manufacturing within the UAE. To address this gap, the chapter aims to present the development of the Integrated Defence Manufacturing Ecosystem Approach for the UAE (IDEA-UAE). It seeks to conceptualise a structured framework that enhances the UAE's defence manufacturing capabilities, ensuring a sustainable and efficient defence sector that meets its strategic needs.

7.2 Designing the IDEA-UAE

In developing a new framework, the research process utilises an inductive approach, beginning with a comprehensive literature review to gather existing knowledge and theories. This review provides a foundation by identifying gaps, trends, and commonalities in the current body of work. A comparative analysis is conducted, systematically evaluating and contrasting different models, frameworks, and case studies from various ecosystems. This analysis helps to highlight the strengths and weaknesses of existing approaches, offering insights into the essential elements and dynamics that should be included in the new framework. Finally, a detailed study of specific ecosystems is undertaken to observe real-world applications and outcomes, synthesising practical insights with theoretical concepts (Figure 7.1). By integrating findings from these three stages—literature review, comparative analysis, and ecosystem study—the research inductively develops a novel framework that addresses identified gaps, builds on proven strengths, and incorporates practical considerations from observed ecosystems.

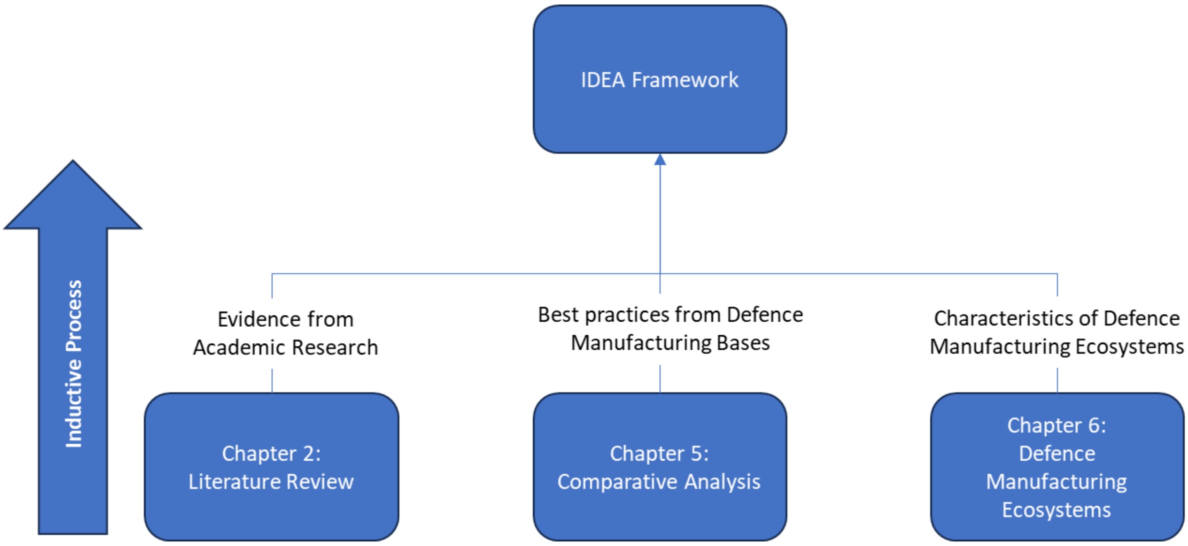

Figure 7.1: Framework Design Process

7.3 Ecosystems for Industrial Applications

The concept of an ecosystem, originally derived from biological sciences, has been increasingly applied to various fields to describe interconnected systems. Among the numerous interpretations (Borgers et al., 2019) available, the definition provided by Jacobides et al. (2018) is particularly well-suited for this study.

"ecosystems are groups of firms that must deal with either unique or supermodular complementarities that are nongeneric, requiring the creation of a specific structure of relationships and alignment to create value."

Within the context of industrial ecosystems, a range of variations can be observed, each with its distinct characteristics. These variations are discussed in detail in the sections that follow, offering a thorough understanding of the diverse forms that industrial ecosystems can take.

7.3.1 Innovation Ecosystems

The importance of innovation ecosystems lies in their ability to foster collaboration, creativity, and the exchange of knowledge among diverse stakeholders, thereby driving economic growth, technological advancement, and societal progress (Murti, 2020). These ecosystems bring together entrepreneurs, businesses, investors, researchers, and policymakers to create a synergistic environment where innovative ideas can flourish and be transformed into marketable products and services. By facilitating access to resources such as capital, talent, and technology, innovation ecosystems help reduce the time and cost associated with research and development, accelerating the commercialisation process.

Innovation ecosystems play a crucial role in the defence manufacturing sector, serving as a nexus for collaboration and technological advancement. For instance, in the development of unmanned aerial vehicles (UAVs), defence manufacturers like Lockheed Martin (Mavridou et al., 2020) and Northrop Grumman engage with tech startups, academic institutions like MIT and Stanford, and government entities such as the Defence Advanced Research Projects Agency (Bonvillian et al., 2020) . This collaboration facilitates the integration of state-of-the-art materials, artificial intelligence, and cybersecurity technologies, significantly enhancing UAV capabilities. Similarly, in military training, companies such as Raytheon and Boeing collaborate with augmented reality (AR) tech firms like Microsoft and academic partners to develop immersive training solutions (Auffinger, 2021). These initiatives leverage AR technology to create realistic training environments, improving the efficiency and effectiveness of military personnel training. Through these strategic partnerships within the innovation ecosystem, defence manufacturers can accelerate the development and deployment of advanced defence technologies and ensure that the defence sector remains at the cutting edge of technological innovation, ready to meet the complex demands of contemporary defence manufacturing challenges.

7.3.2 Supply Chain Ecosystem

The supply chain ecosystem plays a crucial role in the global economy, acting as the backbone of trade and commerce. It encompasses all the activities, organisations, people, information, and resources involved in moving a product or service from supplier to customer (Ivanov & Dolgui, 2022). The efficiency and resilience of this ecosystem are vital for ensuring that goods are produced and delivered in a timely, cost-effective, and sustainable manner. A well-functioning supply chain ecosystem can help companies reduce costs, improve product quality, increase customer satisfaction, and respond more effectively to market changes and disruptions. Moreover, in today's interconnected world, the robustness of the supply chain ecosystem is essential for managing risks, such as those related to geopolitical tensions, natural disasters, or pandemics, thereby ensuring the continuous flow of goods and services across borders and maintaining economic stability.

In defence manufacturing, the importance of the supply chain ecosystem is exemplified by the production of the F-35 Lightning II fighter jet and the Aegis Combat System. The F-35 programme, one of the most advanced and complex defence projects, involves over 1,500 suppliers from around the world (Milet, 2021) H. More Than A Combat Aircraft, The Lockheed Martin F-35. . This global supply chain is crucial for the timely and cost-effective production of the jet, highlighting the need for a well-coordinated and efficient supply chain ecosystem to manage the intricate logistics and manufacturing processes involved.

Another distinct example is the supply chain for the Eurofighter Typhoon, a leading multi-role combat aircraft used by several European countries. The Eurofighter's production involves a consortium of companies from the United Kingdom, Germany, Italy, and Spain, each responsible for different sections of the aircraft. This complex collaboration requires a highly synchronised supply chain ecosystem to manage the cross-border flow of components and technologies. For instance, the aircraft's advanced EJ200 engines are produced by a consortium, Eurojet Turbo GmbH, involving companies from the participating countries (Matthews & Al-Saadi, 2023). The integration of these engines into the airframes necessitates precise coordination and timely delivery of parts and services across the different national supply chains. This example illustrates the critical need for an efficient and resilient supply chain ecosystem in the defence manufacturing sector, where the integration of multinational efforts and resources is essential for producing sophisticated military equipment like the Eurofighter Typhoon.

7.3.3 Regulatory and Policy Ecosystem

The regulatory and policy ecosystem plays a pivotal role in shaping the operational landscape of industries and economies (Baskent, 2020). It consists of the laws, regulations, standards, and policies governing how businesses and organisations operate, ensuring they adhere to ethical, legal, and quality standards. This ecosystem is crucial for maintaining market integrity, protecting consumer rights, and fostering a competitive business environment. For instance, regulatory frameworks like the Basel Accords ensure that banks maintain adequate capital levels in the financial sector, reducing the risk of systemic failures (Mitchell, 2022). In the environmental sphere, policies such as the Paris Agreement (Höhne,

2021) drive efforts to reduce carbon emissions and mitigate climate change impacts. A well-structured regulatory and policy ecosystem promotes fair competition and innovation and helps address societal challenges, such as public health, environmental sustainability, and economic inequality. Setting the rules of the game provides a stable and predictable environment for businesses to thrive while safeguarding public interests and promoting overall societal well-being.

The regulatory and policy ecosystem in the defence manufacturing sector is crucial for ensuring national security, technological superiority, and compliance with international standards. For example, the International Traffic in Arms Regulations (ITAR) in the United States strictly controls the export of defence-related technology and services to safeguard national security and implement foreign policy objectives (Juliannoor, 2023). Companies like Lockheed Martin and Raytheon must navigate these regulations to sell their products internationally, such as the Patriot missile defence system. Another example is the Defence Acquisition Regulations System (DARS), which governs the procurement process for defence equipment in the U.S (DARS). This system ensures that companies like Northrop Grumman, which produces the B-2 Spirit stealth bomber, adhere to strict standards of quality, performance, and ethical conduct (Ronis, 2018). These regulations and policies maintain the integrity of the defence manufacturing industry and ensure that the produced military equipment meets the highest safety, reliability, and effectiveness standards.

7.3.4 Cybersecurity Ecosystem

The cybersecurity ecosystem is a critical component of the modern digital landscape, encompassing a range of elements, including technology, processes, policies, and human factors that work together to protect information systems and networks from cyber threats (Sadik et al., 2020). Its importance cannot be overstated, as it plays a vital role in safeguarding data confidentiality, integrity, and availability in various sectors, including government, healthcare, finance, and defence. A robust cybersecurity ecosystem helps prevent unauthorised access, data breaches, and cyberattacks, which can lead to significant financial losses, damage to reputation, and legal consequences. For example, advanced threat detection systems, encryption technologies, and security protocols are essential in thwarting cybercriminal activities and protecting sensitive information. Moreover, the ecosystem involves continuous monitoring, threat intelligence sharing, and collaboration between organisations and cybersecurity professionals to adapt to the evolving threat landscape. This collaborative approach enhances the overall resilience of the ecosystem, ensuring that businesses and governments can maintain trust and continue to operate effectively in the face of increasing cyber threats.

Cybersecurity is paramount in the defence manufacturing sector due to the sensitive nature of military data and the potential consequences of breaches. For instance, the F-35 Joint Strike Fighter programme, managed by Lockheed Martin, exemplifies the integration of advanced cybersecurity measures to protect against espionage and cyber-attacks (Klosek, 2020). This programme involves a sophisticated supply chain and data-sharing environment where cybersecurity protocols are essential to safeguard classified information and ensure the integrity of the defence systems. Another example is BAE Systems' work on naval combat systems, where cybersecurity measures are integrated into the design and development phases to protect ships from cyber threats (Young & Drees, 2018). These systems are equipped with advanced encryption and intrusion detection technologies to prevent unauthorised access and ensure the operational readiness of naval fleets. These examples highlight the critical role of the cybersecurity ecosystem in defence manufacturing, where protecting sensitive information and maintaining the functionality of defence assets are of utmost importance.

7.3.5 International Ecosystem

The international ecosystem, encompassing the global network of political, economic, social, and environmental interconnections, is crucial for addressing the complex challenges that transcend national borders (Ayensu et al., 1999). This ecosystem facilitates international cooperation and collaboration, enabling countries to work together on climate change, global health, trade, and security issues. For example, the Paris Agreement, a landmark international treaty on climate change, exemplifies how nations can unite to mitigate environmental threats and promote sustainable development. Similarly, the World Health Organization (WHO) represents a vital component of the international ecosystem in coordinating global health responses, as seen during the COVID-19 pandemic. These collaborations help pool resources, knowledge, and expertise, fostering innovation and resilience against global challenges. The international ecosystem's importance lies in its ability to bring diverse stakeholders together, promoting peace, stability, and prosperity on a global scale and highlighting the interconnectedness and interdependence of the modern world.

In the context of defence manufacturing, the international ecosystem plays a critical role in fostering collaborations and alliances that enhance global security and technological advancements. For instance, the NATO (North Atlantic Treaty Organization) alliance heavily relies on the interoperability of defence systems manufactured by member countries, such as the United States' production of F-16 fighter jets and Germany's Leopard 2 tanks (Goldgeier, 2010). These systems are designed to meet shared defence standards, allowing seamless integration and operation across different national armed forces. Another example is the multinational collaboration in the production of the Eurofighter Typhoon, involving defence manufacturers from the United Kingdom, Germany, Italy, and Spain. This project exemplifies cross-border cooperation in defence technology development and strengthens the military capabilities and strategic partnerships within Europe. These examples highlight the importance of the international ecosystem in defence manufacturing, where collaborative efforts lead to enhanced military readiness, shared defence responsibilities, and the collective security of participating nations.

7.3.6 Talent and Workforce Ecosystem

The talent and workforce ecosystem is a cornerstone of any organisation's success, embodying its employees' collective capabilities, skills, and experiences (Gorski et al., 2022). This ecosystem is vital for driving innovation, productivity, and competitive advantage. In industries like technology and healthcare, where rapid advancements and changes are the norm, having a skilled and adaptable workforce is crucial for staying ahead of market trends and meeting the evolving needs of customers and clients. For example, in the tech industry, companies like Google and Apple invest heavily in talent acquisition and development programmes to nurture a workforce capable of pioneering innovations in computing and mobile technologies. Similarly, institutions like the Mayo Clinic and Johns Hopkins Hospital emphasise continuous professional development and training to ensure their staff can deliver the highest patient care and medical research standards. These examples highlight how a robust talent and workforce ecosystem can be a strategic asset, enabling organisations to achieve their goals and maintain leadership in their respective fields.

The talent and workforce ecosystem is crucial for developing and producing advanced military technologies and systems in the defence manufacturing sector. For instance, Lockheed Martin, a leading defence contractor, places significant emphasis on cultivating a skilled workforce capable of innovating in areas like aerospace, where they develop state-of-the-art aircraft such as the F-22 Raptor. This requires diverse expertise from aerospace engineering to cybersecurity, highlighting the importance of a talented workforce in maintaining technological superiority and fulfilling defence contracts (O'Rourke & Bolkcom, 2009). Similarly, General Dynamics, another key player in the defence industry, relies on its skilled engineers and technicians to produce sophisticated naval vessels, including nuclear submarines like the Virginia-class. These examples highlight the critical role of a skilled and dedicated workforce in the defence manufacturing sector, where the ability to deliver complex and reliable defence systems is directly tied to the talent and expertise of the individuals involved.

7.3.7 Sustainability Ecosystem

The sustainability ecosystem, encompassing environmental, social, and economic dimensions, is essential for fostering a balanced and resilient future (Kay et al., 1999). It integrates practices and policies aimed at conserving natural resources, promoting social equity, and driving economic growth without compromising the ability of future generations to meet their needs. In the context of climate change and resource depletion, sustainability ecosystems become paramount. For example, in the renewable energy sector, companies like Vestas and Siemens Gamesa are at the forefront of developing sustainable wind power technologies, reducing reliance on fossil fuels and mitigating environmental impacts. Similarly, in the agricultural industry, practices like sustainable farming and organic agriculture, exemplified by companies like Monsanto and Cargill, aim to enhance food security, preserve biodiversity, and improve soil health. These examples highlight how sustainability ecosystems are vital for addressing global challenges, ensuring that economic development is achieved in harmony with the planet's ecological boundaries and social well-being.

In the defence manufacturing sector, sustainability ecosystems are increasingly recognised for their importance in ensuring long-term operational efficiency and environmental stewardship. For instance, BAE Systems has integrated sustainability (Gopalakrishnan et al., 2012) into its operations by developing hybrid-electric drive systems for combat vehicles, reducing fuel consumption and emissions. This initiative demonstrates a commitment to environmental sustainability and enhances military fleets' operational effectiveness and cost-efficiency. Another example is Raytheon Technologies, which has implemented sustainable practices in its manufacturing processes, such as reducing waste and improving energy efficiency in the production of defence systems like the Patriot missile system. These efforts are part of a broader strategy to minimise the environmental footprint of defence activities while maintaining high performance and reliability standards. Through these examples, it is evident that defence manufacturers are increasingly prioritising sustainability in their ecosystems, balancing the demands of national security with the imperative of environmental and social responsibility.

7.4 Ecosystem Methodologies

Building ecosystems, particularly in sectors like defence manufacturing, can be approached through various methodss, each with its own structure and focus.

(a) Cluster Method - This method focuses on *geographic proximity*, where businesses, suppliers, and associated institutions in a particular field are located near each other.

The West Midlands Automotive Cluster, the powerhouse of the UK automotive industry, is a good example (He et al., 2014). Featuring major manufacturers like Jaguar Land Rover, Aston Martin, and BMW, which have significant manufacturing and R&D facilities in the region. The cluster involves numerous specialised suppliers providing essential components such as engines, transmissions, and electronic systems. Research and development are driven by entities like the Warwick Manufacturing Group (WMG) at the University of Warwick and the MIRA Technology Park in Nuneaton. Support organisations, including the Automotive Council UK and Local Enterprise Partnerships (LEPs), actively promote and fund the industry. The region benefits from a skilled workforce supported by local universities and technical colleges, fostering automotive engineering and innovation expertise. Collaborative networks among companies enhance innovation and competitiveness, while excellent transport links ensure efficient logistics and distribution, reinforcing the cluster's strategic importance.

(b) Hub-and-Spoke Method - In this method, a central organisation (the hub) connects with various other entities (the spokes), such as suppliers, customers, and research institutions. The hub acts as a coordinator, driving collaboration and resource sharing among the entities to foster innovation and growth.

Toyota's global production system is an example of a hub-and-spoke method in manufacturing (Kito et al., 2014). This method maximises efficiency and minimises waste by centralising key operations (the hub) and linking them with various regional facilities (the spokes). It centres on Toyota City, Japan, housing its main production, R&D, and headquarters. Regional spokes include major North American facilities in Kentucky, Texas, Mississippi, and Canada; European plants in the UK (Burnaston) and France (Valenciennes); Asian plants in Thailand and Indonesia; and additional facilities in Brazil and South Africa, all tailored to meet local market needs.

(c) Value Chain Method: This approach emphasises integrating all activities and processes in creating and delivering a product or service. Through close collaboration among participants, the value chain methodl seeks to enhance efficiency and value at each step, from raw materials to end-user delivery.

Apple's iPhone value chain is a model of efficiency and integration (Grimes & Sun, 2016). It starts with extensive research and development (R&D) in California, where innovative features and technologies are conceived. Essential components, such as TSMC processors and Samsung display panels, are sourced globally. The assembly is carried out in advanced facilities like Foxconn in China, maintaining stringent quality standards. A sophisticated logistics network ensures efficient global distribution, supported by powerful marketing campaigns and a robust retail presence online and in Apple Stores. The value chain is completed with exceptional after-sales service through AppleCare, offering technical support, repairs, and warranty management, which ensures high customer satisfaction and loyalty.

(d) Integrated Method: This methodcombines elements of the above methods to create a comprehensive ecosystem. It involves multi-level collaboration across various sectors and disciplines, integrating different aspects of the ecosystem to achieve a synergistic effect.

An example of an integrated method of a manufacturing ecosystem is Tesla's Gigafactory (Lang et al., 2021; Liu et al., 2022). Tesla's Gigafactory illustrates a vertically integrated approach to manufacturing, combining various stages of production, supply chain management, and sustainability within a single, cohesive ecosystem. Tesla produces key components in-house, such as batteries and electric motors, reducing reliance on external suppliers. The factory employs extensive automation, robotics, and 3D printing for efficient and precise production. Local sourcing and just-in-time inventory management streamline the supply chain. The Gigafactory is powered by renewable energy, with energy storage systems ensuring stability. Real-time monitoring, AI, and machine learning optimise workflows and product quality. Close collaboration between design and manufacturing teams allows for rapid iteration and customisation, while closed-loop systems and sustainable practices minimise waste and environmental impact.

Each of these methods has its own advantages and can be chosen based on the specific objectives, resources, and context of the ecosystem being developed. Often, a hybrid or customised approach that combines elements from different methods is used to address the unique needs of a particular ecosystem.

Method	Strengths	Weaknesses
(a) Cluster Method	• Promotes collaboration and innovation through proximity.	• Limited to geographic location, which can exclude remote or international partners.

	• Enhances competitiveness and efficiency.	• Can lead to congestion and high competition for local resources
(b) Hub-and-Spoke Method	• Centralised coordination can improve resource allocation. • Facilitates focused collaboration among diverse entities.	• Over-reliance on the hub can create vulnerabilities. • Spokes may become dependent on the hub, limiting their autonomy.
(c) Value Chain Method	• Enhances efficiency and integration across the production process. • Lead to cost reductions and improved product quality.	• Requires high levels of coordination and integration, which can be complex to manage. • Changes in one part of the chain can have significant ripple effects.
(d) Integrated Method	• Combines strengths of various models to create a comprehensive approach. • Flexible and adaptable to specific needs and contexts.	• Can be complex to design and manage due to its multifaceted nature. • Requires significant coordination and integration efforts.

Table 7.1: Comparison of Methods

The best method for building a defence manufacturing ecosystem depends on various factors, including the specific needs, strategic objectives, existing infrastructure, and the geopolitical context of the region or country. However, given the complexity, scale, and security requirements of defence manufacturing, the integrated methodl, is the most effective. The key reasons are as follows.

(a) Complexity and Scale - Defence manufacturing involves complex and large-scale projects that require the integration of various technologies, capabilities, and processes (Cahyasusila & Timbul, 2022). An integrated method combines ecosystem structures, such as clusters for innovation and collaboration, hub-and-spoke for centralised coordination, and value chains for efficient production processes.

(b) Security and Sovereignty - Defence manufacturing is closely tied to national security and sovereignty (Vasylovych et al., 2020). The integrated method can balance domestic development (ensuring security and control) and international collaboration (for access to advanced technologies and markets).

(c) Public-Private Partnerships (PPP) -Defence projects often require significant investment and resources that can be effectively mobilised through PPPs (Pukhova et al., 2021). This approach leverages the strengths of both the public and private sectors, combining public oversight and private sector efficiency and innovation.

(d) Innovation and Adaptability -The integrated methodsupports continuous innovation and adaptability by fostering collaboration across various entities, including research institutions, industry players, and government agencies (Fauconnet, 2019). This is crucial in the defence sector, where technological advancements and strategic needs evolve rapidly.

(e) Global and Local Integration- Defence manufacturing ecosystems must be integrated locally and globally to access a wide range of resources, technologies, and markets. The integrated method facilitates this by combining local clusters with global networks (Schmitt. 2000).

While the integrated method is often the most effective for building a defence manufacturing ecosystem, it should be tailored to the specific context and needs of the country or region. This approach allows for leveraging the strengths of various ecosystem models to create a robust, innovative, and sustainable defence manufacturing sector.

7.5 Building Integrated Defence Manufacturing Ecosystem Approach for the UAE (IDEA-UAE)

There are no universally recognised guidelines for developing a defence manufacturing ecosystem, leading to significant variability in how countries and organisations approach this critical sector. The absence of standardised protocols means that each entity often devises its own strategies, resulting in fragmented and inconsistent practices. This lack of cohesive guidance hinders the ability to establish best practices, ensure quality control, and foster effective collaboration across the industry. Consequently, developing defence manufacturing ecosystems relies heavily on trial and error, localised expertise, and ad-hoc policies, which may not always align with broader strategic objectives. Comprehensive guidelines are increasingly needed to create a more coordinated and efficient global defence manufacturing landscape.

7.5.1 Business Ecosystems

Given the absence of universally recognised guidelines for developing a defence manufacturing ecosystem, it is valuable to explore how ecosystems are nurtured within general business systems. Business ecosystems thrive on strategic collaboration among diverse stakeholders, including suppliers, distributors, customers, and competitors (Koenig, 2013). Having reviewed the most recent publications on business ecosystem design (Weiller & Neely, 2013; D'Souza et al., 2015; Tsujimoto et al., 2018; Senyo et al., 2019), the approach proposed by Boston Consulting Group, a global consulting firm known for developing novel solutions such as the Growth Share Matrix (Hax & Majluf, 1983), was chosen as the guide for the development of IDEA-UAE.

Figure 7.1: The Six-step Journey of Business Ecosystem Design (Pidun et al., 2020)

7.5.2 IDEA-UAE Conceptual Framework

The IDEA-UAE conceptual model was built upon the framework provided by the Boston Consulting Group and the specific ecosystems described in section 7.2. Recognising the ever-growing significance of cybersecurity and sustainability across various sectors, this work proposes their incorporation as fundamental aspects of all six domains encompassed within the conceptual model. This integration ensures that these critical considerations are systematically addressed throughout the model's application.

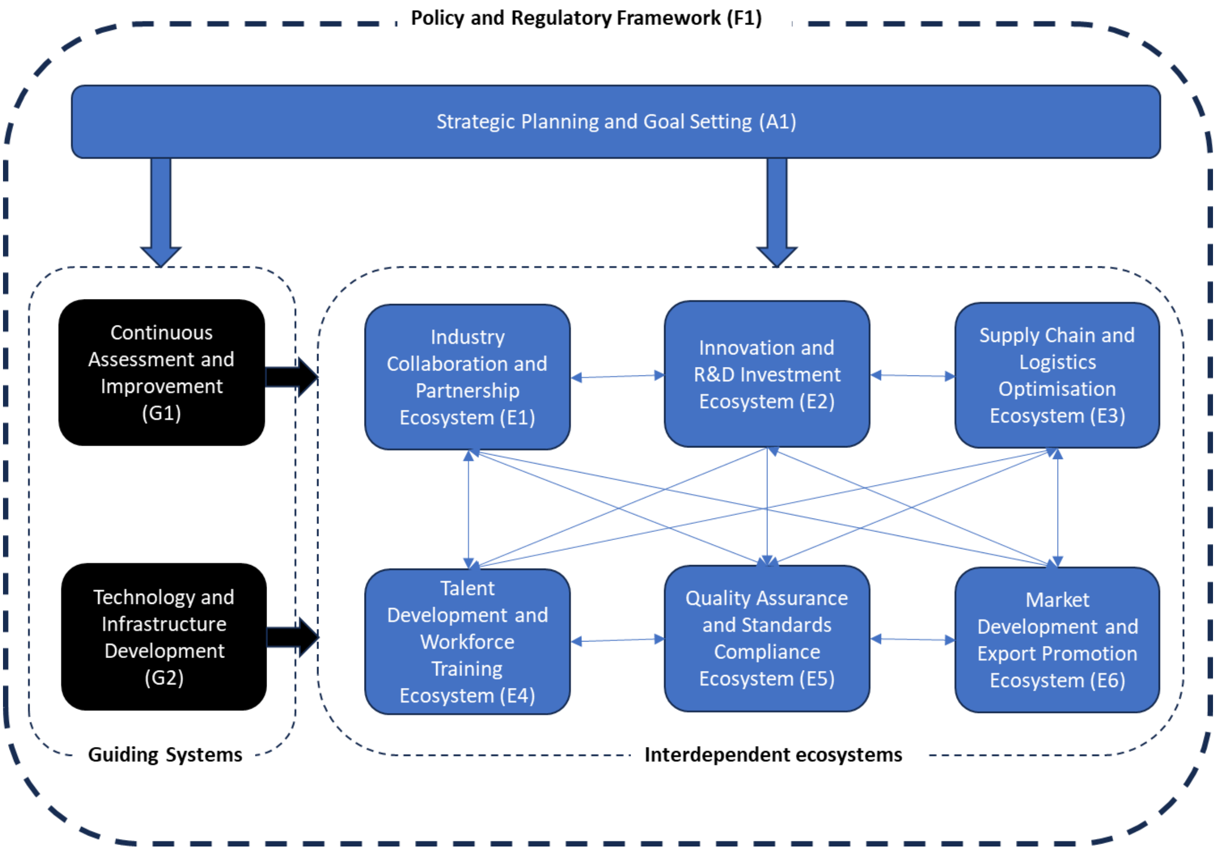

Figure 7.2: IDEA-UAE Conceptual Framework

The following section provides a concise overview of of the four major elements. It then explains each component further, exploring their significance in greater detail.

(a) Overarching Framework

A robust policy and regulatory framework in defence manufacturing is crucial to fostering innovation and maintaining a competitive edge by guiding industry standards and compliance, protecting intellectual property, and facilitating international collaborations.

Policy and Regulatory Framework (F1): Develop and implement a supportive policy and regulatory framework that encourages investment, innovation, and collaboration in the defence sector.

(b) Strategic Directions

Strategic planning and goal setting are essential as they provide a clear roadmap for achieving long-term success, ensuring that resources are effectively utilised and everyone is aligned toward a common vision.

Strategic Planning and Goal Setting (A1): Define clear objectives and long-term goals for the defence manufacturing ecosystem, aligning them with national security needs and economic development priorities.

(c) Guiding Systems

These two components are vital for the ongoing enhancement of ecosystems in defence manufacturing.

Continuous Assessment and Improvement (C1): Regularly assess the performance of the defence manufacturing ecosystem, using feedback and data-driven insights to make continuous improvements and adapt to changing environments.

Technology and Infrastructure Development (C2): Invest in the necessary technology and infrastructure to support advanced manufacturing processes, research and development (R&D), and supply chain logistics.

(d) Interdependent Ecosystems

Interdependent ecosystems in defence manufacturing are essential for creating a cohesive and resilient industry that can efficiently respond to complex challenges.

Industry Collaboration and Partnership Ecosystem(E1): Foster collaboration between government, private sector, academic institutions, and international partners to leverage expertise, resources, and market opportunities.

Innovation and R&D Investment Ecosystem (E2): Encourage innovation through targeted investments in R&D, supporting the development of new products, technologies, and manufacturing processes.

Supply Chain and Logistics Optimisation Ecosystem (E3): Build a robust and efficient supply chain network to ensure reliable sourcing of materials, components, and services, enhancing the ecosystem's resilience and responsiveness.

Talent Development and Workforce Training Ecosystem (E4): Establish education and training programmes to develop skilled professionals in defence manufacturing, including engineers, technicians, and management personnel.

Quality Assurance and Standards Compliance Ecosystem (E5): Implement strict quality control and assurance mechanisms to meet international standards and regulations, ensuring the reliability and safety of defence products.

Market Development and Export Promotion Ecosystem (E6): Develop strategies to penetrate domestic and international markets, promoting the ecosystem's products and services to expand its market reach and competitiveness.

The IDEA-UAE framework provides a comprehensive view of how various ecosystems collaborate to drive innovation and ongoing improvements in the UAE's defence manufacturing industry. By leveraging each ecosystem's unique strengths and capabilities, this integrative approach fosters a dynamic environment conducive to technological advancement and operational excellence.

7.5.3 Key Actors in Defence Manufacturing Ecosystems

Before investigating each ecosystem deeper, it is essential to identify the key actors involved. Recognising these actors is crucial when designing an ecosystem, as they represent the various stakeholders and entities that interact within and influence the system. Understanding the roles and contributions of these actors provides a clearer picture of how the ecosystem functions and facilitates effective collaboration and innovation (Lienhoop & Schröter-Schlaack, 2018).

Interconnected Roles: Each actor within an ecosystem plays a specific role, contributing to the overall functionality and sustainability of the system. In natural ecosystems, these actors include producers, consumers, and decomposers. In human-designed ecosystems, such as business or technology ecosystems, actors can be companies, customers, suppliers, regulators, and other stakeholders.

Ecosystem Services: Different actors provide various ecosystem services essential for other actors' survival and well-being. For example, service providers, manufacturers, and retailers contribute to the value chain in economic ecosystems, supporting the ecosystem's overall health.

Adaptive and Co-Evolutionary Processes: Actors within an ecosystem often co-evolve, adapting to each other's presence and actions. This co-evolution can drive innovation and adaptability, helping the ecosystem respond to external pressures and changes. In technology ecosystems, for example, the development of complementary technologies and standards often results from the interactions between different actors.

Conflict and Cooperation: Interactions between actors can involve conflict and cooperation, shaping the ecosystem's dynamics and evolution. Competition can drive improvements and efficiencies while cooperation can lead to synergies and collective benefits.

The table below lists the key actors in the defence manufacturing sector.

Actor(s)	Description	Actors in the UAE (Examples)
Government Agencies and Military Departments	These are the primary customers for defence products and services. They are responsible for issuing requirements, overseeing procurement processes, and managing contracts	• Ministry of Defence (MoD) • Tawazun Economic Council • Edge Group • General Headquarters (GHQ) of the UAE Armed Forces
Prime Contractors	These large corporations are at the top tier of the defence supply chain. They manage large-scale defence projects and often coordinate with numerous subcontractors and suppliers.	• Edge Group • Advanced Military Maintenance, Repair and Overhaul Centre (AMMROC)

		• Abu Dhabi Ship Building (ADSB) • International Golden Group (IGG)
Subcontractors and Suppliers	These are the companies that supply parts, components, and services to the prime contractors. They are essential for the production of specialised components like engines, electronic systems, and weaponry. Many small and medium-sized enterprises (SMEs) fall into this category.	• Strata Manufacturing • Bayanat Engineering UAE • EPI (Emirates Precision Industries)
Research Institutions and Universities	These organisations provide the technological innovations and advancements that drive the defines industry forward. They often work closely with defence contractors and governments on research and development projects	• Masdar Institute: (Part of the Khalifa University of Science and Technology) • Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) • UAE University (UAEU)
International Partners and Allies	In many cases, defence projects involve collaboration between countries. International partnerships can be crucial for sharing technologies, joint manufacturing, and coordinated defence strategies.	• USA • UK • France • China • Soth Korea
Regulatory Bodies	These are responsible for ensuring compliance with national and international laws, including arms control treaties, export regulations, and safety standards.	• Emirates Authority for Standardisation and Metrology (ESMA) • The General Civil Aviation Authority (GCAA)
Financial Institutions and Investors	These provide the necessary capital for large-scale defence projects. Defence manufacturing often requires substantial investment and financial institutions play a critical role in financing these endeavours.	• Sovereign Wealth Funds

Table 7.2: Key Actors in the Defence Manufacturing Ecosystem

7.5.4 Critique of interactions between key actors

Several factors characterise the interactions between key actors in the UAE defence manufacturing sector, including collaboration, government support, and international partnerships. The effectiveness of these interactions has significant implications for the sector's overall efficiency, innovation capabilities, and role in the UAE's broader strategic objectives.

(a) Government support and regulation

The UAE government plays a pivotal role in the defence manufacturing sector. It not only acts as a regulator but also as a major customer and facilitator. The government's strategic vision aims to position the UAE among the world's leading nations in defence technology. Significant investment and favourable policies have been implemented to stimulate growth and self-reliance in defence capabilities.

(b) Collaboration among Local Companies

There is a strong push towards increasing collaboration among local companies within the UAE’s defence industry. The government encourages mergers and partnerships to consolidate skills, share technologies, and optimise resources. Such collaborations are crucial for developing a competitive edge on the global stage.

(c) International partnerships

International cooperation is a cornerstone of the UAE's defence manufacturing strategy. The UAE has established extensive partnerships with global defence contractors and governments to enhance its technological capabilities and production capacity. These partnerships often involve technology transfer agreements, joint ventures, and collaborative research and development projects.

(d) Challenges in Interactions

Despite these strengths, some challenges affect interactions among the key actors:

(i) *Technology Dependency:* While international partnerships help boost local capabilities, they can also lead to a dependency on foreign technology and expertise.

Balancing technology transfer with the development of indigenous capabilities is a strategic challenge.

(ii) *Integration of Private Sector:* Integrating private sector innovations into government-led projects can sometimes be bureaucratic and slow. Ensuring that small and medium-sized enterprises (SMEs) have fair access to defence contracts is an ongoing issue.

(iii) *Geopolitical Sensitivities*: The Middle East's geopolitical dynamics can influence international partnerships, affecting collaboration and technology-sharing agreements.

It is argued that the IDEA-UAE framework will significantly enhance the interactions among various stakeholders. This framework is designed to foster collaboration, communication, and cooperation among diverse groups, including government agencies, private sector entities, academic institutions, and civil society organisations. By providing a structured approach to engagement, the IDEA-UAE framework aims to create synergies that drive innovation, economic growth, and social development. Enhanced interactions among these actors are expected to result in more effective policymaking, increased investment opportunities, and the development of sustainable solutions to pressing challenges. Overall, the implementation of the IDEA-UAE framework is anticipated to lead to a more integrated and dynamic ecosystem that benefits all participants.

7.6 Constructing Individual Elements of IDEA-UAE

The IDEAE-UAE Conceptual Model, as depicted in Figure 7.2, encompasses ten (10) distinctive elements. Each plays a critical role in the overall framework of the model, contributing to its comprehensive nature. Below is a detailed description of the construction and significance of each element.

When interactions occur between different components of the conceptual model, they are emphasised in **blue**. Additionally, references to the corresponding elements are included to provide clear connections and enhance understanding. This ensures that the relationships between various parts of the model are easily identifiable and comprehensible, facilitating a better understanding of how these components interact and influence each other.

The tables in sections 7.5.1 to 7.5.10 draw on a wide range of publications for detailed information on each ecosystem. For improved readability, these sources are not cited within this section. However, they have been appropriately cited in the preceding sections.

7.6.1 Policy and Regulatory Framework (F1)

Building a Policy and Regulatory Framework specifically for the defence manufacturing industry involves distinct steps that account for the sensitive nature of defence, the integration of advanced technologies, and the importance of national security.

Step	Description
Identify Strategic Objectives	Define national security goals and the role of the defence industry. Identify necessary areas for policy development.
Assessment of Current Policies	Review existing regulations affecting defence manufacturing and identify gaps or outdated policies due to technological changes.
Stakeholder Engagement	Engage with a range of stakeholders, from defence contractors to experts, and hold consultations to gather insights on needed regulatory measures.
Security and Risk Assessment	Assess risks in defence manufacturing, including cyber threats and international security implications.
Drafting Policy Proposals	Draft policy proposals addressing technological transfer, intellectual property, compliance with international norms, and clear enforcement measures.
Public and Confidential Consultations	Conduct public feedback sessions for general policy aspects and confidential reviews with cleared stakeholders for sensitive information, balancing transparency with security.

Impact Analysis	Analyse proposed policies' economic, security, and technological impacts, assessing how they affect industry competitiveness and innovation.
Legal Review	Ensure proposed policies comply with national and international laws; resolve legal conflicts.
Finalisation and Approval	Finalise proposals after incorporating feedback and legal reviews, then proceed through governmental approval processes, such as legislative passage or executive ratification.
Implementation and Training	Develop implementation plans, timelines, and resource allocations, and provide training to ensure stakeholders understand and comply with new regulations.
Monitoring and Compliance	Establish systems for monitoring compliance, using audits and inspections to ensure adherence to regulations.
Ongoing Review and Adaptation	Review the regulatory framework regularly to ensure it remains effective and adapts to changes in technology, the defence industry, and the international security environment. Update policies as needed.

Table7.3: Policy & Regulatory Framework (F1)

This comprehensive process ensures that the policy and regulatory framework for the defence manufacturing industry is robust, secure, and adaptable to the changing dynamics of global defence and security environments. The Policy and Regulatory Framework establishes the overall direction and guidelines for the sector's governance, development, and operational activities. Therefore, it is essential for all actors to participate in this process. Additionally, a central government entity should coordinate the development of this framework to ensure coherence and effectiveness.

7.6.2 Strategic Planning and Goal Setting (A1)

Strategic planning and goal setting are essential for providing direction and focus, enabling efficient resource allocation, and fostering proactive management. They help organisations anticipate future challenges, measure performance, engage stakeholders, and remain adaptable to change. This structured approach enhances decision-making, ensures competitive advantage, motivates employees, and supports long-term sustainability, ultimately driving the organisation towards success.

Step	Description
Define Vision and Mission	Establish the long-term vision and purpose of the organisation. Develop a clear mission statement outlining the core values and objectives.
Conduct Environmental Scanning	Perform SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) and PEST analysis (Political, Economic, Social, Technological factors) to understand internal and external environments.
Set Objectives and Goals	Develop specific, measurable, achievable, relevant, and time-bound (SMART) goals. Prioritise these objectives based on their strategic importance and potential impact.
Formulate Strategy	Create strategic initiatives and detailed action plans to achieve the goals. Identify key performance indicators (KPIs) to monitor progress.
Allocate Resources	Determine the necessary resources (financial, human, technological) for strategy implementation and allocate them efficiently.
Develop Implementation Plan	Outline detailed steps, timelines, and responsibilities for executing the strategies. Establish communication plans to keep stakeholders informed and engaged.
Monitor and Evaluate	Set up a system for regular tracking and evaluation of progress. Use performance data to assess the effectiveness of strategies and adjust as necessary.
Foster Continuous Improvement (C2)	Implement feedback mechanisms and continuous improvement practices. Adapt strategies and plans based on new information and changing circumstances.
Engage Stakeholders	Identify and involve key stakeholders throughout the planning process. Ensure their alignment and support to foster collaboration and commitment.

Manage Risks	Identify potential risks and develop mitigation strategies. Continuously monitor and manage risks throughout the implementation of the strategic plan.

Table 7.4: Strategic Planning and Goal Setting (A1)

The above principles apply across all domains in the defence manufacturing sector. Therefore, it is essential for all actors within this sector to participate actively in strategic planning and goal setting.

7.6.3 Continuous Assessment and Improvement (C1)

Continuous assessment and improvement in the defence manufacturing industry involve a systematic approach to ensure ongoing quality, efficiency, and security enhancements.

Step	Description
Establish Baseline Metrics	Define initial performance metrics for quality, efficiency, security, and compliance. Establish benchmarks to measure progress.
Regular Performance Reviews	Conduct periodic reviews of processes, products, and systems to evaluate performance against established benchmarks. Use key performance indicators (KPIs) to assess effectiveness.
Data Collection and Analysis	Implement robust data collection mechanisms to gather information on production processes, product quality, and operational efficiency. Use data analytics to identify trends, anomalies, and areas for improvement.
Feedback Mechanisms	Create channels for feedback from employees, stakeholders, and customers. Use surveys, suggestion boxes, and regular meetings to collect insights and suggestions for improvement.
Root Cause Analysis	When issues are identified, perform root cause analysis to determine underlying problems. Use techniques like the 5 Whys, Fishbone Diagram, and Failure Mode and Effects Analysis (FMEA) to pinpoint root causes.

Implement Corrective Actions	Develop and implement corrective action plans based on root cause analysis. Ensure actions are specific, measurable, achievable, relevant, and time-bound (SMART).
Standardisation of Best Practices	Identify best practices from successful improvements and standardise them across the organisation. Document and communicate these practices to ensure consistent application.
Employee Training and Development (E4)	Provide employees with continuous training and development programmes to enhance their skills and knowledge. Focus on areas such as new technologies, quality management, and regulatory compliance.
Technology Upgrades (C2)	Assess and upgrade technology and equipment regularly to stay current with industry advancements. Invest in automation, AI, and other Industry 4.0 technologies to enhance production capabilities.
Compliance Audits	Conduct regular internal and external audits to ensure compliance with industry standards, regulatory requirements, and best practices. Address any non-compliance issues promptly.
Innovation and R&D (E2)	Foster a culture of innovation by investing in research and development (R&D). Encourage collaboration with academic institutions, research organisations, and industry partners to drive technological advancements.
Continuous Monitoring	Establish systems for continuous monitoring of processes and systems. Use real-time data and dashboards to track performance and quickly identify areas needing attention.
Periodic Strategic Reviews	Conduct periodic strategic reviews to reassess goals, market conditions, and technological advancements. Adjust strategies and plans to align with evolving industry needs and organisational objectives.
Customer Feedback Integration	Gather and integrate customer feedback regularly into the improvement process. Continuous product quality and service enhancements ensure that customer needs and expectations are met.

Sustainability and Environmental Considerations	Incorporate sustainability and environmental impact assessments into the continuous improvement process. Implement eco-friendly practices and technologies to reduce the environmental footprint of manufacturing operations.
Benchmarking Against Industry Standards	Compare performance with industry standards and leading practices. Use benchmarking to identify gaps and set improvement targets based on the industry's best performers.
Documentation and Reporting	Maintain thorough documentation of all processes, improvements, and outcomes. Regularly report progress to stakeholders, highlighting achievements, challenges, and future plans.

Table 7.5: Continuous Assessment and Improvement (C1)

This systematic approach ensures that defence manufacturing processes stay efficient, innovative, and aligned with the latest industry standards, ultimately resulting in higher-quality products and enhanced operational performance. With Continuous Assessment and Improvement as a core component, all stakeholders will contribute to developing appropriate systems within their respective domains.

7.6.4 Technology and Infrastructure Development (C2)

The steps involved in technology and infrastructure development for the defence manufacturing industry are essential to ensure that the industry stays at the forefront of innovation and maintains robust operational capabilities.

Step	**Description**
Needs Assessment	Identify and prioritise technological and infrastructure needs based on current capabilities, strategic goals, and emerging threats. Conduct gap analysis to determine areas requiring development or enhancement.
Research and Development (E2)	Invest in R&D to innovate and develop cutting-edge technologies. Collaborate with academic institutions, research organisations, and

	private sector partners to leverage expertise and accelerate development.
Technology Acquisition	Acquire new technologies through procurement, partnerships, or licensing agreements. Ensure that acquisitions align with strategic objectives and enhance operational capabilities.
Infrastructure Modernisation	Upgrade existing infrastructure to support new technologies. This includes facilities, production lines, and IT infrastructure to handle advanced manufacturing processes and data management requirements.
Integration of Industry 4.0 Technologies	Implement Industry 4.0 technologies such as IoT, AI, robotics, and big data analytics. These technologies enhance automation, efficiency, and real-time decision-making in manufacturing processes.
Cybersecurity Measures	Develop and implement robust cybersecurity measures to protect sensitive data and systems. This includes securing networks, deploying encryption, and conducting regular security audits.
Skills Development and Training (E4)	Provide continuous training and development programmes for employees to ensure they are skilled in using new technologies and systems. Focus on building expertise in areas such as AI, cybersecurity, and advanced manufacturing techniques.
Pilot Projects and Prototyping	Launch pilot projects to test new technologies and manufacturing processes on a smaller scale before full-scale implementation. Use prototyping to refine technologies and address potential issues early.
Quality Assurance and Testing	Establish rigorous quality assurance and testing protocols to ensure new technologies and processes meet required standards. This includes both functional and operational testing to validate performance and reliability.
Regulatory Compliance (F1)	Ensure all technology and infrastructure developments comply with national and international regulations and standards. This includes obtaining necessary certifications and adhering to defence-related regulations.

Sustainability Considerations	Incorporate sustainability practices in technology and infrastructure development. This includes energy-efficient systems, waste reduction, and the use of eco-friendly materials and processes.
Continuous Monitoring and Evaluation (C1)	Continuously monitor and evaluate the performance of new technologies and infrastructure. Use feedback and data analytics to identify areas for further improvement and make necessary adjustments.
Scalability and Flexibility	Design technology and infrastructure with scalability and flexibility in mind. Ensure systems can be easily scaled up or down based on demand and adapt to future technological advancements and changes in defence needs.
Investment and Funding	Secure adequate funding for technology and infrastructure projects through government grants, private investments, or internal budget allocations. Ensure that funding is allocated efficiently and effectively to maximise impact.
Collaboration and Partnerships	Foster collaboration and partnerships with industry stakeholders, including other defence contractors, technology providers, and government agencies. These partnerships can facilitate technology transfer and innovation.

Table 7.6: Technology and Infrastructure Development (C2)

This comprehensive approach ensures the defence manufacturing industry remains technologically advanced, operationally efficient, and resilient against emerging threats and challenges.

7.6.5 Industry Collaboration and Partnership Ecosystem (E1)

The steps involved in building an Industry Collaboration and Partnership Ecosystem for the defence manufacturing industry are essential for fostering innovation, sharing expertise, and enhancing capabilities.

Step	Description
Identify Strategic Goals	Define clear strategic objectives for collaboration and partnerships that align with national defence priorities and organisational goals.
Stakeholder Mapping	Identify and map potential stakeholders, including defence contractors, technology providers, research institutions, government agencies, and industry associations. Evaluate their capabilities and potential contributions to the partnership ecosystem.
Engage Key Stakeholders	Initiate engagement with key stakeholders through meetings, workshops, and forums to discuss potential areas of collaboration and mutual benefits.
Establish Partnership Models	Develop various collaboration models, such as joint ventures, strategic alliances, public-private partnerships, and consortiums. Define the roles, responsibilities, and expectations for each type of partnership.
Legal and Regulatory Framework (F1)	Ensure that all collaborations comply with relevant legal and regulatory requirements. Draft agreements that address intellectual property rights, data sharing, confidentiality, and compliance with defence regulations.
Develop Collaboration Platforms	Create platforms for collaboration, such as industry networks, online portals, and innovation hubs where stakeholders can share knowledge, technologies, and best practices.
Funding and Resource Allocation	Secure funding and allocate resources for collaborative projects. Explore funding opportunities from government grants, defence contracts, and private investments to support joint initiatives.
Research and Development (E2)	Promote joint R&D projects to drive innovation in defence technologies. Leverage partners' combined expertise and resources to accelerate the development and deployment of advanced solutions.
Technology Transfer and Sharing (C2)	Facilitate the transfer and sharing of technologies between partners to enhance capabilities. Implement mechanisms for licensing agreements, technology exchanges, and collaborative development projects.
Skills Development and Training	Organise joint training programmes and workshops to build skills and knowledge among partners. Focus on emerging technologies, best

(E4)	practices, and compliance requirements to ensure a highly skilled workforce.
Joint Ventures and Pilot Projects	Launch joint ventures and pilot projects to test new technologies and solutions in real-world scenarios. Use these projects to validate concepts, refine approaches, and demonstrate the benefits of collaboration.
Performance Metrics and Evaluation	Establish metrics to evaluate partnerships' performance and impact. Monitor progress, measure outcomes, and assess the value generated from collaborative initiatives. Use this data to make informed decisions and adjustments.
Continuous Improvement (C1)	Foster a culture of continuous improvement within the partnership ecosystem. Review and refine collaboration strategies, processes, and outcomes to ensure ongoing relevance and effectiveness.
Communication and Reporting	Maintain open and transparent communication channels among partners. Regularly report on collaborative projects' progress, achievements, and challenges to keep all stakeholders informed and engaged.
Conflict Resolution Mechanisms	Develop mechanisms for resolving conflicts and disputes that may arise during collaboration. Ensure that there are clear procedures for addressing issues and maintaining positive working relationships.
Leverage Global Networks	Engage with international partners and global defence networks to expand the collaboration ecosystem. Participate in international forums, conferences, and trade shows to explore new opportunities and share insights.
Scalability and Sustainability	Design collaborative initiatives with scalability and sustainability in mind. Ensure that successful projects can be scaled up and sustained over the long term, providing lasting benefits to all partners involved.
Documentation and Knowledge Management	Maintain thorough documentation of all collaborative activities, agreements, and outcomes. Implement knowledge management systems to capture and share insights, lessons learned, and best practices across the partnership ecosystem.

Table 7.7: Industry Collaboration and Partnership Ecosystem (E1)

This comprehensive approach ensures that the defence manufacturing industry can leverage the strengths of multiple stakeholders, fostering innovation, enhancing capabilities, and maintaining a competitive edge.

7.6.6 Innovation and R&D Investment Ecosystem (E2)

The steps involved in creating an Innovation and R&D Investment ecosystem for the defence manufacturing industry are crucial for driving technological advancements and maintaining a competitive edge.

Step	Description
Identify Strategic Priorities	Define the strategic priorities and goals for innovation and R&D in alignment with national defence objectives and industry needs. Focus on areas that offer the highest potential for technological advancements and operational improvements.
Conduct Market and Technology Research	Perform comprehensive market and technology research to identify emerging trends, potential disruptors, and opportunities for innovation within the defence sector.
Secure Funding and Resources	Obtain funding from government grants, private investments, and internal budget allocations. Ensure sufficient financial, human, and technological resources are dedicated to R&D initiatives.
Establish R&D Infrastructure	Develop and maintain state-of-the-art R&D facilities, including laboratories, testing sites, and innovation hubs. Equip these facilities with the latest tools, technologies, and equipment for advanced research and development.
Form Strategic Partnerships (E1)	Build partnerships with academic institutions, research organisations, technology firms, and other defence contractors. Collaborate on joint R&D projects, share knowledge, and leverage each partner's strengths.

Create an Innovative Culture (E2)	Foster a culture of innovation within the organisation by encouraging creativity, experimentation, and risk-taking. Provide incentives and support for employees to engage in innovative activities and contribute ideas.
Develop a Robust IP Management System	Implement a system for managing intellectual property (IP) to protect innovations and maintain IP rights. Facilitate the licensing and commercialisation of technologies developed through R&D efforts.
Launch R&D Projects and Programmes (E2)	Initiate and manage R&D projects focusing on high-impact areas such as advanced materials, autonomous systems, cybersecurity, and artificial intelligence. Ensure projects are well-planned, resourced, and aligned with strategic priorities.
Implement Agile Methodologies	Use agile project management methodologies to enhance flexibility and responsiveness in R&D processes. This allows for iterative development, rapid prototyping, and quick adjustments based on feedback and findings.
Promote Cross-Disciplinary Collaboration (E1)	Encourage collaboration across different disciplines and departments to integrate diverse perspectives and expertise. This multidisciplinary approach can lead to more holistic and innovative solutions.
Leverage Emerging Technologies (C2)	Invest in and explore emerging technologies such as quantum computing, nanotechnology, and biotechnology. Assess their potential applications in defence manufacturing and integrate them into R&D projects where applicable.
Track and Measure Performance	Establish metrics to track the performance and impact of R&D activities. Regularly evaluate progress, outcomes, and return on investment to ensure alignment with strategic goals and make data-driven decisions.
Facilitate Knowledge Transfer	Implement mechanisms for knowledge transfer to ensure that insights and innovations from R&D activities are effectively communicated and utilised across the organisation and industry. This includes publishing findings, sharing best practices, and conducting training.

Engage with Innovation Networks (E2)	Participate in innovation networks, conferences, and forums to stay informed about the latest developments in defence technology and foster collaborations with other innovators and industry leaders.
Support Startups and SMEs	Encourage the participation of startups and small-to-medium enterprises (SMEs) in the innovation ecosystem. Provide support through funding, mentorship, and collaborative opportunities to leverage their agility and innovative capabilities.
Ensure Regulatory Compliance (F1)	Ensure that all R&D activities comply with national and international regulations and standards. Maintain transparency and adherence to ethical guidelines throughout the innovation process.
Continuously Review and Adapt	Review the R&D strategy and processes regularly to adapt to changing technological landscapes, market demands, and regulatory environments. Ensure that the ecosystem remains dynamic and capable of sustaining long-term innovation.
Document and Disseminate Results	Maintain thorough documentation of R&D projects and outcomes. Disseminate results through reports, publications, and presentations to share knowledge, celebrate successes, and provide transparency to stakeholders.

Table 7.8: Innovation and R&D Investment Ecosystem (E2)

This comprehensive approach ensures a robust and dynamic Innovation and R&D Investment ecosystem that can drive continuous technological advancements in the defence manufacturing industry.

7.6.7 Supply Chain and Logistics Optimisation Ecosystem (E3)

Optimising the supply chain and logistics ecosystem for defence manufacturing involves several critical steps to ensure efficiency, reliability, and resilience.

Step	Description

Needs Assessment	Identify and evaluate the specific needs and requirements of the defence manufacturing supply chain, including key components, materials, and services.
Mapping the Supply Chain	Create a detailed map of the entire supply chain, including all suppliers, manufacturers, distributors, and logistics providers. Understand the flow of materials and information through each stage.
Supplier Evaluation and Selection	Assess and select suppliers based on criteria such as reliability, quality, cost, and compliance with defence regulations. Establish strong relationships with key suppliers to ensure consistency and trust.
Risk Management and Resilience	Identify potential risks within the supply chain, such as geopolitical issues, natural disasters, and cyber threats. Develop contingency plans and strategies to mitigate these risks and enhance the supply chain's resilience.
Implement Advanced Technologies (C2)	Use technologies such as IoT, blockchain, AI, and big data analytics to improve visibility, traceability, and efficiency within the supply chain. These technologies can help monitor real-time data and predict and address disruptions proactively.
Optimise Inventory Management	Implement inventory management systems to ensure optimal stock levels, reduce excess inventory, and prevent shortages. Use techniques such as Just-In-Time (JIT) and demand forecasting to balance supply with demand effectively.
Enhance Logistics Operations	Streamline logistics operations by optimising routes, improving transportation management, and consolidating shipments. Use advanced logistics software to enhance coordination and reduce costs.
Supplier Collaboration and Integration	Foster collaboration with suppliers through integrated systems and platforms for seamless communication and coordination. Share forecasts, demand planning, and inventory levels to align efforts and improve efficiency.

Quality Control and Compliance (E5)	Establish stringent quality control processes to ensure all components and materials meet defence manufacturing standards. Ensure compliance with regulatory requirements and industry best practices.
Sustainability and Environmental Considerations	Incorporate sustainability practices in the supply chain and logistics operations. Focus on reducing carbon footprint, using eco-friendly materials, and optimising energy consumption.
Continuous Monitoring and Analytics (C1)	Track supply chain performance using real-time monitoring and data analytics. Continuously analyse and report data to identify bottlenecks, inefficiencies, and areas for improvement.
Training and Development (E4)	Provide training programmes for supply chain and logistics personnel to enhance their skills and knowledge in using advanced technologies, managing risks, and implementing best practices.
Develop Strategic Partnerships	Form strategic partnerships with key logistics providers, technology companies, and other stakeholders to leverage their expertise and capabilities in optimising the supply chain.
Regular Audits and Reviews	Conduct regular audits and reviews of the supply chain and logistics processes to ensure compliance, efficiency, and effectiveness. Use findings to make informed decisions and continuous improvements.
Customer and Stakeholder Engagement	Engage with customers and stakeholders to understand their needs and expectations. Use their feedback to refine supply chain strategies and improve service delivery.
Leverage Data and Forecasting	Utilise advanced forecasting models and data analytics to predict demand and plan supply chain activities accordingly. Ensure that data-driven decision-making is a core component of supply chain management.
Scalability and Flexibility	Design the supply chain to be scalable and flexible, able to adapt to changing demands and unexpected disruptions. Implement modular systems and processes that can be easily adjusted as needed.

Performance Metrics and KPIs	Establish key performance indicators (KPIs) to measure supply chain and logistics performance. Regularly track and evaluate these metrics to ensure goals are met and identify areas for further improvement.
Innovation and Continuous Improvement	Encourage a culture of innovation and continuous improvement within the supply chain and logistics ecosystem. Regularly review and update processes, technologies, and strategies to stay ahead of industry trends and challenges.

Table 7.9: Supply Chain and Logistics Optimisation Ecosystem (E3)

This structured approach ensures that the supply chain and logistics for defence manufacturing are optimised for efficiency, reliability, and resilience, enabling the industry to meet its strategic objectives effectively.

7.6.8 Talent Development and Workforce Training Ecosystem(E4)

Talent development and workforce training ecosystems are vital for ensuring that organisations remain competitive and innovative. By continuously enhancing employee skills and capabilities, businesses can address skill gaps, adapt to technological advancements, and meet evolving market demands. Effective training programmes boost employee engagement and retention, foster a culture of continuous improvement, and prepare the workforce for future leadership roles.

Step	Description
Needs Assessment	Identify the current and future skills required by the organisation through analysing business goals, industry trends, and workforce capabilities. Conduct surveys, interviews, and performance reviews to gather data on skill gaps.
Goal Setting and Planning	Define clear, measurable objectives for talent development and workforce training. Develop a strategic plan outlining the initiatives, timelines, and resources needed to achieve these goals.

Program Design and Development	Create training programmes and development initiatives tailored to the identified needs. This includes designing curriculum, selecting training methods (e.g., workshops, e-learning, on-the-job training), and developing materials.
Resource Allocation	Allocate the necessary resources (budget, trainers, technology) to support training and development programmes. Ensure alignment with organisational priorities and strategic goals.
Implementation	Roll out the training programmes and development initiatives. This involves scheduling sessions, enrolling participants, and delivering the training using selected methods. Ensure continuous communication and support to participants.
Monitoring and Evaluation	Establish metrics and key performance indicators (KPIs) to assess the effectiveness of training programmes. Collect feedback from participants and measure outcomes against objectives. Based on evaluation results, adjust programmes as needed.
Continuous Improvement (C1)	Use evaluation data to refine and improve training programmes continuously. Implement best practices, update curriculum, and incorporate new learning technologies to enhance the training ecosystem.
Career Development and Succession Planning	Integrate training programmes with career development paths and succession planning. Identify high-potential employees, provide them with targeted development opportunities, and prepare them for future leadership roles.
Employee Engagement and Retention	Foster a culture of continuous learning and development to engage employees. Recognise and reward participation in training programmes and development efforts to improve retention rates.
Stakeholder Collaboration	Engage stakeholders, including management, employees, and external partners, in the talent development process. Ensure alignment with organisational goals and gain support for training initiatives.

Table 7.10: Talent Development and Workforce Training Ecosystem(E4)

The above steps are crucial for the defence manufacturing sector to ensure a highly skilled and capable workforce.

7.6.9 Quality Assurance and Standards Compliance Ecosystem (E5)

A robust Quality Assurance and Standards Compliance Ecosystem offers numerous benefits, including enhanced product reliability and safety, which are critical in the defence manufacturing sector. It ensures compliance with stringent industry regulations and standards, minimising the risk of legal and financial penalties.

Step	Description
Define Quality Standards and Regulatory Requirements	Identify and understand relevant quality standards (e.g., ISO, AS9100) and regulatory requirements specific to the industry. Establish internal quality benchmarks aligned with these standards.
Conduct a Gap Analysis	Assess current processes, systems, and products to identify gaps between existing practices and required standards. Evaluate the organisation's readiness for compliance and quality assurance.
Develop Quality Policies and Procedures	Create comprehensive quality policies and standard operating procedures (SOPs) that align with identified standards and regulatory requirements. Ensure these policies are documented, accessible, and communicated to all stakeholders.
Implement Quality Management System (QMS)	Establish a robust QMS to monitor, control, and improve quality across all operations. Integrate quality assurance processes into the overall business strategy and daily operations.
Train and Educate Employees	Provide training programmes to ensure employees understand quality standards, compliance requirements, and their roles in

(E4)	maintaining quality. Foster a culture of quality and continuous improvement.
Perform Regular Audits and Inspections	Conduct internal audits and inspections to verify compliance with quality standards and regulatory requirements. Identify non-conformities and areas for improvement.
Establish Supplier Quality Management	Develop and implement processes to ensure that suppliers and vendors meet the organisation's quality standards. Conduct supplier audits, assessments, and performance reviews to maintain high-quality supply chain standards.
Monitor and Measure Performance	Implement key performance indicators (KPIs) and metrics to monitor quality performance. Use data analytics to track progress, identify trends, and make informed decisions.
Implement Corrective and Preventive Actions	Develop and enforce procedures for addressing non-conformities and implementing corrective actions. Establish preventive measures to avoid the recurrence of issues and ensure continuous compliance.
Engage Stakeholders	Involve all relevant stakeholders, including suppliers, customers, and regulatory bodies, in the quality assurance process. Ensure their requirements and feedback are integrated into the QMS.
Review and improve	Conduct regular reviews of the QMS and quality policies to ensure they remain effective and relevant. Continuously seek opportunities for improvement through feedback, innovation, and best practices.

Table 7.11: Quality Assurance and Standards Compliance Ecosystem (E5)

7.6.10 Market Development and Export Promotion Ecosystem (E6)

A robust Market Development and Export Promotion Ecosystem is crucial for businesses seeking to expand their global footprint and drive growth. This ecosystem facilitates comprehensive market research, strategic entry planning, and compliance with local regulations, ensuring a smooth and successful market entry.

Step	Description
Market Research and Analysis	Conduct comprehensive market research to identify potential markets for expansion. Analyse market trends, customer preferences, competitive landscape, and regulatory requirements in target markets.
Identify Target Markets	Based on the research, identify and prioritise target markets with the highest potential for growth and profitability. Consider factors such as market size, growth rate, and ease of entry.
Develop Market Entry Strategies	Formulate strategies for entering selected markets. This may include exporting, forming joint ventures, establishing local partnerships, or setting up local offices.
Compliance and Regulatory Planning (F1)	Ensure compliance with local regulations, standards, and certification requirements in target markets. Plan for obtaining necessary licenses and certifications.
Product Adaptation and Development	Adapt products or services to meet the specific needs and preferences of target markets. This may involve modifying features, packaging, and marketing materials to align with local cultural and regulatory standards.
Marketing and Branding	Develop tailored marketing and branding strategies to promote products in the new markets. This includes creating local language marketing materials, leveraging local media channels, and building brand awareness.
Sales and Distribution Channels	Establish effective sales and distribution networks in target markets. Identify and partner with local distributors, agents, or sales representatives to ensure efficient product delivery and customer service.
Training and Capacity Building (E4)	Provide training to local sales teams, distributors, and partners to ensure they understand the product, brand values, and sales strategies. Enhance their capacity to effectively market and sell the products.

Export Financing and Risk Management	Secure export financing options to support market development activities. Implement risk management strategies to mitigate potential risks associated with international trade, such as currency fluctuations and political instability.
Monitor and Evaluate Performance (C1)	Continuously monitor market performance and gather feedback from customers and partners. Evaluate the effectiveness of market entry strategies and promotional activities. Adjust and refine approaches based on performance data and market feedback.
Develop Support Infrastructure	Establish local support infrastructure such as customer service centres, technical support teams, and after-sales services to ensure customer satisfaction and loyalty in new markets.
Foster Government and Industry Relationships	Engage with government agencies, industry associations, and trade organisations in target markets to build strong relationships, gain market insights, and leverage support programmes and incentives for exporters.

Table 7.12: Market Development and Export Promotion Ecosystem (E6)

7.6.11 Summary of designing IDEA-UAE

Developing a holistic ecosystem for defence manufacturing involves integrating several critical components to ensure sustained growth, innovation, and competitiveness. Establishing a supportive Policy and Regulatory Framework (F1) lays the foundation by encouraging investment, innovation, and collaboration across the sector. Clear Strategic Planning and Goal Setting (A1) aligns objectives with national security needs and economic priorities, providing a focused direction for the ecosystem. Continuous Assessment and Improvement (C1) ensures the ecosystem remains adaptive and efficient, using feedback and data to drive ongoing enhancements. Investing in Technology and Infrastructure Development (C2) supports advanced manufacturing, R&D, and logistics, crucial for maintaining cutting-edge capabilities. Fostering an Industry Collaboration and Partnership Ecosystem (E1) leverages the strengths of government, private sector, academia, and international partners, enhancing resource sharing and market opportunities. Innovation and R&D Investment Ecosystem (E2) drives the creation of new technologies and processes, keeping the ecosystem at the forefront of defence manufacturing. Optimising the Supply Chain and Logistics Ecosystem (E3) ensures reliable and efficient sourcing, boosting the ecosystem's resilience. Developing a Talent Development and Workforce Training Ecosystem (E4) equips professionals with the necessary skills, supporting a knowledgeable and capable workforce. Implementing a robust Quality Assurance and Standards Compliance Ecosystem (E5) guarantees products meet stringent international standards, ensuring safety and reliability. Finally, strategies for Market Development and Export Promotion Ecosystem (E6) expand market reach and competitiveness, promoting the ecosystem's products and services domestically and internationally. Together, these steps create a cohesive, dynamic, and resilient defence manufacturing ecosystem that can adapt to evolving challenges and opportunities.

7.7 Validation of IDEA-UAE framework

Validating a framework that encompasses multiple interacting ecosystems to create a holistic approach is a complex task. Four domain experts were consulted for a comprehensive evaluation to ensure the robustness and effectiveness of this framework.

The validation process incorporated two critical elements:

(a) Diversity of Participants: This element focuses on evaluating the range and variety of businesses and stakeholders involved in the ecosystem. By ensuring a diverse set of participants, the framework can address a wide array of perspectives and needs, thereby enhancing its overall applicability and relevance.

(b) Connectivity: This component assesses the level of interconnectedness between different entities within the ecosystem. High connectivity indicates strong relationships and interactions among the participants, which is essential for the smooth functioning and resilience of the ecosystem.

By incorporating these elements, the validation process aims to thoroughly understand the framework's capability to integrate and manage diverse ecosystems. The insights from the domain experts will guide further refinement and enhancement of the framework, ensuring it meets the desired standards and objectives.

Participant A	
Diversity of Participants	“This framework is exceptionally comprehensive, capturing the key aspects of defence manufacturing. It thoroughly understands the industry by addressing supply chain management, production methodologies, quality control, regulatory compliance, technological advancements, and strategic planning. This holistic approach ensures valuable insights for stakeholders navigating and excelling in this field.”
Connectivity	“A commendable effort has been made to identify the key players. Including references to specific players in the UAE would have been beneficial.”
Participant B	
Diversity of Participants	“This framework is notably comprehensive, covering the key aspects of defence manufacturing.
Connectivity	“A diagram outlining the connections would have been useful, providing a clear visual representation of how each component interacts, facilitating easier understanding.”
Participant C	
Diversity of Participants	“I understand that sustainability aspects are integrated within each element, but it would be beneficial to give them more prominence. Highlighting sustainability more explicitly could enhance the overall framework, emphasising its importance and ensuring it receives the attention it deserves.”
Connectivity	“Your effort to display the connections using tables is appreciated, but a diagram would be significantly more helpful in illustrating the relationships and connections.”

Participant D	
Diversity of Participants	“This work effectively highlights the necessity of adopting a holistic and integrated approach to defence manufacturing in the UAE.”
Connectivity	“There are numerous additional complex relationships that could be considered; however, I understand that it is not feasible to include all of them within the scope of this work.”

Table 7.13: Feedback from the industry Experts

The comments collectively praise the framework for its comprehensive coverage of key aspects in defence manufacturing, including supply chain management, production methodologies, quality control, regulatory compliance, technological advancements, and strategic planning. They highlight the framework's depth of understanding and its potential to provide valuable insights to stakeholders. However, there is a suggestion to give more prominence to sustainability aspects within the framework. Explicitly highlighting sustainability could enhance the framework by emphasising its importance and ensuring it receives the necessary attention. Overall, the framework is recognised for its holistic and integrated approach, particularly in the UAE's defence manufacturing context.

The comments collectively commend the effort made to identify key players in the context of the work. However, they suggest that including references to specific players in the UAE would have added value. Additionally, there is a consensus that a diagram outlining the connections would significantly enhance understanding by providing a clear visual representation of the interactions between components. While using tables to display connections is appreciated, a diagram is deemed more effective for illustrating relationships. Lastly, it is acknowledged that while numerous additional complex relationships could be considered, it is understood that it is not feasible to include all of them within the scope of this work.

Given the complexity involved in developing a diagram to illustrate the connections, it was decided not to produce one. Sustainability is believed to be an integral part of every ecosystem; therefore, it was not included as a separate element in the framework.

7.8 Integration of Industry 4.0

At the inception of this research, Industry 4.0 was beginning to penetrate the defence manufacturing sector. Since then, numerous studies have been conducted demonstrating how Industry 4.0 can become an integral component of the defence manufacturing ecosystem. These studies have highlighted various advancements, such as the integration of smart technologies, automation, data analytics, and the Internet of Things (IoT) into manufacturing processes. Rather than attempting to reinvent the wheel, it is logical to identify and consolidate the best available approaches within this context by analysing existing research and case studies,

7.8.1 Need for Industry 4.0

Volko et al. (2020) discuss the necessity for Ukraine's defence-industrial complex (DIC) to transition from the outdated technologies of Industry 2.0 and 3.0 to the advanced technologies of Industry 4.0. This transition needs to include adopting modern digital technologies such as automation, cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), and smart factories. The integration of these technologies is vital for enhancing the production and functionality of modern weaponry. The authors argue that despite the existing challenges, such as funding and data management, the strategic implementation of Industry 4.0 can significantly boost productivity, reduce costs, and create a "digital leap" in the defence sector. Volko et al. (2020) outline a comprehensive approach for this transition, emphasising the need to develop a strategic implementation plan, launch pilot projects, and enhance digital competencies. Key steps include adopting digital platforms to facilitate stakeholder interactions, focusing on international standards, and utilising modular, smart factory designs.

7.8.2 Framework for integrating Industry 4.0 defence manufacturing.

Several frameworks and approaches have been developed to guide the integration of Industry 4.0 into manufacturing and defence manufacturing sectors.

Framework	Overview	Use
RAMI 4.0 (Reference Architectural Model Industry 4.0) (Neto et al., 2020)	RAMI 4.0 is a structured model for helping industries integrate Industry 4.0 principles. It breaks down complex systems into manageable layers and views, facilitating interoperability and standardisation.	Defence manufacturers can use RAMI 4.0 to ensure that new technologies are integrated into existing systems smoothly, enhancing collaboration and efficiency.
Industrial Internet Reference Architecture (IIRA) (Leitão et al., 2023)	Developed by the Industrial Internet Consortium (IIC), IIRA provides a framework to design interoperable, secure, and scalable Industrial Internet systems.	IIRA can guide defence manufacturers in building systems that connect various machines, devices, and software, ensuring robust data exchange and operational efficiency.
Cyber-Physical Systems (CPS) Frameworks (Bousdekis et al., 2020)	CPS frameworks focus on the integration of physical processes with computation and networking. They provide a foundation for creating smart systems that can interact with their environment in real time.	Defence manufacturing can leverage CPS frameworks to develop smart factories with self-optimised interconnected machines and processes.
Digital Twin Framework (Onaji et al., 2022)	Digital twins are virtual representations of physical assets or systems that can simulate, predict, and optimise performance. Frameworks for digital twins help in creating accurate and actionable models.	Using digital twins, defence manufacturers can simulate production processes, predict equipment failures, and optimise maintenance schedules, leading to reduced downtime and improved efficiency.
Industrial Data Space (IDS) (Guo et al., 2023)	IDS is an initiative aimed at creating a secure data exchange environment. It ensures data sovereignty while enabling seamless sharing across different stakeholders.	Defence manufacturers can adopt IDS principles to securely share sensitive data with partners and suppliers without compromising data ownership or security.
Smart Manufacturing Leadership Coalition (SMLC) Framework (Shukla & Shankar, 2022)	The SMLC framework provides guidelines for implementing smart manufacturing technologies and processes, emphasising collaboration, standards, and best practices.	By following the SMLC framework, defence manufacturers can adopt best practices for smart manufacturing, ensuring consistent and efficient integration of new technologies.

Table 7.14: Models for Integrating Industry 4.0

Framework	Benefits	Challenges
RAMI 4.0	• Structured approach to integration • Enhances interoperability and standardisation • Provides clear guidelines and models	• Complexity in implementation- • Requires significant training and adaptation • High initial cost and time investment
IIRA (Industrial Internet Reference Architecture)	• Promotes interoperability, security, and scalability • Facilitates robust data exchange • Enhances operational efficiency	• Complexity in aligning with existing systems • Requires a detailed understanding of the architecture • Potential high costs for integration
Cyber-Physical Systems (CPS) Frameworks	• Enables real-time interaction and optimisation • Enhances automation and smart factory capabilities • Improves predictive maintenance and operational efficiency	• High complexity and technical requirements • Security and privacy concerns • Integration with legacy systems can be difficult
Digital Twin Framework	• Allows for accurate simulations and optimisations • Enhances predictive maintenance and operational efficiency	• High costs of creating and maintaining digital twins • Requires significant data and computational resources • Integration challenges with existing systems

	• Improves decision-making with real-time data	
Industrial Data Space (IDS)	• Ensures secure data exchange and data sovereignty • Enhances collaboration with partners and suppliers • Facilitates trust in data sharing	• Complexity in setting up secure data spaces • High implementation and maintenance costs • Requires robust security measures
SMLC Framework	• Provides best practices for smart manufacturing • Enhances collaboration and standardisation • Supports continuous improvement	• Requires organisational change management • Initial setup can be resource-intensive • Ensuring adherence to best practices

RAMI 4.0 serves as an excellent framework. It offers a detailed, structured, scalable approach to integrating Industry 4.0 technologies, enhancing interoperability, and ensuring future-proofing. Combining RAMI 4.0 with defence-specific standards can provide a robust and comprehensive strategy for modernising defence manufacturing.

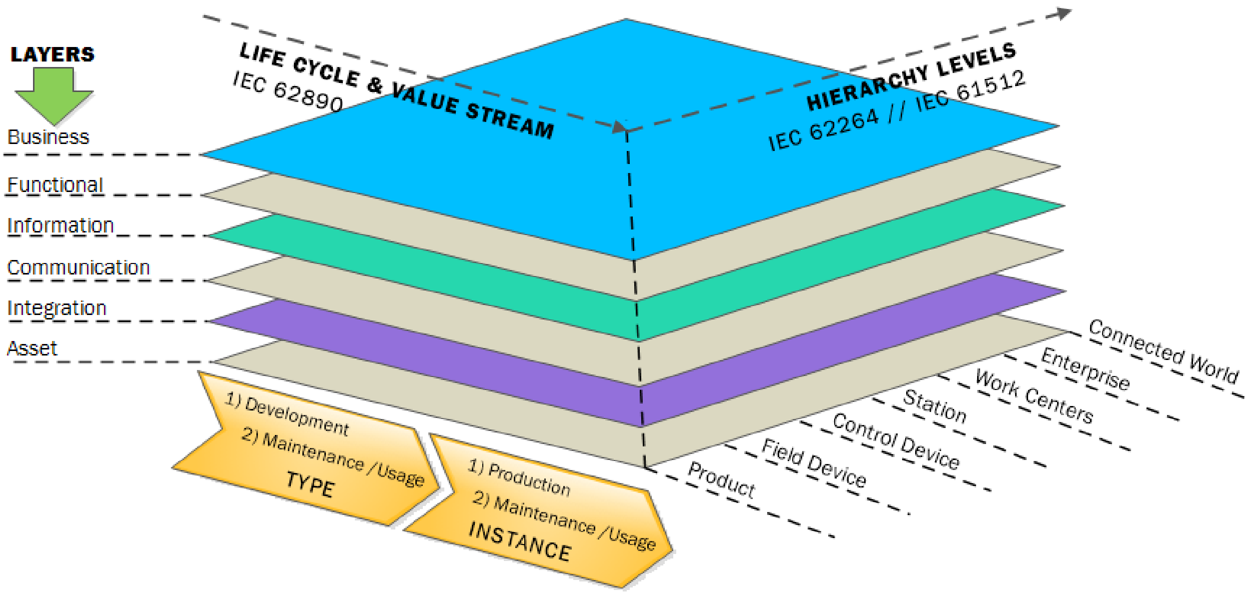

Figure 7.3: RAMI 4.0 Structure ((Neto et al., 2020)

RAMI 4.0 holds significant importance within Supply Chain and Logistics Optimisation Ecosystems, as it comprehensively integrates both production and distribution functions. This model serves as a vital framework that aligns with the principles of Industry 4.0, enhancing the efficiency and connectivity of supply chain processes. Figure 7.4 illustrates the incorporation of Industry 4.0 elements, highlighting how these advanced technologies are being seamlessly added to optimise and modernise the existing systems.

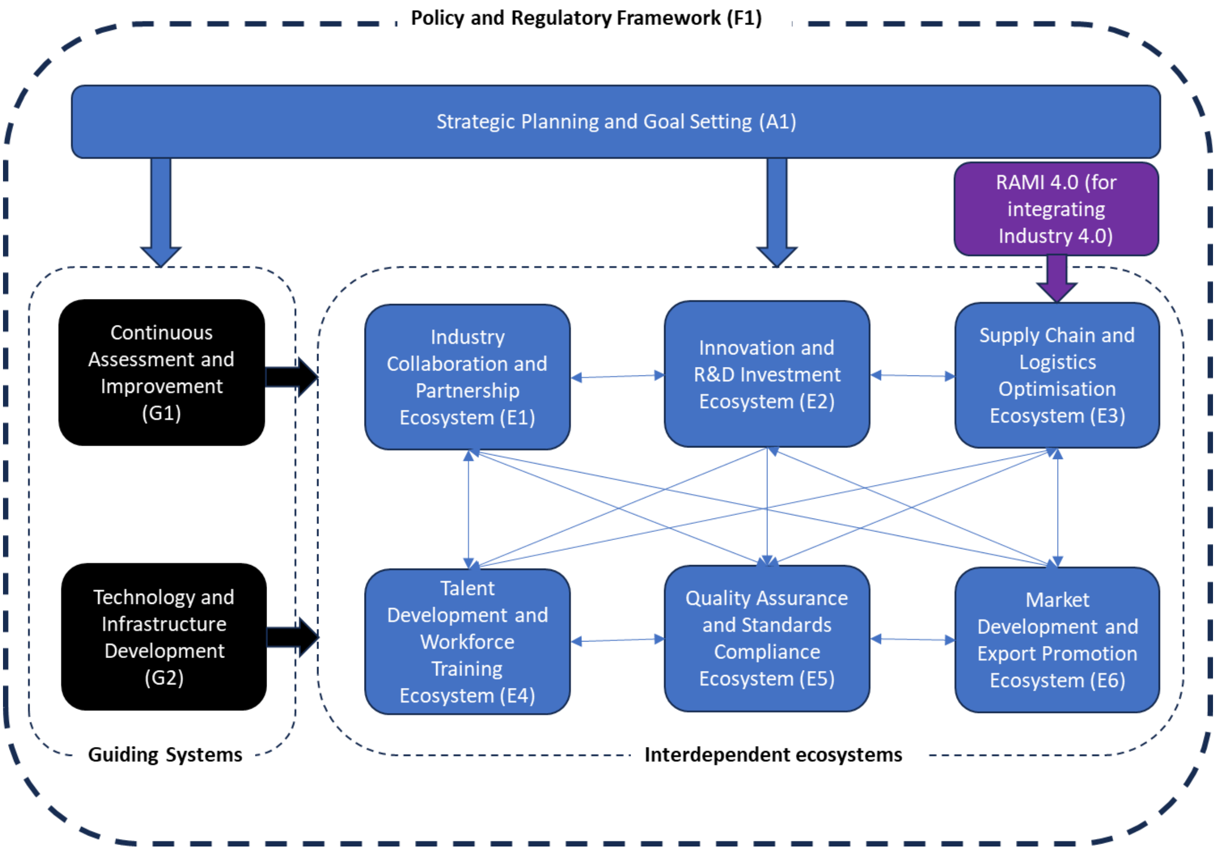

Figure 7.4 : Intégration Industry 4.0 through RAMI 4.0

7.9 Conclusions

The IDEA-UAE framework is a comprehensive approach designed to enhance the interactions among various stakeholders in the UAE's defence manufacturing sector. This framework aims to foster collaboration, communication, and cooperation among diverse groups, including government agencies, private sector entities, academic institutions, and civil society organisations. By providing a structured approach to engagement, the IDEA-UAE framework seeks to create synergies that drive innovation, economic growth, and social development. The implementation of this framework is anticipated to lead to a more integrated and dynamic ecosystem, benefiting all participants and resulting in more effective policymaking, increased investment opportunities, and the development of sustainable solutions to pressing challenges.

Constructing individual elements of the IDEA-UAE involves a detailed process for each component to ensure a comprehensive and effective framework. For instance, the Policy and Regulatory Framework (F1) includes steps such as identifying strategic objectives, assessing current policies, engaging stakeholders, conducting security and risk assessments, drafting policy proposals, and ensuring ongoing review and adaptation. This rigorous process ensures that the policy and regulatory framework remains robust, secure, and adaptable to the changing dynamics of global defence and security environments. Similar detailed steps are outlined for other elements like strategic planning, technology and infrastructure development, industry collaboration, innovation and R&D investment, supply chain and logistics optimisation, talent development, quality assurance, and market development.

Selecting the best Industry 4.0 framework for defence manufacturing involves considering various structured models that facilitate the integration of advanced technologies. The RAMI 4.0 (Reference Architectural Model Industry 4.0) stands out due to its structured approach to integration, enhancing interoperability, scalability, and futureproofing. This model breaks down complex systems into manageable layers and views, facilitating a systematic approach to integrating new technologies into existing systems. Although it presents challenges like high initial costs and the need for significant training, its benefits align well with the complex needs of the defence manufacturing sector. RAMI 4.0 is complemented by other frameworks, such as the Industrial Internet Reference Architecture (IIRA) and Cyber-Physical Systems (CPS) frameworks, which together provide a robust strategy for modernising defence manufacturing.

Chapter 8: Conclusions, Contribution to Knowledge and Further Work

8.1 Introduction

This chapter presents the findings and insights from the research, highlighting its contributions to the existing body of knowledge and suggesting future research avenues. It begins by outlining the rationale, objectives, and aims that guided the study, followed by a detailed discussion of key findings and their implications. The chapter then critically evaluates the research's limitations, enhancing its credibility by defining its boundaries and providing context for interpreting results and conclusions. Finally, it proposes potential directions for future research, offering a roadmap for further exploration and development in the subject area.

8.2 Rationale

Chapter 2 comprehensively reviews the UAE's defence manufacturing industry, tracing its historical evolution, key technological advancements, and strategic importance. It discusses the UAE's shift from import reliance to developing indigenous capabilities through alliances, technology transfers, and initiatives like the Tawazun Economic Council and EDGE Group. It also identified challenges such as limited technology, human capital development, and supply chain issues and highlighted the need for enhanced R&D, investment in local talent, and robust supply chain management. It also explores Industry 4.0's impact on defence manufacturing through technologies like blockchain and AI and stresses the importance of fostering an Integrated Defence Manufacturing Ecosystem through academic and research collaborations.

8.3 Answering Research Questions

Research Questions 1: What best practices can be derived from rapidly developed defence industrial bases in recent years?

The analysis of the defence manufacturing industry in newly industrialised countries (NICs) such as Turkey, South Korea, South Africa, and Brazil reveals several key conclusions about the factors contributing to the development and success of their defence sectors. These conclusions underscore the importance of a multifaceted approach to building a robust defence industry, emphasising the critical roles of government policy and support, investment in research and development (R&D), strategic partnerships and collaboration, a strong industrial base and infrastructure, and the development of human capital and skills. The comparative analysis of the defence industry development in the UAE versus Turkey, South Africa, South Korea, and Brazil presents a compelling argument for the UAE to establish a comprehensive defence manufacturing ecosystem. The experiences of these countries highlight the transformative impact such an ecosystem can have on national security, technological independence, and economic diversification.

Research Questions 2: What are the key elements of the defence manufacturing ecosystem, and how can they be adapted to develop the UAE's defence industrial base?

The development of the IDEA-UAE framework represents a monumental advancement in establishing a structured and comprehensive approach to implementation within the defence manufacturing sector. This innovative framework is composed of ten meticulously detailed elements, each designed to support effective and efficient execution. By addressing critical aspects of the implementation process, the IDEA-UAE framework ensures a holistic and well-coordinated strategy that aligns with the unique demands and standards of the defence industry. This comprehensive approach enhances operational efficiency and promotes consistency, quality, and innovation across all stages of defence manufacturing. Each element within the framework has been carefully crafted to address specific challenges and opportunities, providing a robust foundation for sustained growth and success in this critical sector.

Research Question 3: Given the benefits of Industry 4.0 technologies, how can the concept be used to enhance UAE defence manufacturing capabilities?

Alternative models for defence manufacturing were identified, and among them, the Reference Architectural Model Industrie 4.0 (RAMI 4.0) was chosen as the most comprehensive framework for implementation. RAMI 4.0 provides a structured approach to integrating advanced technologies, ensuring interoperability, and enhancing efficiency across the manufacturing process. This framework is designed to support the digital transformation of manufacturing operations by incorporating elements such as smart factories, cyber-physical systems, and the Internet of Things (IoT). Its multi-layered architecture allows for a detailed mapping of manufacturing processes, facilitating better decision-making, increased flexibility, and improved scalability. Consequently, RAMI 4.0 stands out as the most robust and adaptable model for modernizing defence manufacturing, aligning with industry standards and future technological advancements.

8.4 Contribution to the knowledge

Contributing to knowledge in doctoral-level research lies at the very heart of studies. It serves as a testament to the researcher's deep understanding of their field while expanding the existing knowledge boundaries.

8.4.1 Industrial perspectives

As presented in Chapter 4, the findings derived from a survey of industry participants and an analysis of industry research reports have uncovered several inherent challenges facing the UAE's defence manufacturing industry. Key issues identified include the development of human capital, integrating small and medium-sized enterprises (SMEs), and enhancing research and development (R&D) capabilities. Despite the UAE government's ongoing efforts to cultivate a robust defence industry ecosystem, the current landscape remains fragmented. The initiatives aimed at fostering growth and cohesion within this sector have not yet achieved the desired level of integration and efficiency.

8.4.2 Best Practices Other nations

The analysis of the defence manufacturing industry in newly industrialised countries (NICs) such as Turkey, South Korea, South Africa, and Brazil reveals several key conclusions about the factors contributing to the development and success of their defence sectors, highlighting the importance of government policy, investment in research and development (R&D), strategic partnerships, a strong industrial base, infrastructure, and the development of human capital. This comparative analysis also underscores the potential benefits for the UAE in establishing a comprehensive defence manufacturing ecosystem, demonstrating the transformative impact on national security, technological independence, and economic diversification. In support of this process, eleven (11) factors were identified to conduct the comparison. No other studies have such a range of factors.

Figure 8.1: Key Factors in Assessing NICs' Defence Manufacturing Development

8.4.3 IDEA-UAE Framework

The most significant outcome of this research study is the development of a comprehensive framework comprising ten distinct elements designed to enhance the UAE's defence manufacturing sector. This framework provides a structured approach to bolster various aspects of the industry, addressing key areas such as technological advancement, supply chain optimisation, talent development, regulatory compliance, and strategic partnerships. By implementing these elements, the UAE can achieve greater self-reliance, improved efficiency, and heightened innovation within its defence manufacturing capabilities, ultimately strengthening national security and fostering economic growth.

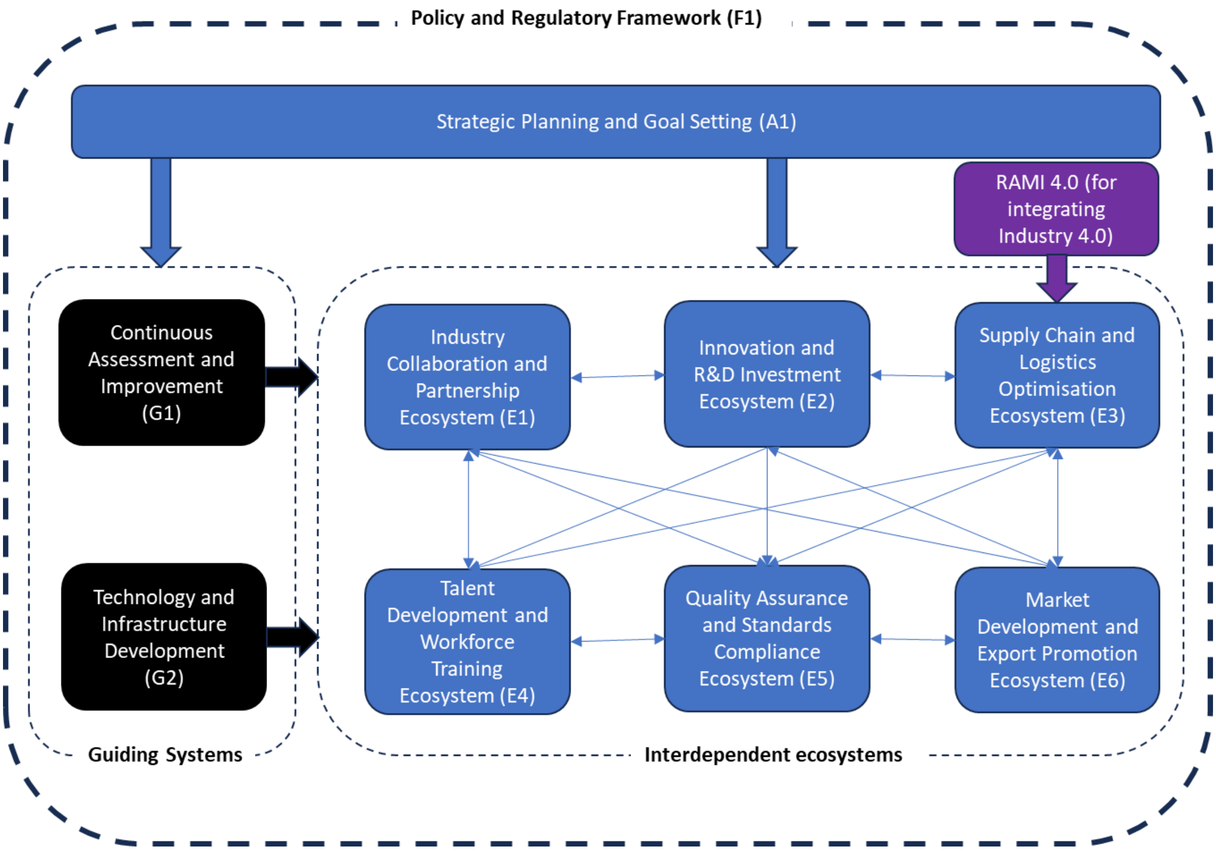

Figure 8.2: IDEA-UAE Framework

8.4.4 Collection of Steps for Building Ecosystems

A comprehensive and detailed plan for each step is provided for each component of the IDEA-UAE framework. This meticulous guidance supports practitioners in identifying and executing the necessary actions throughout the process of developing robust ecosystems. The framework ensures that every stage, from initial assessment to final implementation, is clearly outlined. By following these structured steps, practitioners can effectively navigate the complexities involved in ecosystem development, ensuring that all critical elements are addressed systematically. This approach enhances the clarity and efficiency of the process and promotes the creation of sustainable and resilient ecosystems tailored to specific needs and contexts.

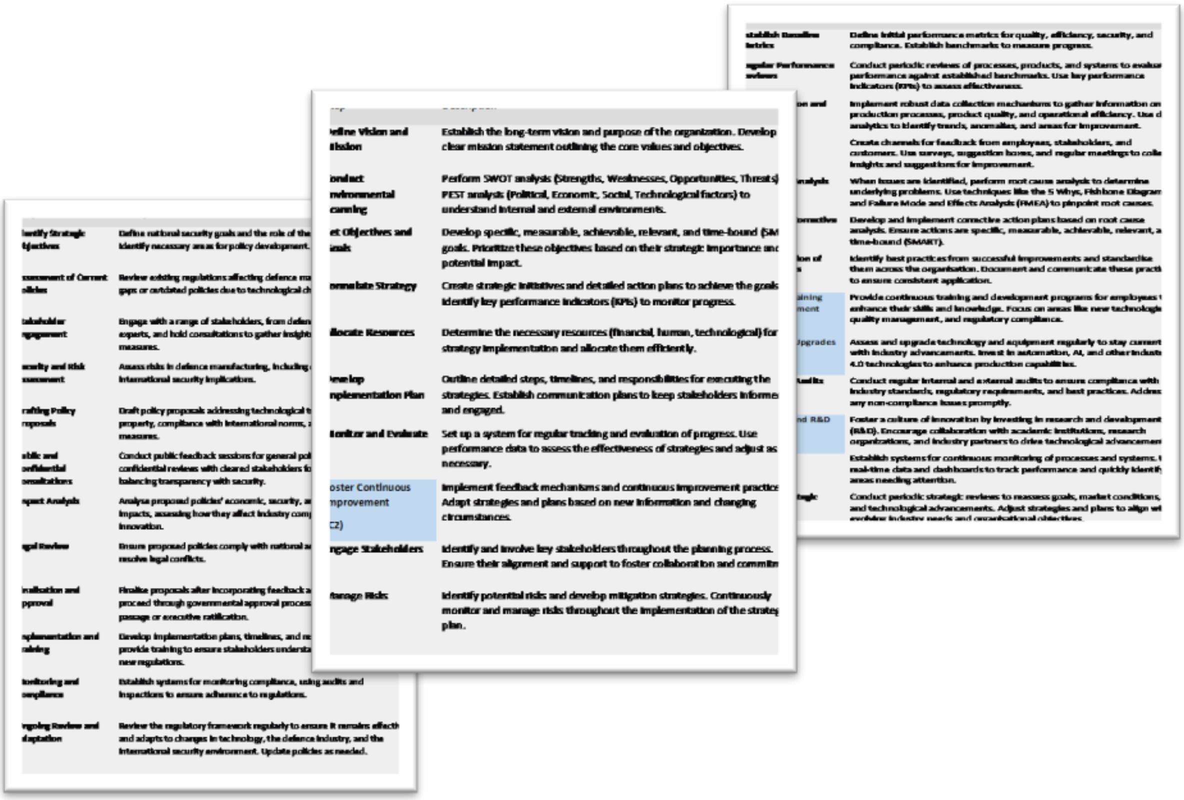

Figure 8.3: Steps involved in developing elements of the IDEA-UAE framework

8.4.5 Integrating Industry 4.0

After thoroughly evaluating multiple frameworks for integrating Industry 4.0 technologies, we determined that the Reference Architectural Model for Industry 4.0 (RAMI4.0) is the most effective and comprehensive approach. RAMI4.0 stands out due to its structured and multi-layered architecture, which seamlessly incorporates all aspects of Industry 4.0, from physical assets to business processes. Its detailed framework systematically integrates IoT, cyber-physical systems, and smart manufacturing, ensuring interoperability, scalability, and flexibility. This model facilitates the seamless communication between various industrial components and supports the implementation of advanced analytics and machine learning, paving the way for enhanced productivity and innovation in the defence manufacturing sector.

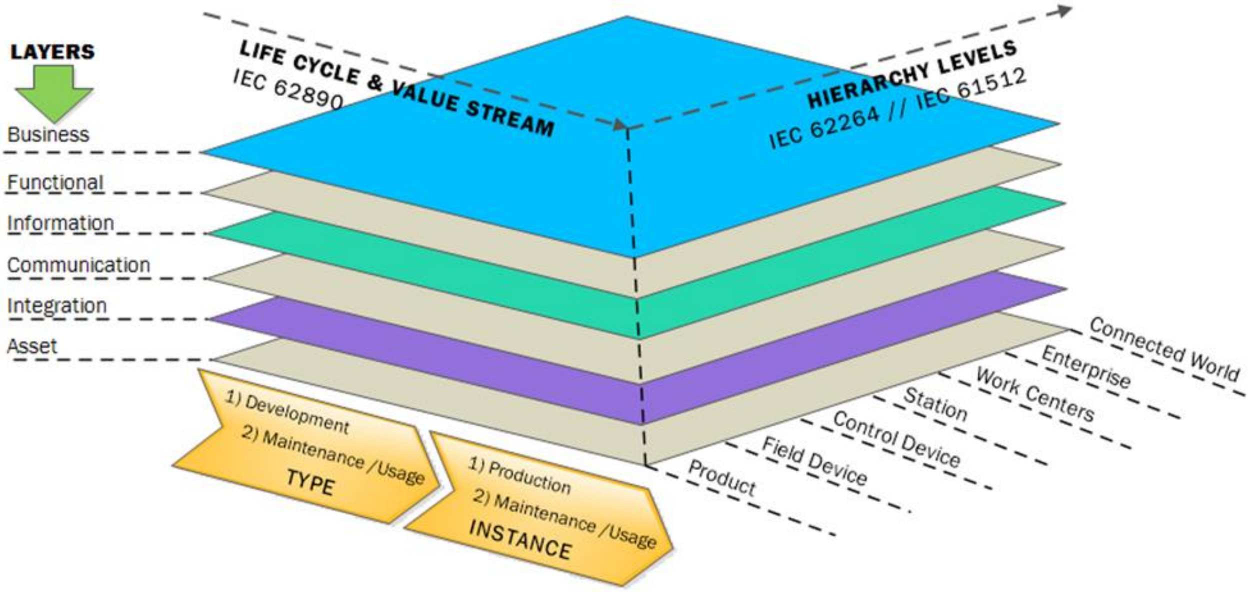

Figure 8.4: RAMI 4.0 Structure ((Neto et al., 2020)

8.5 Limitations of The Research

The primary limitations encountered in this study were twofold:

(a) Lack of Published Research on UAE Defence Manufacturing: One significant challenge was the scarcity of existing academic and industry literature on the subject of defence manufacturing within the United Arab Emirates. This dearth of published research made it difficult to draw on established knowledge or compare findings with previous studies, thereby limiting the contextual foundation upon which the current analysis could be built.

(b) **Access Restrictions Due to Confidentiality:** Another major limitation was the restricted access to relevant data and information, stemming from the high level of confidentiality associated with the defence sector. Many crucial details, such as specific manufacturing processes, technologies used, and strategic plans, are often classified or sensitive in nature. This restriction impeded the ability to conduct a comprehensive and transparent examination of the industry, as obtaining detailed insights required navigating through strict confidentiality protocols.

(c) Limited Applicability - In the context of defence manufacturing ecosystems, the proposed framework encounters additional limitations that impact its applicability. One major constraint is the stringent regulatory and security requirements inherent in defence industries, which the framework may not fully address. These sectors often operate under strict government oversight, with unique compliance standards that the framework may not adequately account for, leading to potential legal and operational alignment gaps.

8.6 Future Research

Organising a workshop to disseminate the need for a comprehensive defence manufacturing ecosystem in the UAE is a critical step. Such a workshop would bring together key stakeholders, including government officials, defence contractors, industry experts, and academic researchers, to discuss the strategic importance of building a robust domestic defence manufacturing base.

The IDEA-UAE framework offers a comprehensive strategy for developing a holistic ecosystem that supports the advancement of the defence sector. However, before implementation, it is crucial to thoroughly understand the sector's current status to address any readiness issues effectively.

A detailed assessment of the existing defence infrastructure and capabilities is necessary to ensure the successful implementation of the IDEA-UAE framework. This includes evaluating current technologies, resources, personnel, and strategic goals. Stakeholders can develop targeted strategies to enhance overall readiness by identifying strengths and weaknesses. Additionally, engaging with key industry players, government agencies, and international partners will provide valuable insights and foster collaboration. This collaborative approach will help in addressing any gaps in knowledge, technology, or resources, thereby ensuring a smooth transition to the new framework.

Ultimately, a well-informed and methodically planned implementation of the IDEA-UAE framework will significantly contribute to the development of a robust and dynamic defence sector ecosystem, positioning the UAE as a leader in defence innovation and capability.

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Appendix 1: Questionnaire

UAE Defence Manufacturing Sector – Challenges and Priorities

Introduction: You are invited to participate in a survey to advance the defence manufacturing sector in the United Arab Emirates (UAE). This study is part of a PhD research study at Sheffield Hallam University, United Kingdom. Your participation will offer valuable insights to help develop a framework for further strengthening the UAE's defence manufacturing capabilities.

Purpose of the Survey: This survey seeks to gather input from stakeholders engaged in the UAE's defence manufacturing sector.

Procedures: If you choose to participate in this survey, you will be asked to complete a questionnaire that will take approximately 5 minutes.

Voluntary Participation: Your participation in this survey is completely voluntary. You may opt out or withdraw from the survey at any time without any consequences.

Confidentiality: All information gathered in this survey will be kept confidential. Your responses will be anonymised, and the data will be reported in aggregate form to ensure that individual answers cannot be traced back to you.

Contact Information: If you have any questions or concerns about this survey, please feel free to contact Prof Terrence Perera (t.d.perera@shu.ac.uk)

Consent: By continuing with this survey, you confirm that you have read and understood the information provided above and agree to participate in this study.

Thank you for dedicating your time and providing your valuable insights. Your contribution is greatly appreciated and will play a crucial role in the success of this research.

Khalifa Murad Alblooshi

PhD Researcher

Sheffield Hallam University

Sheffield

United Kingdom

Mobile No: (removed)

S1: Your years of experience in the UAE defence manufacturing sector (Please tick one)

( ) Upto 2 years

( ) 2 -5 years

( ) 5 - 10 years

( ) Over 10 years

S2: Your main functional area (please tick one)

( ) Importing defence equipment

( ) Using defence equipment

( ) Maintaining defence equipment

( ) Deference industry consultancy

( ) Defence Industry Research and Development

( ) Designing defence equipment

( ) Manufacturing defence equipment

( ) Other, please state ……………………………….

S3: Statements – Please indicate your opinion on the following statement by placing a cross

Statement	Strongly Disagree	Disagee	Neutral	Agree	Strongly Agree
UAE has a clear and coherent strategy for developing its own defence manufacturing industry					
The government has made the necessary investment to simulate the growth of a local defence manufacturing industry.					
Government investment mainly supports only very large companies.					
There is a shortage of Emirati workforce to support the					

development of defence manufacturing industry.					
There are no significant research and development capabilities within the UAE to support the development of the defence manufacturing sector.					
Current defence manufacturing capabilities within the UAE are fragmented; hence, a clear path is required to develop robust supply chains within the UAE					
Small and medium-sized companies require more support from the government to engage in defence manufacturing supply chain.					
UAE does not require its own defence manufacturing industry.					
UAE should develop its own defence manufacturing industry with minimal collaboration with overseas companies					
UAE defence manufacturing industry should focus on niche products so that UAE can become the world leader for those products in the future					
UAE defence manufacturing industry should focus on a limited product range of those products that are strategically important to UAE.					
UAE defence manufacturing industry should focus on high-value products					