CHALLENGES FACED IN BECOMING AN ELECTRONIC COMPONENTS MANUFACTURING HUB - THE CASE OF INDIA

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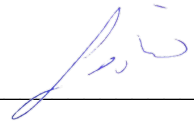

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Dedication

This is dedicated to all those who have a deep passion for research and to individuals who exhibit the determination and bravery to chase their aspirations.

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ABSTRACT

CHALLENGES FACED IN BECOMING AN ELECTRONIC COMPONENTS MANUFACTURING HUB - THE CASE OF INDIA

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In recent years, the global landscape of electronic component manufacturing has witnessed a dynamic transformation, with countries like Taiwan, China and Vietnam achieving remarkable growth. However, the contrasting trajectory in India prompts an exploration into the factors contributing to its comparatively slower advancement in this sector. This research aims to identify key barriers to scaling manufacturing, assess India's comparative position across major competitiveness dimensions and examine strategies relevant to strengthening the sector. A mixed method secondary research design was adopted. Qualitative content analysis was conducted using government policy documents, industry and market reports, academic literature, and trade publications to identify recurring themes related to manufacturing constraints and ecosystem development. This analysis was complemented by descriptive quantitative comparisons using secondary indicators related to production scale, exports, innovation, investment, and workforce development across selected countries. The findings show that India's manufacturing challenges are systemic, driven by regulatory, infrastructure, supply chain, financing, skill, and innovation gaps. Compared with established hubs India lags in scale, cost efficiency, quality, innovation, and global value chain integration. Policy initiatives have been introduced to support electronics manufacturing. The study concludes that sustained competitiveness will require coordinated, ecosystem level strategies focused on infrastructure, supplier depth, innovation systems, workforce development, and policy coherence rather than isolated interventions.

Keywords: Electronic components manufacturing; Manufacturing ecosystem constraints; Industrial policy effectiveness; Global value chain integration; Innovation and skills development

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CHAPTER I:

INTRODUCTION

This chapter examines in detail the challenges that continue to hinder India's aspiration to develop into a major hub for electronic component manufacturing, while situating the discussion firmly within the existing academic and policy literature. Electronic components are widely recognised as the foundational elements that enable progress across the broader electronics sector and its associated industries (EB Bureau, 2020). In the present period, shaped by the rapid expansion of the Silicon Age and the growing prevalence of digitally driven lifestyles worldwide, the conception, design, and production of electronic systems have emerged as one of the fastest-expanding segments of the global industrial landscape.

Within this context, the chapter provides essential background on the barriers affecting multiple dimensions of electronic component manufacturing. Particular emphasis is placed on critical factors that demonstrate the complexity of achieving this strategic transformation, including India's persistent difficulty in moving beyond basic assembly-oriented activities toward higher value manufacturing capabilities (Sharma, 2021). These challenges are further intensified by the limited development of strong domestic manufacturing ecosystems capable of supporting long term industrial depth and strategic self reliance (IANS, 2021).

The need to identify and address these constraints is therefore underscored, highlighting their significance in reshaping the current trajectory of electronic component production. This requirement is especially pronounced considering the ongoing obstacles associated with establishing semiconductor fabrication capabilities within the country, which remain a central bottleneck in the electronics value chain (Banerji, 2021). In addition, this chapter outlines the rationale for the present study and clarifies its expected contributions, reinforcing the relevance of research within the contemporary industrial and economic environment. Building on this

foundation, a problem statement is subsequently developed to guide the formulation of focused and analytically meaningful research questions.

Finally, this section highlights a clear gap within the existing literature that the study seeks to address, with the objective of advancing understanding of the constraints that continue to limit India's progress toward becoming a leading center for electronic component manufacturing (Rawat, Raj & Agarwal, 2020).

1.1 Research Background and Scope

The electronics manufacturing services sector ranks among the fastest growing industries at the global level. In this expanding field, India is actively scaling its electronics manufacturing capabilities and currently accounts for approximately three percent of global electronics production. This position reflects the country's gradual emergence as an increasingly important international centre for the manufacture of electronic and electrical components (EB Bureau, 2020).

Industry based evidence suggests that the sector is expected to maintain consistent expansion in the years ahead, driven by rising domestic consumption and the introduction of supportive industrial and manufacturing policies (IANS, 2021). In agreement of this expansion, concerted efforts are being made to enhance domestic production across a broad spectrum of electronic components, including capacitors, resistors, relays, cables, connectors, sensors, micro-controllers, semiconductor chips, and battery cells. These initiatives align closely with India's wider strategic objective of strengthening self reliance and reducing external dependence within the electronics manufacturing ecosystem (Sharma, 2021).

The government and industry bodies continue to encourage the establishment of additional electronic component manufacturing firms within the country, as this would create greater opportunities for major international original equipment manufacturers (OEMs) to establish facilities in India (Rawat, Raj & Agarwal, 2020). Both electronic industry associations

and the Government of India are actively striving to streamline and reinforce the electronic component manufacturing ecosystem (IANS, 2021).

India's electronic components industry is largely defined by the dominance of electro-mechanical parts, including printed circuit boards and connectors, along with passive components such as resistors and wound elements (EB Bureau, 2020). However, in recent years, active components such as integrated circuits and diodes, along with related components such as optical discs, RF tuners and magnets, have also experienced notable expansion. Industry organizations including the India Electronics and Semiconductor Association (IESA) note that India now manufactures a wide range of discrete components, passive devices, electro-mechanical parts, coils, transformers and similar products. With broader industrial initiatives, the Government of India has undertaken steps towards establishing domestic semiconductor fabrication facilities. Even after all these efforts, progress in this area remains constrained by the high capital-intensive nature of semiconductor manufacturing and the limited readiness of the supporting industrial and technological ecosystem required to sustain such facilities at scale (Banerji, 2021).

1.2 Research Problem

The electronics sector continues to expand at a swift speed globally, with electronic component manufacturing forming the fundamental base upon which this growth depends (EB Bureau, 2020). Within this context, India's electronics industry has recorded sustained growth in recent years, supported by rising domestic demand and a range of policy initiatives aimed at strengthening national manufacturing capacity (IANS, 2021). Despite these developments, and notwithstanding multiple industry reports and government-led initiatives intended to position India as a competitive manufacturing destination, a critical challenge remains unresolved: the transition from a predominantly component assembly-oriented model to a full-scale, end to end production hub capable of delivering higher value added output (Sharma, 2021). The present

research therefore seeks to examine and clarify the range of factors that continue to slow India's progression toward becoming a recognised hub for electronic component manufacturing.

Although India has achieved measurable progress in developing its electronics manufacturing ecosystem and has articulated ambitions to emerge as a global leader in electronic component production, numerous structural obstacles persist. Sectoral expansion remains constrained by limitations in infrastructure provision, regulatory complexity, and shortages of specialised technical skills (EB Bureau, 2020). While various programmes and initiatives aim to enhance manufacturing capacity, enduring gaps remain in areas such as technological innovation capability, supply chain resilience, and the protection of intellectual property (Rawat, Raj & Agarwal, 2020). At the same time, global developments including accelerated digital adoption, evolving demand patterns, and recurring disruptions to international supply chains underscore the urgency for India to strengthen its position as a reliable and resilient manufacturing hub. In response, this research aims to identify, analyse, and propose remedies for the interconnected challenges constraining India's advancement toward becoming a major producer of electronic components, with the broader objective of supporting sustained economic growth and enhancing international competitiveness (Banerji, 2021).

1.3. Purpose Statement

This study is undertaken to examine and critically analyse the principal challenges that continue to restrict India's progress toward establishing itself as a global hub for electronic component manufacturing. The focus of the analysis is on a broad set of interrelated barriers, including structural, economic, technological, policy related and infrastructural constraints that limit domestic component production and influence India's overall position within the global electronics value chain (EB Bureau, 2020).

In addition to identifying these constraints, the study seeks to explore potential policy directions, strategic actions, and industry level initiatives that could contribute to strengthening India's electronic components ecosystem. By addressing these areas, the research aims to support pathways for more sustainable growth and improved long term competitiveness within the sector, in line with evolving industrial priorities and national manufacturing objectives (IANS, 2021).

The purpose of this study is to undertake a comprehensive evaluation of the challenges that constrain India's progression toward becoming a global hub for electronic component manufacturing. The research seeks to generate deeper insight into the barriers affecting the development of a robust domestic electronic component production base, while also examining the underlying factors responsible for India's continued lag in the manufacturing of active electronic components. These constraints are closely linked to technological limitations and gaps within the broader industrial ecosystem that supports advanced electronics manufacturing (Sharma, 2021).

In addition, the study explores potential strategies and targeted interventions that could accelerate progress within India's electronic component manufacturing landscape, thereby contributing to the broader objectives of the "Make in India" initiative (Rawat, Raj & Agarwal, 2020). The specific research objectives include assessing the current challenges facing the sector, identifying deficiencies in active component production capabilities, outlining steps that may support the development of "Made in India" electronic products, and considering the likely future trajectory of electronic component manufacturing within the country (Banerji, 2021). Overall, this research aims to provide valid recommendations for policymakers, industry stakeholders, and academic institutions, with the intention of supporting the development of a competitive, resilient, and sustainable electronic component manufacturing ecosystem in India.

1.4. Research Goal, Aim and Objectives

The goal of this research is to develop a clear understanding of how India's electronic component manufacturing sector can compete effectively at the global level and to identify the pathways that could support its structural transformation. To achieve this, the study examines the strategies and development trajectories adopted by leading electronic component manufacturing economies, particularly countries such as China and Taiwan, which have consolidated their global positions through coordinated industrial policies, sustained investment in skilled labour development, and the establishment of strong innovation ecosystems (Saxenian, 2005).

In addition, the research considers the critical factors that have contributed to the success of these manufacturing hubs and seeks to generate insights that may be relevant to the Indian context. By analysing the global competitive environment and reviewing successful practices within the electronic components manufacturing industry, the study aims to strengthen understanding of the structural and systemic barriers that continue to slow India's progress toward becoming a major electronic component manufacturing hub (EB Bureau, 2020).

The aim of this study is to examine the main barriers that prevent India's transition from component assembly-oriented base to a fully developed electronic components manufacturing hub and to develop strategic recommendations that can enhance India's competitiveness in the global electronics manufacturing field.

The core objectives of this research involve developing a detailed assessment of the current condition of India's electronics sector, identifying the principal challenges that continue to restrict its progress, and proposing practical recommendations to support the sustained expansion of electronic component manufacturing units within the country (IANS, 2021). While achieving these objectives, the study draws on a comprehensive examination of

international experiences and prevailing industry trends in order to inform policymakers, industry stakeholders, and academic contributors about the critical actions required to strengthen India's position within the global electronic components landscape (Rawat, Raj & Agarwal, 2020). Ultimately, the research seeks to contribute to the formulation of strategic initiatives capable of advancing India's ambition to emerge as a significant participant in electronic component production. By addressing the structural and systemic constraints identified, the study aims to support broader economic growth and longterm industrial development within the national manufacturing ecosystem (Banerji, 2021).

1.5. Research Questions

The following research questions will guide this research.

Primary research question

What critical challenges limit India's transition from a component-assembly base to a full-scale electronic component manufacturing hub?

Specific research questions

RQ1. What are the key quantitative differences in policy interventions, public investments, infrastructure, and global integration supporting electronic components manufacturing between India and established hubs like China, Taiwan, and Vietnam?

RQ2. How do differences in technological capabilities, R&D infrastructure, and skill availability between India and established hubs like China, Taiwan, and Vietnam constrain India's ability to produce advanced electronic components, as evidenced by qualitative themes and quantitative indicators?

RQ3. How does India compare with established manufacturing hubs (China, Taiwan, Vietnam) in technological capabilities, R&D infrastructure, skill availability, cost structures, quality, and innovation, as evidenced by qualitative themes from secondary sources and current quantitative indicators?

RQ4. Given India's comparative gaps with established manufacturing hubs (China, Taiwan, Vietnam) in cost structures, quality, and innovation, what strategies and policy interventions are reported in secondary sources to accelerate India's transition toward a globally competitive electronic components manufacturing hub?

1.6 Significance of Research

This study holds important implications for India's economic growth and its positioning within the global electronic components manufacturing industry. By systematically examining both the obstacles and potential opportunities associated with India's efforts to evolve into a competitive manufacturing hub, the research seeks to generate insights of value to policymakers, industry stakeholders, and the academic community. In doing so, the study contributes to a deeper understanding of the strategic importance of electronic component manufacturing in supporting industrial development, value chain participation, and longterm economic resilience within the Indian context (EB Bureau, 2020).

First, the findings of this research have the potential to inform strategic decision making at the government level by guiding the formulation of policies and programmes aimed at addressing the challenges identified in the study and strengthening the overall enabling environment for electronic component manufacturing. By resolving issues such as infrastructure inadequacies, regulatory constraints, and shortages in skilled labour, policymakers can more effectively unlock the growth potential of India's electronic manufacturing ecosystem. Addressing these constraints may also enhance investor confidence and encourage increased participation from both domestic enterprises and international manufacturing firms seeking to expand their presence in India (IANS, 2021; Sharma, 2021).

Second, the study's analysis of competitive dynamics and established best practices within the global electronic components industry offers valuable direction for industry participants, including manufacturers, trade associations and original equipment manufacturers

(OEMs). By reviewing the strategic approaches, operational models, and market trends adopted by leading manufacturing economies such as China and Taiwan, Indian firms can more effectively benchmark their own practices, recognise existing performance gaps, and implement targeted improvements. Such learning and adaptation can contribute to strengthening operational efficiency and enhancing the global competitiveness of India's electronic component manufacturing sector (Saxenian, 2005; Rawat, Raj & Agarwal, 2020).

In addition, the findings of this research contribute to the academic literature by providing a comprehensive understanding of the range of challenges that continue to constrain India's transition towards becoming a major electronic component manufacturing hub. The analysis offers a structured foundation that future researchers can build upon a extend inquiry into specific dimensions of the sector, examine evolving constraints in greater depth and develop innovative analytical or policy-oriented approaches to address emerging issues within the electronic components manufacturing sector (Banerji, 2021).

Ultimately, the value of this study lies in its potential to support India's long term developmental trajectory within the electronic components manufacturing sector by contributing to economic growth, employment creation, and broader industrial advancement. By systematically identifying the key barriers that constrain progress and by outlining recommendations aimed at addressing these challenges over the long term, the research seeks to facilitate India's movement toward realising its ambition of emerging as a globally competitive leader in electronic component production.

1.7 Research Design

This research adopts a mixed methodological approach to examine the challenges confronting India in its pursuit of becoming an electronic component maufacturing hub (Flick, 2022). The study analysis India's electronic component manufacturing field through an in depth analysis supported by both qualitative interpretation and structured examination of secondary

quantitative indicators. This design enables a detailed assessment of the multiple factors shaping India's manufacturing environment and supports the development of informed insights into existing constraints, emerging opportunities, and potential pathways for sectoral advancement (Pawson, 2006). The study allows focused examination of firms, regions and government programmes that provide rich evidence of both challenges encountered and outcomes achieved within the manufacturing ecosystem (Schreier, 2018).

Ethical standards are maintained throughout the research process, including the protection of participant confidentiality, adherence to informed consent requirements, and compliance with established ethical standards governing data collection and analysis (Tripathy, 2013). By employing a mixed methods research design, the study seeks to identify structural and systemic barriers affecting the expansion of electronic component manufacturing in India, while also generating evidence-based insights to support future policy development and industry decision making (Suri, 2011; Ruggiano & Perry, 2019; Wickham, 2019).

1.8. Summary

Chapter one establishes the foundational context of the study by tracing the evolution, status and strategic significance of India's electronic components manufacturing industry. It situates this discussion within the broader backdrop of the rapid global expansion of the electronics sector and positions India as an emerging manufacturing aspirant that, despite strong domestic demand and the introduction of government led initiatives such as the Production Linked Incentive (PLI) scheme, SPECS, EMC 2.0 and the India Semiconductor Mission, continues to account for only a limited share of global electronics production (IANS, 2021; EB Bureau, 2020). The chapter further outlines the structural, technological, infrastructural and policy related constraints that restrict India's transition from an assembly-oriented ecosystem to a more robust and integrated electronic component manufacturing base

challenges that have been widely documented in assessments of India's electronics ecosystem (Sharma, 2021; Rawat, Raj & Agarwal, 2020).

The research problem is then identified by highlighting the disconnect between India's stated industrial ambitions and its actual progress in developing a globally competitive electronic component manufacturing sector, particularly in high value segments such as semiconductor fabrication and advanced component production (Banerji, 2021). Following this, the chapter presents the research goals and objectives, which centre on examining the barriers limiting sectoral growth, assessing constraints affecting active component production, identifying pathways to strengthen "Made in India" manufacturing capabilities and considering the future direction of the industry

The significance of the study is framed in terms of its potential contributions to policymakers, industry stakeholders and academic communities by providing evidence-based insights that can inform strategic interventions and support the strengthening of India's electronic manufacturing ecosystem (IANS, 2021). The chapter concludes by outlining the overall research design, which adopts a mixed method approach while maintaining ethical standards relating to data collection and analysis (Flick, 2022; Schreier, 2018; Tripathy, 2013). Overall, chapter one sets the scope, rationale and intellectual direction for the thesis and clearly identifies the gap in the existing literature that are addressed in chapter two (Suri, 2011).

CHAPTER II:

REVIEW OF LITERATURE

2.1 Introduction

This literature review aims to synthesise existing academic perspectives on the challenges India faces in its efforts to become an electronic component manufacturing hub. By reviewing prior research on policy, industrial development and manufacturing capability, the chapter clarifies how these challenges have been examined in the literature while identifying key gaps that justify the need for the present study. The review synthesises academic, industry-based and policy-related literature to build a comprehensive foundation for examining India's position within the global electronics and components value chain (EB Bureau, 2020; IANS, 2021).

The electronics manufacturing sector has increasingly been recognised in the literature as a strategic driver of economic growth, technological upgrading and industrial competitiveness, particularly for emerging economies. Scholars emphasise that electronic component manufacturing occupies a critical position within this ecosystem, as it underpins downstream industries such as consumer electronics, automotive systems, telecommunications, medical devices and industrial automation. As a result, the development of domestic component manufacturing capability is widely viewed as a prerequisite for achieving higher levels of value addition and deeper participation in global production networks. Within this context, India's ambition to strengthen its electronic components manufacturing base has attracted growing scholarly attention, with researchers seeking to understand the structural, institutional and capability related factors shaping its industrial trajectory.

Aligned with the research purpose, this chapter is structured around a series of thematic sections that progressively develop the conceptual foundation for the study. The opening

sections outline the global electronics industry and trace the evolution of electronic components manufacturing in India. Subsequent sections examine the role of business models in shaping industrial competitiveness (Teece, 2010), review the models currently applied within the electronic components sector and highlight their associated risks and structural limitations. The chapter then considers the broader challenges that continue to drive India's progress in electronic manufacturing, despite national initiatives such as Make in India and Digital India (Banerji, 2021; Sharma, 2021).

Existing literature further suggests that progress in electronic component manufacturing is influenced by a closely interconnected set of factors, including policy coherence, infrastructure readiness, access to finance, skill formation systems, research and development capacity and integration with global value chains. Rather than operating in isolation, these factors interact within complex industrial ecosystems, where constraints in one area may offset advances achieved in others. This systemic perspective provides an important analytical lens for understanding why manufacturing outcomes vary across countries and why late industrialising economies often struggle to replicate the success of established manufacturing hubs such as Taiwan, China and South Korea.

Overall, the literature review establishes the theoretical and contextual grounding required to understand the structural, technological and strategic barriers influencing India's manufacturing ecosystem. By synthesising existing studies, the chapter not only highlights current knowledge but also reveals gaps, inconsistencies, and areas requiring deeper investigation. In particular, the literature points to a need for integrated analysis that connects policy intent with manufacturing capability development, ecosystem coordination and comparative international performance. Addressing these gaps supports the rationale for the present research and provides a structured basis for examining why India's electronic components manufacturing sector has not expanded at the same pace as leading global hubs.

2.2 Documentation

The literature reviewed in this chapter was identified through a structured and systematic search process to ensure relevance, credibility, and alignment with the objectives of the study. A combination of scholarly peer reviewed articles, industry white papers, government reports and publications from recognised institutions was consulted to develop a comprehensive understanding of the electronics and electronic components manufacturing sectors. Academic sources were primarily accessed through databases such as Google Scholar, IEEE Xplore, ResearchGate, and ScienceDirect, while industry specific insights were drawn from reputable platforms including ElectronicsB2B, Business Today, Invest India, the India Electronics & Semiconductor Association (IESA), and reports issued by the Ministry of Electronics and Information Technology (MeitY). Industry publications such as EB Bureau (2020), IANS (2021), and Banerji (2021) were included due to their strong relevance to India's electronics manufacturing area and their frequent use in policy and industry level analyses.

The literature published within the last decade is prioritised in the inclusion criteria. Earlier foundational works, including Teece (2010) and Porter (1980), were incorporated selectively to support discussions related to business models and competitive frameworks where current analyses continue to draw upon these established theoretical foundations. Sources were included if they addressed one or more key themes relevant to the study, such as the status of India's electronics industry, electronic component manufacturing capabilities, global benchmarks, supply chain dynamics, business model structures, sectoral risks, or strategic challenges. Literature was excluded where sources lacked academic or institutional credibility, were misaligned with the research focus, or failed to provide verifiable and contextually relevant insights for the Indian electronics manufacturing sector.

In addition to database driven searches, a backward and forward citation tracking approach was employed to enhance the depth of the literature review. Key academic articles

and policy documents were examined to identify frequently cited works that have shaped discourse on electronics manufacturing, industrial policy, and manufacturing competitiveness. Forward citation analysis was used to locate more recent studies that build upon these foundational works, enabling the review to capture evolving perspectives and contemporary developments within the sector. This approach helped ensure that the literature review reflects both established knowledge and emerging scholarly debates relevant to electronic component manufacturing.

To improve analytical rigour, the selected literature was systematically organised and reviewed using a thematic categorisation approach. Sources were grouped according to dominant focus areas, including policy and regulatory frameworks, infrastructure and industrial ecosystems, supply chain integration, technology and innovation capability, skills and workforce development and comparative international performance. This structured organisation facilitated cross source comparison and supported the identification of recurring patterns, convergent findings, and points of divergence across academic, policy, and industry perspectives.

Attention was given to distinguishing between descriptive industry reporting and analytically grounded academic research. While industry and policy reports provided valuable contextual and empirical insights, peer reviewed academic studies were used to support theoretical framing, conceptual clarity and critical interpretation. This balance helped mitigate potential biases associated with relying solely on industry or policy narratives and strengthened the scholarly robustness of the review.

Finally, the documentation process was guided by a critical appraisal of source reliability, transparency, and methodological soundness. Where possible, data and claims presented in industry or policy documents were cross-checked against multiple sources to enhance validity. This cautious and systematic documentation strategy ensures that the

literature review provides a credible and well-substantiated foundation for analysing the challenges limiting India's progress in electronic component manufacturing and for positioning the present study within the broader academic and policy discourse.

2.3 Theoretical Framework

This study is based on a mixed theoretical framework that integrates Porter's five forces model with Teece's business model and dynamic capabilities perspective, enabling a multidimensional analysis of the challenges confronting India's electronic components manufacturing sector. Porter's Five Forces framework (Porter, 1980) is applied to assess the competitive structure of the industry by examining factors such as supplier power, buyer influence, the threat posed by substitute products, barriers to entry for new firms, and the intensity of rivalry among existing competitors.

Within the context of electronics and semiconductor manufacturing, industry dynamics are strongly influenced by global supply chain asymmetries, technological dependence and high levels of competitive pressure. These characteristics make Porter's model particularly relevant for evaluating India's constrained competitive position when compared with established manufacturing hubs such as Taiwan, South Korea and China, where scale, capability depth and ecosystem maturity provide significant strategic advantages (Banerji, 2021; Sharma, 2021).

Applying Porter's framework to the electronic components sector also allows for systematic identification of structural disadvantages that are not immediately visible through production or output indicators alone. For example, high supplier power in semiconductor-grade materials and fabrication equipment limits cost control for domestic manufacturers, while strong buyer power exercised by global original equipment manufacturers places additional pressure on pricing and quality standards. These forces collectively shape entry

conditions and long-term competitiveness within the industry, reinforcing the relevance of an industry structure based analytical lens for this study.

Teece's framework is particularly relevant in the context of fast-evolving technology-intensive industries such as electronic components manufacturing, where competitiveness depends on the ability to sense technological opportunities, seize them through timely investment, and transform organisational processes accordingly. In the Indian context, limitations in these dynamic processes constrain firms' ability to adapt to rapid shifts in technology standards, customer requirements, and global production practices, thereby reinforcing dependence on assembly-focused activities.

Speaking highly of Porter's industry level analysis, Teece's business model and dynamic capabilities theory emphasises how firms create, deliver and capture value through resource configurations, innovation and strategic processes (Teece, 1986, 2006, 2010). This is a critical lens for examining India's electronics ecosystem because much of the sector continues to operate on low value, assembly driven models rather than innovation led, capability building manufacturing structures. The absence of advanced fabrication facilities limited intellectual property creation and dependency on imported technologies further highlight gaps in India's organisational and national level dynamic capabilities (IANS, 2021).

In addition, contemporary business model frameworks, including Johnson et al.'s (2008) four component model and Wirtz et al.'s (2015) value centric approach, provide useful lenses for assessing how Indian firms structure customer value propositions, profit mechanisms, key resource, and core processes within an increasingly competitive global electronics industry. These frameworks highlight the importance of strong value creation systems, organisational adaptability and the effective integration of technological competencies as prerequisites for sustaining competitiveness in electronic component manufacturing. Supporting strategic management perspectives, such as those proposed by Hill & Jones (2001), alongside

foundational analytical tools like the SWOT framework (Humphrey, 1960), further contribute to understanding the structural constraints associated with infrastructure limitations, capability gaps and policy inconsistencies that continue to shape India's position within the global electronics landscape.

Together, these complementary business model perspectives support a firm-level understanding of how strategic choices related to production configuration, technology adoption, and value capture influence long-term competitiveness. In the Indian electronics components sector, these frameworks help explain why many firms struggle to move beyond cost-based competition and into differentiated, innovation led market positions.

Taken together, Porter's five forces framework and Teece's dynamic capabilities theory provide a comprehensive and complementary theoretical foundation for the present study. Porter's model facilitates analysis of India's external competitive environment by examining industry structure and competitive pressures. Teece's framework offers insight into internal strategic constraints, capability development challenges and the evolution of business models within the electronic components sector. The integration of these perspectives enables a assessment of the systemic barriers that continue to prevent India from moving beyond assembly-oriented production towards more advanced value electronic component manufacturing.

This integrated theoretical approach is particularly suitable for analysing complex manufacturing ecosystems where firm-level strategies, policy environments, and global market forces interact. By combining industry-level and capability-based perspectives, the study is able to capture both external constraints and internal limitations that jointly influence manufacturing outcomes.

Beyond considerations of industry structure and firm level capabilities, the combined theoretical framework also supports examination of how global value chain (GVC) dynamics

shape India's ability to scale electronics manufacturing. Porter's framework draws attention to the strong bargaining power exercised by foreign suppliers and technology owners, particularly in areas such as semiconductor fabrication, equipment provision, and design related intellectual property, which collectively limit India's strategic autonomy within the global ecosystem (Invest India, 2022). Teece's focus on value appropriation further helps explain why Indian firms capture a relatively small share of global electronics value despite increasing domestic demand. In contrast, economies such as Taiwan and South Korea have strengthened their dynamic capabilities through sustained investment in research and development, skill formation, and fabrication infrastructure, whereas India remains largely concentrated in lower value assembly activities due to persistent capability gaps and a fragmented industrial ecosystem (IBEF, 2023).

From a global value chain perspective, the framework helps illustrate how limited upgrading opportunities, weak backward linkages, and shallow supplier networks restrict India's movement into higher value segments of electronics manufacturing. This reinforces the importance of coordinated capability development as a prerequisite for meaningful participation in global production networks.

The mixed theory also supports evaluation of policy initiatives such as Make in India, Digital India and the Production Linked Incentive (PLI) scheme. While these programmes aim to strengthen domestic manufacturing, Porter's Five Forces framework indicates that persistent structural constraints including high entry barriers, limited access to advanced technologies and intense global competition which continue to restrict India's ability to attract high value electronic component manufacturing investment. From the perspective of Teece's dynamic capabilities theory, policy incentives alone cannot compensate for gaps in firm level capabilities such as innovation capacity, technological adaptability and business model upgrading. Industry analyses similarly suggest that, without parallel development of research

ecosystems, skilled workforce pipelines and robust intellectual property frameworks, India's electronics manufacturing sector is likely to remain focused on assembly-oriented activities rather than progressing toward higher value production (Skill India Newsletter, 2021; Whitepaper ESDM).

Overall, the theoretical framework adopted in this study provides a robust analytical foundation for examining India's electronic components manufacturing challenges across multiple levels. By integrating industry structure, firm-level capability development, business model configuration, and global value chain dynamics, the framework enables a nuanced understanding of why manufacturing upgrading has remained limited and informs the empirical analysis undertaken in subsequent chapters.

2.4 The Present State of the Indian Electronics Industry

India's electronics sector is widely viewed as strong growth, supported by ongoing technological advancements and government initiatives aimed at promoting domestic production (IANS, 2021). Building innovation and an expanding ecosystem of manufacturers, suppliers and technology creators, the Indian electronics industry has gained increasing visibility and recognition within the global market (IBEF, 2023). In recent years, the sector has undergone a notable transformation driven by the digital revolution and the adoption of advanced technologies such as artificial intelligence, the Internet of Things (IoT) and 5G connectivity. These developments have reshaped consumer electronics while enabling new applications across sectors including healthcare, automotive systems and telecommunications (Skill India Newsletter, 2021).

Beyond demand side growth, this transformation reflects a gradual shift in India's electronics landscape from pure consumption toward partial domestic value creation. Increased integration of electronics across multiple sectors has expanded the breadth of applications, raising the strategic importance of electronics manufacturing within the broader industrial

economy. As electronics become embedded in critical infrastructure and services, the sector's performance increasingly influences productivity, innovation capacity, and industrial competitiveness at the national level (NITI Aayog, 2021; IBEF, 2023).

Government support has further reinforced this growth through national initiatives such as Make in India and Digital India, which have encouraged investment in domestic manufacturing and innovation (Invest India, 2022). Complemented by supportive regulatory frameworks, fiscal incentives and policy measures, these programs have attracted both domestic and international firms to establish manufacturing facilities and research centers in India. In parallel, India's demographic advantage characterized by a young, technologically proficient population provides a large and expanding consumer base for electronic products and services (IANS, 2021; Skill India Newsletter, 2021). Rising urbanization and increasing disposable incomes further strengthen the outlook for sustained industry expansion (Invest India, 2022; IBEF, 2023; EB Bureau, 2020).

At the same time, the concentration of electronics demand within emerging urban centres and fast-growing semi-urban markets has encouraged firms to localise assembly and testing operations to remain cost-competitive. This localisation trend has supported employment generation and incremental capability development, although it has not yet resulted in widespread upgrading into advanced component manufacturing. The gap between consumer demand growth and domestic production depth remains a defining characteristic of the sector (MeitY Annual Report, 2022; EB Bureau, 2020).

Despite these favorable conditions, the sector continues to face significant challenges, including infrastructure constraints, shortages of skilled labor and intense competition from established global manufacturing hubs (Banerji, 2021; Sharma, 2021; MeitY Annual Report, 2022). Effectively addressing these limitations, while making use of existing strengths and emerging opportunities, remains critical for unlocking the full potential of India's electronics

sector and securing its position as a competitive global player in the digital era (NITI Aayog, 2021; Whitepaper ESDM Sector; DPIIT, 2022).

These constraints highlight the uneven nature of India's electronics growth, where market expansion has outpaced the development of manufacturing ecosystems capable of supporting complex, high-value production. As a result, India's role within global electronics markets continues to be shaped more by assembly and final-stage manufacturing than by upstream technological leadership (Sharma, 2021; Whitepaper ESDM Sector).

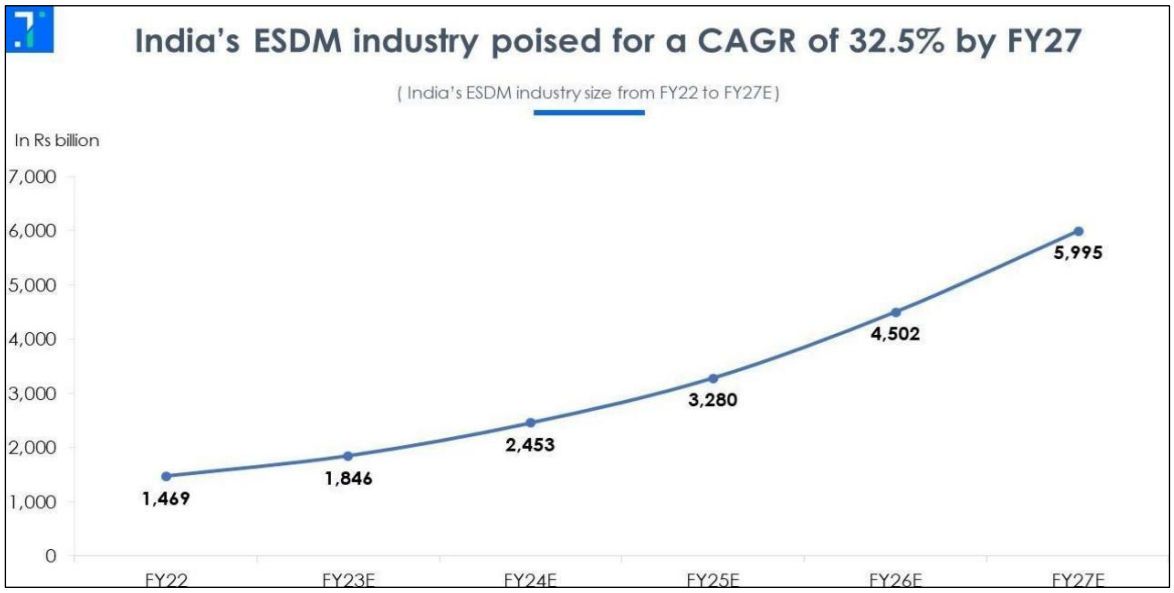

Figure 2.1 Growth Trajectory of Indian Electronics Industry

Source: Whitepaper ESDM sector

The Indian electronics industry growth trajectory for the year 2022 to 2027 is shown in figure 2.1. The industry value expected to increase from approximately 1,469 billion rupees to nearly 7,000 billion rupees (Whitepaper ESDM Sector; IBEF, 2023). This growth, estimated at a CAGR of around 32 percent, is driven by rising electronics consumption, increased rural penetration, growth in electric mobility and wider application of electronics in sectors such as healthcare (Invest India, 2022; MeitY Annual Report, 2022). However, India's per capita electronics consumption remains low at about 78 US dollars annually, compared to the global

average of 324 US dollars, indicating substantial unrealised domestic demand (Skill India Newsletter, 2021; EB Bureau, 2020).

The disparity between aggregate market growth and low per capita consumption suggests that India's electronics expansion is still at an early stage relative to mature markets. This gap presents both an opportunity and a challenge: while future demand growth is likely to remain strong, meeting this demand through domestic manufacturing rather than imports requires significant strengthening of production capabilities and supplier ecosystems (IBEF, 2023; NITI Aayog, 2021).

India's electronics industry comprises multiple segments, including consumer electronics, telecommunications, IT hardware, semiconductor fabrication and electronic components. Consumer electronics particularly smartphones have been a major contributor to growth, supported by rising digital adoption and demand across urban and rural markets. India has emerged as one of the world's largest smartphone markets, attracting both domestic and global manufacturers due to competitive costs, expanding internet access and a young technology-oriented population (IBEF, 2023; Skill India Newsletter, 2021; MeitY Annual Report, 2022; Banerji, 2021).

While smartphone manufacturing has contributed significantly to output and employment, the majority of value addition remains concentrated in assembly and integration stages. High-value components such as semiconductors, advanced sensors, and specialised integrated circuits continue to be sourced predominantly from global suppliers, reinforcing India's dependence on external technology ecosystems (Banerji, 2021; Whitepaper ESDM Sector).

Government initiatives such as Make in India, Digital India and the Production Linked Incentive (PLI) scheme have further encouraged domestic manufacturing and reduced reliance on imports (Invest India, 2022; MeitY Annual Report, 2022). Alongside consumer electronics,

segments such as automotive, healthcare and defence electronics have also recorded steady growth, driven by regulatory requirements, digital healthcare expansion, and policies promoting defence production (NITI Aayog, 2021; Sharma, 2021; DPIIT, 2022).

The expansion of electronics into automotive, healthcare and defence sectors has increased demand for higher-reliability and application-specific components. However, the domestic capability to produce such components at scale remains limited, creating a mismatch between sectoral demand growth and indigenous manufacturing capacity (NITI Aayog, 2021; MeitY Annual Report, 2022).

Despite this progress, the sector continues to face challenges, including infrastructure constraints, skill shortages, supply chain vulnerabilities, regulatory complexity, intellectual property concerns and strong competition from established global manufacturing hubs (Banerji, 2021; Sharma, 2021; NITI Aayog, 2021). Addressing these limitations through targeted investment in infrastructure, skills development, regulatory reform and supply chain resilience is critical for India to fully realise its potential as a globally competitive electronics manufacturing hub (IBEF, 2023; Invest India, 2022; EB Bureau, 2020).

In summary, while India's electronics industry exhibits strong demand-side momentum and favourable demographic fundamentals, its long-term competitiveness will depend on the ability to deepen manufacturing capabilities, strengthen supplier ecosystems, and transition from assembly-led growth to higher-value production. This structural imbalance between market expansion and production sophistication forms a central theme for understanding the challenges discussed in subsequent sections of this literature review (Sharma, 2021; Whitepaper ESDM Sector; IBEF, 2023).

2.5 The Present State of the India's Electronic Components Manufacturing Sector

Existing literature highlights a limitation within India's electronic component manufacturing sector, particularly the imbalance between passive and active component

production. Faisal Kawoosa, founder of techArc, noted that while India has established a strong base in passive electronic component manufacturing, it continues to face significant challenges in producing active components, which has constrained sectoral growth (EB Bureau, 2020). Passive components, such as resistors and capacitors, operate without external power and are comparatively easier to manufacture, whereas active components like transistors, diodes and integrated circuits require external power, advanced fabrication capabilities and technological expertise (Invest India, 2022; IBEF, 2023).

This imbalance has important implications for value creation within the electronics ecosystem. Passive components typically account for a smaller share of total product value, while active components form the technological core of advanced electronic systems. India's limited presence in active component manufacturing therefore restricts its ability to capture higher value within global electronics supply chains and reinforces dependence on imported technologies for critical inputs (Banerji, 2021; Whitepaper ESDM Sector).

Electronic components are commonly categorised into active, passive, electro-mechanical, and associated components, each differing in functional complexity and manufacturing requirements (Skill India Newsletter, 2021; MeitY Annual Report, 2022; Whitepaper ESDM Sector; DPIIT, 2022). Countries such as India have been able to develop capabilities in passive component manufacturing due to lower technological barriers, while active component production demands sophisticated infrastructure, skilled labour and sustained investment in research and development (Banerji, 2021; Sharma, 2021; NITI Aayog, 2021). As a result, India's electronics manufacturing ecosystem remains largely concentrated in lower value segments.

The persistence of this concentration reflects structural constraints rather than a lack of market opportunity. Global demand for advanced electronic components continues to expand, driven by applications in telecommunications, automotive electronics, renewable energy

systems and digital infrastructure. However, India's limited fabrication capacity and weak integration between design, manufacturing and testing functions reduce its ability to respond effectively to these demand shifts (NITI Aayog, 2021; MeitY Annual Report, 2022).

This structural gap is further reinforced by limited infrastructure, skill shortages, weak intellectual property capabilities, and the absence of domestic semiconductor fabrication facilities, leading to continued dependence on foreign technology providers that are often reluctant to share proprietary knowledge (EB Bureau, 2020; Skill India Newsletter, 2021; Whitepaper ESDM Sector). These constraints restrict India's ability to meet rising demand for advanced electronic products and slow the sector's overall progression. Addressing these challenges requires investment in advanced manufacturing technologies, workforce development and industry collaboration (IBEF, 2023; Invest India, 2022; MeitY Annual Report, 2022).

In addition, limited domestic testing, certification and validation infrastructure constrains the ability of Indian component manufacturers to meet stringent global quality and reliability standards. This further weakens competitiveness in high-reliability segments such as aerospace, defence and automotive electronics, where compliance and certification play a critical role in supplier selection (NITI Aayog, 2021; Whitepaper ESDM Sector).

At the same time, technological shifts such as the 5G networks and the expansion of Internet of Things (IOT) applications are accelerating demand for electronic products. Government initiatives including digital India and smart city programmes have further strengthened this momentum, contributing to an increase in India's share of global electronic systems manufacturing from 1.3 percent in 2012 to 3.6 percent in 2019 (InvestIndia, 2022). India's electronics production value has also grown substantially, rising from 30 billion US dollars in 2014-15 to 75 billion US dollars in 2019-20, with projections indicating potential

growth to 250 billion US dollars by 2025 under continued policy support and export expansion (EB Bureau, 2020; Invest India, 2022; Whitepaper ESDM; DPIIT, 2022).

Despite this rapid growth in system-level manufacturing, domestic component value addition remains comparatively limited. A large share of this expansion is driven by final assembly and system integration activities, with critical components such as semiconductors, sensors and advanced integrated circuits continuing to be imported. This asymmetry between system manufacturing growth and component capability development remains a defining characteristic of India's electronics sector (Banerji, 2021; Whitepaper ESDM Sector).

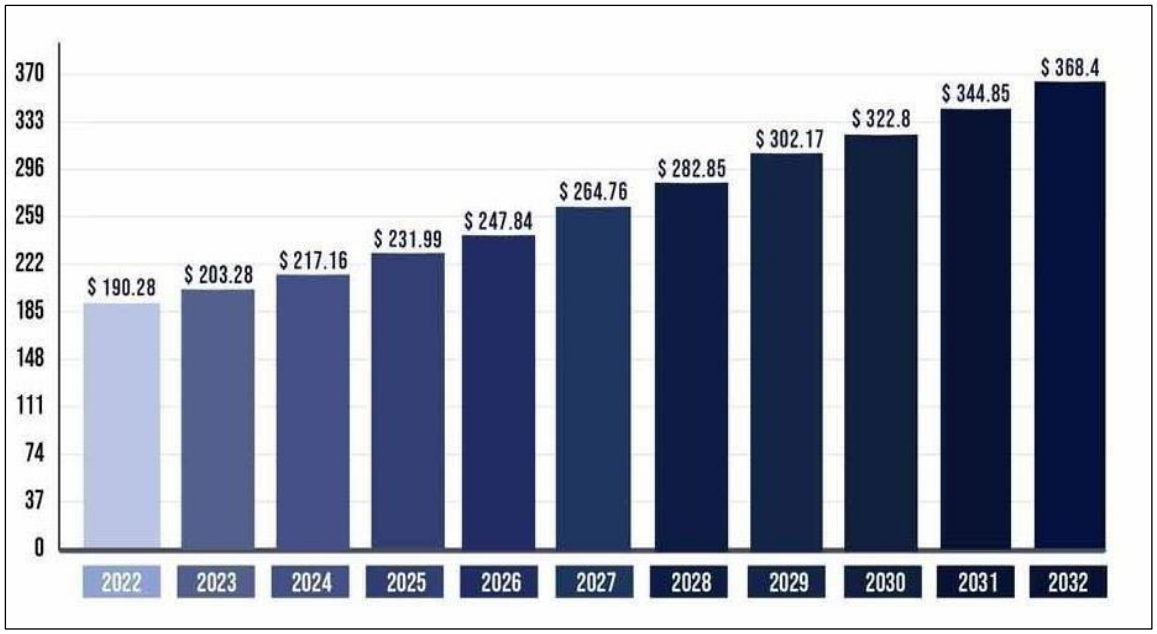

Figure 2.2 Market size of electronic components, 2022 to 2032 (USD BILLION)

Source: www.precedenceresearch.com

The consumer electronics category is witnessing strong expansion, supported by a broad manufacturing base, a sizeable customer market and intense competition driven by the participation of international brands. Demand for consumer electronics has risen sharply, propelled by India's growing and increasingly aspirational population. Additionally, computers and related peripherals form another rapidly expanding segment within this broader market (IBEF, 2023; Invest India, 2022; Skill India Newsletter, 2021; MeitY Annual Report, 2022).

While consumer electronics demand supports overall market growth, it also intensifies pressure on domestic component manufacturers to improve quality, reliability and cost efficiency. Without corresponding upgrades in component manufacturing capabilities, rising demand risks further widening the import gap rather than strengthening domestic value creation (IBEF, 2023; EB Bureau, 2020)

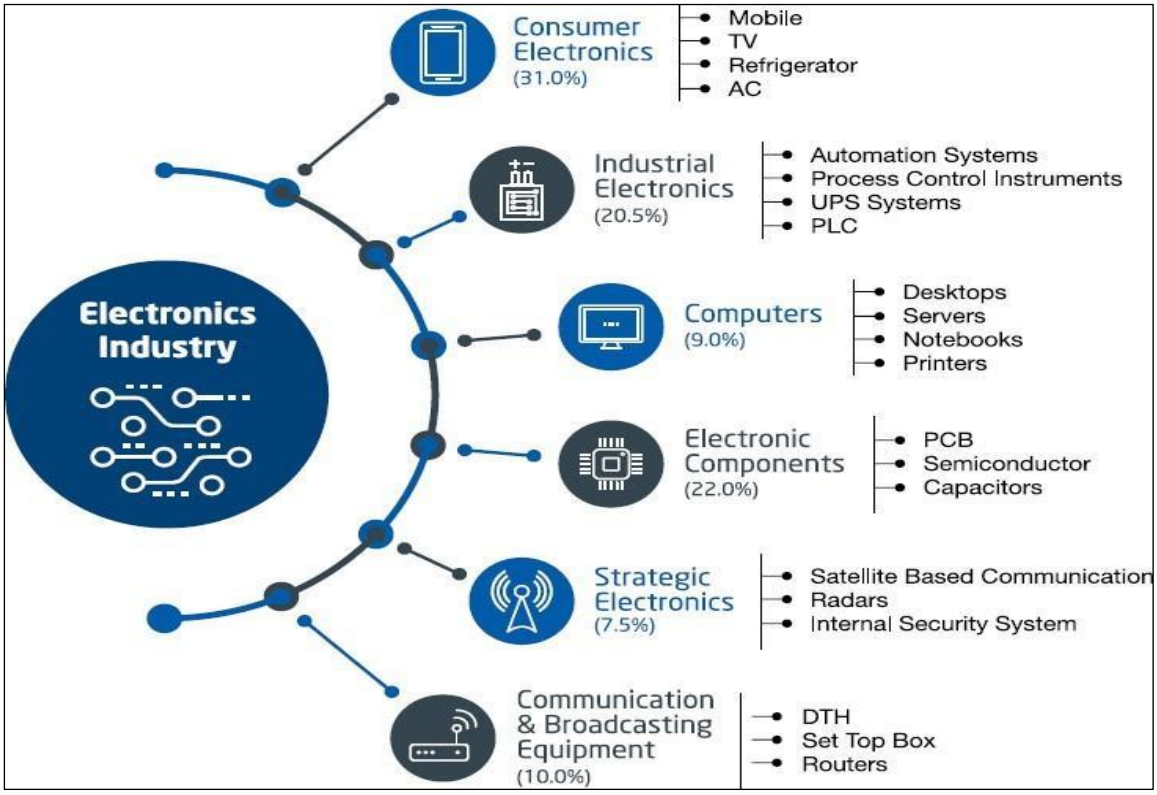

Figure 2.3 Major categories of electronics industry

Source: Skill Talks Newsletter, Ministry of skill development and entrepreneurship

The industrial electronics performance is closely tied to investments and demand patterns in other industries, as industrial electronic products are extensively used by other sectors. India has been implementing progressive reforms in strategic electronics, promoting the utilization of state-of-the-art technologies like electromagnetic wave applications, intelligent sensors, RFID, micro-robotics, intelligent materials, microelectronic systems, secure data communication, as well as millimeter wave and microwave devices (MeitY Annual Report, 2022; NITI Aayog, 2021; Skill India Newsletter, 2021).

However, the limited domestic availability of advanced industrial-grade components constrains localisation in these strategic segments. As a result, many high-technology applications continue to rely on imported components, reducing opportunities for domestic learning and capability accumulation (NITI Aayog, 2021; Whitepaper ESDM Sector).

As of electronic components, India has emerged as an exporter of various electronic components, including cables, speakers and cathode ray tubes, among others (IBEF, 2023; Invest India, 2022). Revenue from local manufacturing of electronic components contributes to the overall size of the ESDM market. Around 2013 to 2015, this segment experienced a Compound Annual Growth Rate (CAGR) of 2% and it is anticipated to grow at an even faster rate of 34.9% from 2014 to 2020. The effectiveness of Make in India, the Indian government's flagship initiative, depends significantly on the development and scaling of the nation's electronic component manufacturing sector (Whitepaper ESDM Sector; DPIIT, 2022; Sharma, 2021; EB Bureau, 2020).

Sustaining this growth trajectory will require a shift from volume-driven expansion toward capability-driven development. Without strengthening upstream component manufacturing, growth in system assembly may yield limited long-term competitiveness and expose the sector to external supply-chain risks (Sharma, 2021; NITI Aayog, 2021).

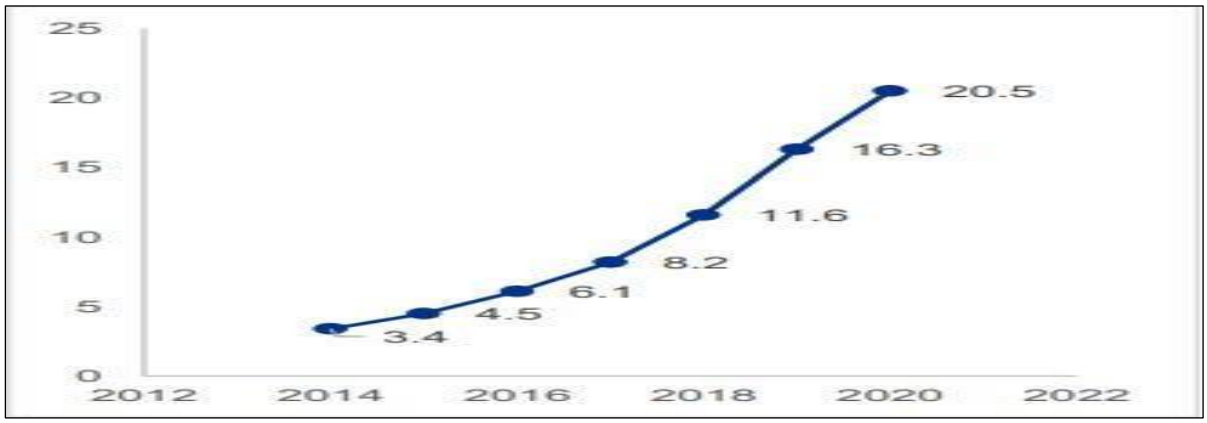

Figure 2.4 Income from Electronic Components (USD Billion)

Source: Whitepaper ESDM Sector

As reported by the Indian Brand Equity Foundation (IBEF), the Electronics System Design & Manufacturing (ESDM) sector includes a wide variety of electronic hardware products and components spanning numerous fields such as information technology (IT), office automation, telecommunications, consumer electronics, aviation, aerospace, defence, solar photovoltaics, nanoelectronics and medical electronics. In addition, the sector also covers essential design-oriented functions, including product design, chip design, Very Large-Scale Integration (VLSI), circuit board design and embedded systems development (IBEF, 2023; MeitY Annual Report, 2022; Whitepaper ESDM Sector).

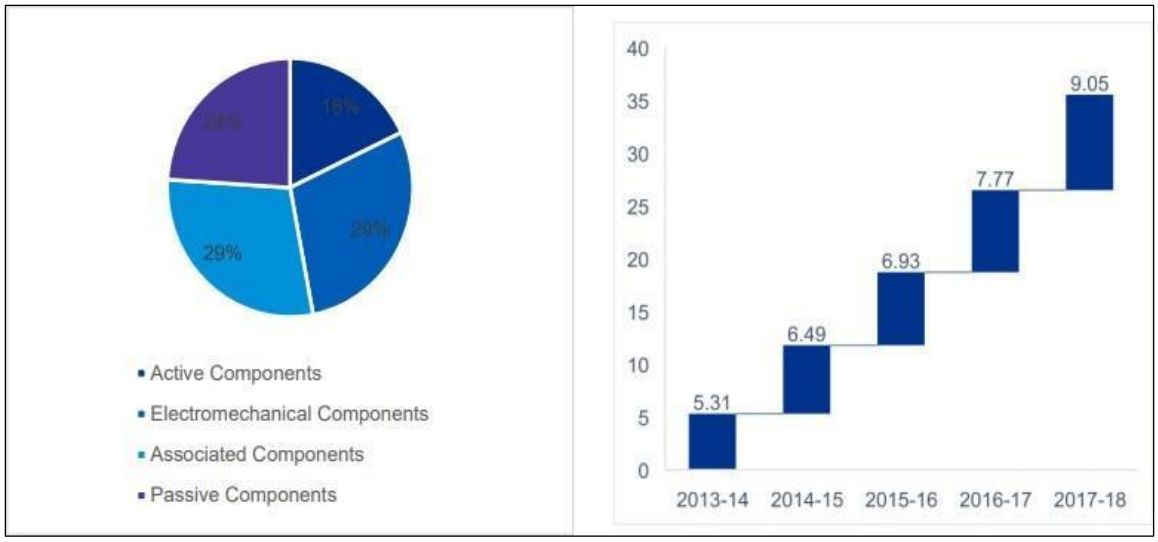

Figure 2.5 Breakdown of component categories in total output and Electronic Components Income (USD Billion)

Source: Whitepaper ESDM Sector

Projected to expand at a Compound Annual Growth Rate (CAGR) of 16.1% from 2019 to 2025, India's electronics manufacturing sector is set for substantial advancement, driven by strong market demand, supportive government measures and accelerating digitalization efforts (Invest India, 2022; DPIIT, 2022; Skill India Newsletter, 2021; NITI Aayog, 2021).

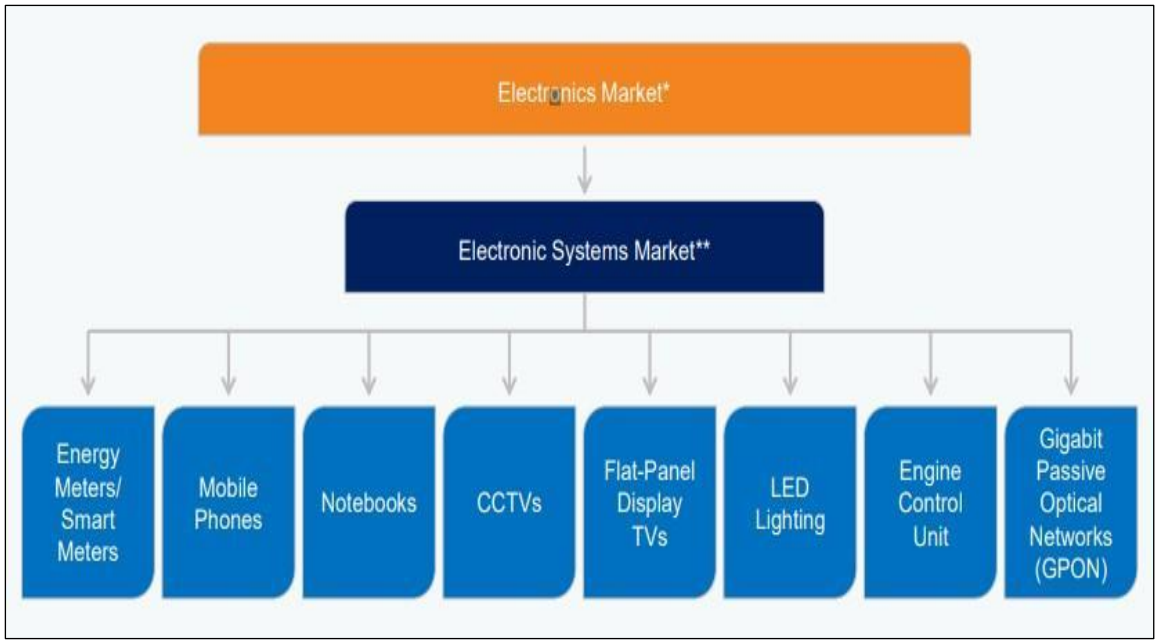

Figure 2.6 Major Product Segments

Source: India Electronics & Semiconductor Association (IESA), Make in India

India possesses the world's second-largest digital user base, with expansion rates surpassing those of many major global economies. In Fiscal Year (FY) 2023, exports of electronic goods rose sharply, reaching USD 23.57 billion, representing an impressive 50.52% increase compared with FY22. Remarkably, electronic goods exports alone amounted to USD 2 billion in September 2022 (IBEF, 2023; Invest India, 2022; MeitY Annual Report, 2022).

Looking ahead, India has established ambitious production goals, including increasing mobile handset output to one billion units, with an estimated value of around thirteen lakh crores. Of this total, six hundred million handsets are planned for export, carrying an approximate value of seven lakh crores (NITI Aayog, 2021; Skill India Newsletter, 2021; Whitepaper ESDM Sector; DPIIT, 2022).

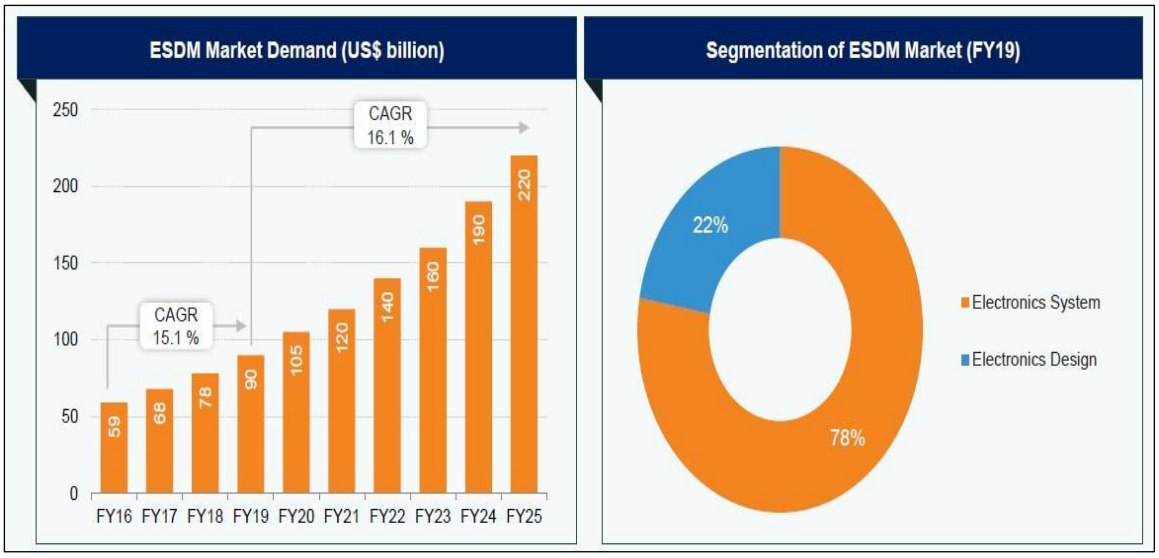

Figure 2.7 ESDM demand outlook (USD billion) and segmentation of the ESDM market.

Source: India Electronics & Semiconductor Association (IESA), Make in India

The electronics sector recorded a Compound Annual Growth Rate (CAGR) of 14% between 2016 and 2019 and is expected to expand even faster at a CAGR of 16.6% from 2020 to 2025. By Fiscal Year (FY) 2025, overall electronics demand is forecast to approach USD 540 billion (IBEF, 2023; Invest India, 2022).

In Fiscal Year (FY) 2023, India's electronic goods imports stood at USD 73.46 billion, whereas exports were USD 22.68 billion. Between April and October 2023, electronic imports amounted to USD 51.33 billion, while exports for the same period totaled USD 15.48 billion (MeitY Annual Report, 2022; DPIIT, 2022).

Forecasts suggest that the Electronics System Design & Manufacturing (ESDM) industry is expected to create economic value estimated between USD 100 billion and USD 130 billion by 2025 (Whitepaper ESDM Sector; NITI Aayog, 2021).

In line with its objectives, the Indian government focus to position electronics goods among the top 2 or 3 exports of the country by 2026. This ambition aligns with forecasts indicating a substantial increase in electronics goods exports from an anticipated USD 15 billion in 2021-22 to USD 120 billion by 2026 (Skill India Newsletter, 2021; EB Bureau, 2020).

The Production Linked Incentive (PLI) scheme, launched by the Ministry of Electronics and Information Technology (MeitY) in April 2020, targeting large scale electronics manufacturing, has been extended from the existing five-year period (FY21- FY25) to a duration of six years (FY21-FY26) (Sharma, 2021; MeitY Annual Report, 2022).

2.6 Business Models

Business frameworks have existed since the 1980s, when Porter authored the five forces framework (Porter, 1980). Since then, there have been several iterations and additions to frameworks, such as the generic strategy framework (Porter, 1980), the generic building blocks framework by Hills & Jones (2001) and the SWOT analysis framework (Albert Humphrey, 1960). It was only in the early 2000s that the term "business model" started to surface, especially in context of the rise of the dot-com industry. One of the earliest references to business models is in a paper from 2002 by Magretta, who wrote about how the term "business model" became a buzzword in the dot-com boom. A strong business model is indispensable for any successful organization, whether it's a fledgling startup or a seasoned industry leader. However, the term has gained more acceptance and is now extremely important to define properly to make sense of any business (Teece, 2010; Johnson et al., 2008; Wirtz et al., 2015; IBEF, 2023).

The growing prominence of business model thinking reflects broader shifts in competitive environments, where firms are increasingly required to compete not only on products and technologies but also on how value is structured, delivered and captured. In technology-intensive industries, such as electronics manufacturing, the choice of business model plays a decisive allowing role in determining whether firms can respond effectively to rapid technological change, cost pressures and evolving customer requirements (Teece, 2010; Wirtz et al., 2015).

The most concise definition advanced is that a business model is the story of a company explaining how the company works (Teece, 2010). Since the business model is an all-encompassing "story", it is expected that it is adapted to fit the company's goals. Furthermore, the "story" is continually modified to fit prevailing market conditions. Given the importance of a business model to its parent business, academic interest for this topic has been growing over the years. In 2015, Wirtz et al. found the number of scholarly articles related to business models in 2013 were 380, as compared to 51 in 2000, an increase of 645% (Wirtz et al., 2015). The interest in the topic continues to grow and for good reason (Johnson et al., 2008; Hills & Jones, 2001; Porter, 1980; IBEF, 2023).

This expansion in academic interest highlights the recognition that business models function as dynamic mechanisms rather than static structures. Particularly in manufacturing sectors exposed to global competition, firms must continuously adjust their business models to accommodate changes in input costs, supply-chain configurations, customer expectations and regulatory environments (Teece, 2010; Invest India, 2022).

A business model delineates the methods through which a company creates value for its customers and retains a portion of that value to ensure profitability. It consists of several components that regulate how costs, revenues and profits are distributed across the organisation. The creation and implementation of a business model are vital to a firm's success, as they significantly influence profitability alongside technological decisions and operational methods. The business model establishes the mechanism through which technological innovation and know-how combined with the utilization of tangible and intangible assets are converted into a stream of profits (Teece, 1986, 2006; Johnson et al., 2008; Wirtz et al., 2015; Hills & Jones, 2001; Invest India, 2022).

In manufacturing-oriented industries, this conversion process is particularly complex, as it involves coordination between technology adoption, production scale, supplier

relationships and cost management. For electronic component manufacturers, the business model determines how investments in capital-intensive facilities, specialised labour and process innovation translate into sustainable revenue streams and long-term competitiveness (Banerji, 2021; IBEF, 2023).

There are several advantages of having a well-defined business model. A good business model also can be pivoted rather than being recreated to create better value and capture market share (Hacklin, Johnson et al., 2018). Furthermore, constant changes in technology can be augmented with an evolving business model to match customer needs or needs emerging directly from customers.

This ability to pivot is particularly relevant in electronics manufacturing, where rapid innovation cycles and shifting standards require firms to reconfigure production, pricing and delivery mechanisms without undermining operational stability. Firms with rigid or narrowly defined business models often struggle to adapt to such shifts, limiting their ability to sustain competitive advantage (Wirtz et al., 2015; Banerji, 2021).

Another key characteristic of a business model is that it provides a competitive advantage for managers (Teece, 2010). For this to be valid, the business model should also be malleable from the inside of the business, through its stakeholders as well as flexible to suit external impetus, such as an emerging trend.

Managerial capability to design and adjust business models is therefore a strategic asset, particularly in industries where cost structures, technology trajectories and market demand are subject to frequent disruption. In the context of electronic components manufacturing, managerial decisions regarding outsourcing, vertical integration and pricing strategies significantly shape firm performance and resilience (Hills & Jones, 2001; Teece, 2010).

Since the early 2000s, there are several authors who have proposed business model frameworks. Johnson et al. (2008) suggested a framework with 4 elements: customer value

proposition, profit formula, key resources and key processes. This framework supports general purpose business goals. Another framework proposed by Rayna and Striukova in 2014 is a value-centric framework comprised of: value proposition, value creation, value delivery, value capture and value communication in context of the video game industry. As can be seen, frameworks can be designed vastly differently based on the underlying philosophy. However, all of them tend to share similar traits. One such trait is the revenue model. At a simplistic level, a revenue model can be termed as the steps taken to earn revenue. A business may have several revenue models as part of its business model (Wirtz et al., 2015; Hills & Jones, 2001; Porter, 1980; IBEF, 2023).

Despite differences in structure, most business model frameworks emphasise the alignment between value creation and value capture mechanisms. In capital-intensive manufacturing industries, misalignment between these elements can result in thin margins, underinvestment in innovation and long-term competitiveness challenges (Teece, 2006; Wirtz et al., 2015).

For example, a business may sell a base version of programmed chips as a one-time purchase, then additionally sell priority support for the programmed chips (value added service), timely updates to the program through recurring subscriptions and finally upsell existing customers to a new version when released, at a discount. Revenue models often provide synergies to each other with the end goal of monetizing a customer for the longest period. In a 2017 paper, Klimas noted that it was possible to exploit more than one monetization model under a specific revenue model. Further, he noted that several revenue streams could be exploited by a company and these would co-create the revenue model (Rayna & Striukova, 2014; Johnson et al., 2008; Wirtz et al., 2015; Invest India, 2022).

In electronic component manufacturing, however, opportunities for diversified monetisation are often constrained by price sensitivity, standardisation and intense global

competition. As a result, many manufacturers rely on high-volume, low-margin models that prioritise cost efficiency over differentiation, reinforcing structural challenges in value capture (Banerji, 2021; IBEF, 2023).

In the electronic components manufacturing industry, revenue models and business models are often used interchangeably and for good reason. Unlike in the earlier example, the primary revenue models in the electronic components manufacturing industry are often at odds with each other. For this paper, I used “business model” and “revenue model” interchangeably (Teece, 2010; Johnson et al., 2008; Wirtz et al., 2015; Banerji, 2021).

This overlap reflects the central role of revenue logic in shaping strategic choices within the sector. Given the dominance of cost-driven competition and limited differentiation in many component categories, business model design in electronic components manufacturing is closely tied to pricing structures, scale economics and long-term supplier relationships rather than standalone product innovation (Sharma, 2021; IBEF, 2023).

2.7 Business Models in the Electronic Components Manufacturing Industry

The manufacturing sector is booming, as the global contract manufacturing industry is projected to reach $2.7 trillion by 2023 (EB Bureau, February 26, 2020). While the sector has seen numerous developments over the past years, manufacturers have continued to follow the traditional manufacturer business model. Developments in e-commerce, combined with rapid technological change have altered traditional market structures and encouraged manufacturers to rethink and adapt their business models to remain competitive (InvestIndia, 2022; IBEF, 2023; Skill India Newsletter, 2021).

In electronics, this pressure to adapt is stronger because component demand is closely tied to technology cycles, standard changes, and the purchasing strategies of large OEMs. As customer requirements shift toward smaller form factors, higher reliability, and faster delivery, manufacturers are often forced to revisit how they position themselves in the value chain and

how they balance cost leadership with capability upgrading (Porter, 1980; Wirtz et al., 2015; IBEF, 2023).

A manufacturer's business model represents a deliberately structured framework that defines how a production-oriented organisation aims to create, deliver and capture value across economic, social and cultural dimensions. In essence, it specifies the approaches and mechanisms through which the manufacturer operates, earns revenue and sustains long-term growth, stability and success (Teece, 2010; Johnson et al., 2008; Wirtz et al., 2015).

Within electronic components manufacturing, value creation is typically shaped by three tightly linked decisions: (i) which component categories the firm will specialise in, (ii) whether it will operate mainly as a high-volume supplier or a specialist provider of higher-precision components, and (iii) how it will develop capabilities across design support, process control, certification, and customer integration. These choices influence profitability because the sector often faces low switching costs for buyers, intense price competition, and strong bargaining power from dominant OEM customers (Porter, 1980; Teece, 2010; Banerji, 2021).

A key distinction among manufacturing business models lies in whether sales are invoiced directly to consumers (B2C), to other businesses (B2B) or to both segments. Some manufacturers adopt a direct-to-customer (D2C) approach, selling their products straight to end-users without relying on intermediaries. In contrast, many manufacturers follow a traditional model in which goods are provided to distributors, retailers or other third-party partners, who then handle the final sale to consumers (Hills & Jones, 2001; Porter, 1980; DPIIT, 2022; NITI Aayog, 2021).

In electronic components, B2B models dominate because most components are intermediate inputs purchased by OEMs, EMS providers, and industrial customers rather than end-consumers. As a result, competitive advantage often depends on meeting strict technical specifications, ensuring predictable supply, maintaining quality consistency, and supporting

customers with application guidance and engineering collaboration (Johnson et al., 2008; Wirtz et al., 2015; MeitY Annual Report, 2022).

Another important distinction in electronics manufacturing relates to how firms position themselves between design and production. Some firms operate as pure manufacturers, while others combine manufacturing with design support, prototyping, and testing services. Where firms can provide early-stage engineering input or rapid iteration support, they may improve customer lock-in and strengthen value capture, even in markets where component prices are under pressure (Teece, 2010; Johnson et al., 2008; Invest India, 2022).

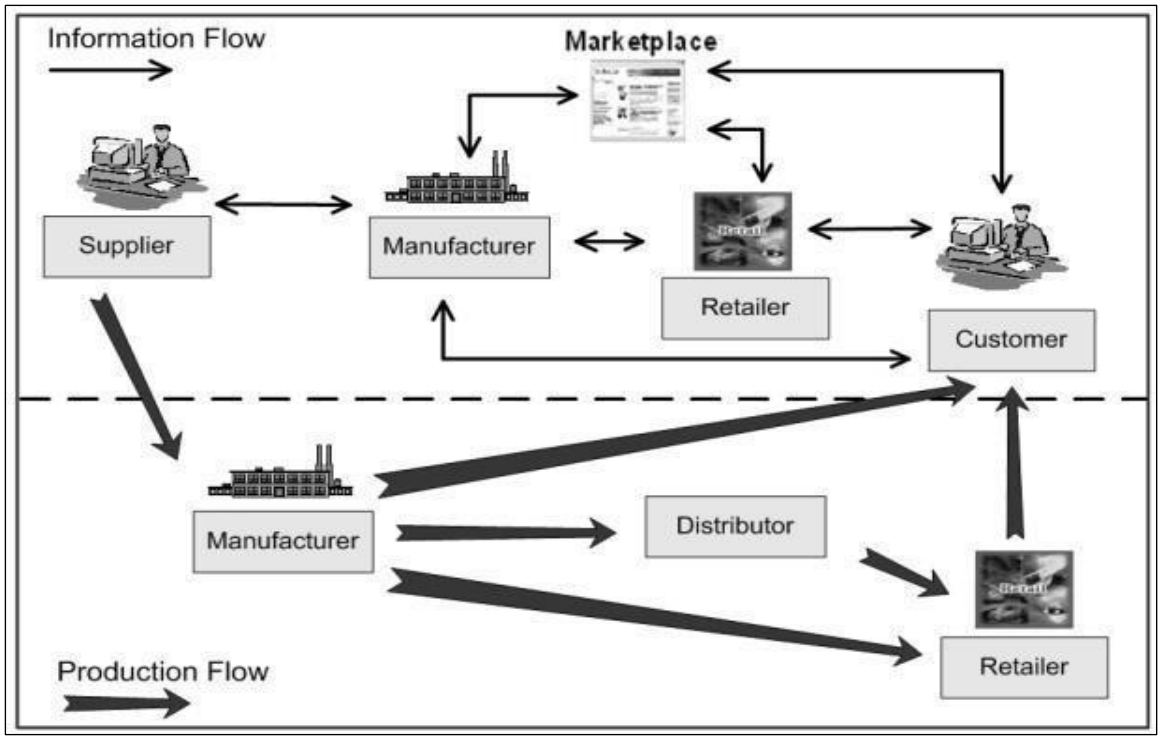

Figure 2.8 Manufacturer Business Model in Electronic Components Manufacturing Framework

Source: Standards Framework for Intelligent Manufacturing Systems Supply Chain book (Jardim-Goncalves et al., 2007)

Each manufacturer's business model incorporates several tiers within the supply chain. These tiers must be examined routinely to maintain maximum supply chain performance.

Effective supply chain management requires sustaining a balanced alignment between demand and supply. At one end of this balance are the raw materials required for producing new items, while at the opposite end are the completed products intended for delivery to end consumers (Porter, 1980; Hills & Jones, 2001; Whitepaper ESDM Sector; Invest India, 2022).

In electronic components manufacturing, this alignment is often harder to maintain because lead times for specialised inputs can be long and demand can shift quickly due to new product launches or sudden changes in customer forecasts. This increases the operational value of accurate planning, supplier reliability, and inventory strategy, especially for manufacturers that depend on imported inputs or specialised materials (Sharma, 2021; EB Bureau, 2020; Invest India, 2022).

The left portion of the figure depicts the flow of information across the supply chain. The figure 2.8 shows the interaction between information flows and material flows within a typical supply chain. Market demand originating from the marketplace guides supplier decisions, which subsequently influence manufacturers production planning. Manufacturers then communicate product availability to downstream actors such as retailers, ensuring alignment between production output and market requirements. This information flow highlights the importance of coordination and communication among supply chain participants in responding effectively to demand signals (NITI Aayog, 2021; MeitY annual report, 2022; Skill India Newsletter, 2021; IBEF, 2023).

For the electronic components segment, information flow also includes technical information such as design changes, testing standards, qualification requirements, and compliance documentation. These information requirements can shape supplier selection and can influence whether buyers treat a supplier as interchangeable or as a long term partner, particularly for components that are safety critical or used in regulated environments (MeitY Annual Report, 2022; DPIIT, 2022; Wirtz et al., 2015).

Alongside information exchange, the physical movement of materials follows a sequential path from suppliers to manufacturers, distributors, retailers and end users. Raw materials and components are transformed into finished goods at the manufacturing stage and subsequently distributed through intermediary channels before reaching customers. Understanding the interaction between material and information flows is essential for improving supply chain efficiency, reducing operational bottlenecks and enhancing responsiveness to customer needs. From a strategic perspective, supply chain structures may vary depending on business models, distribution strategies and customer engagement approaches, with some firms adopting multi tier supplier network models to enhance value creation and competitive advantage (Porter, 1980; Hill & Jones, 2001; Johnson et al., 2008; Wirtz et al., 2015; Teece, 2010).

In India's case, the structure of these flows is frequently influenced by limited local supplier depth and the need to import high-value inputs, which can add cost, extend lead times, and increase exposure to disruption. This context makes supply-chain strategy a central part of business model performance, particularly for firms attempting to move beyond assembly-oriented activities into higher-value component production (Whitepaper ESDM Sector; NITI Aayog, 2021; Sharma, 2021).

In the electronic components manufacturing industry, different business models govern how companies generate, deliver and retain value. Below are key aspects of these business models, accompanied by figures illustrating their components (Rayna & Striukova, 2014; Banerji, 2021; MeitY Annual Report, 2022).

Value Proposition

The value proposition defines what value the company's products or services offer to customers. Figure 2.4 illustrates the components of a value proposition in the electronic

components manufacturing industry, including quality, reliability, performance and cost-effectiveness (Johnson et al., 2008; Wirtz et al., 2015).

Figure 2.9 Components of a value proposition in the electronic components manufacturing industry

Source: OHIO Manufacturing Institute

A value proposition is a clear, concise statement that communicates the benefits of a product or service to a customer.

Quality: This refers to the overall quality of the product or service.

Innovation: This refers to the new and improved features of the product or service.

Cost: This refers to the price of the product or service.

Speed/Reliability: This refers to how quickly and consistently the product or service can deliver results.

Supply: This refers to the availability of the product or service.

Risk: This refers to the level of risk associated with using the product or service.

Business Relationship: This refers to the quality of the relationship between the company and the customer.

A strong value proposition will take all of these elements into account and communicate to the customer how the product or service will solve their problems or improve their lives (NITI Aayog, 2021; Invest India, 2022; IBEF, 2023; Skill India Newsletter, 2021).

Revenue Streams

Revenue generation arises from selling electronic components to a range of stakeholders. Possible revenue sources in the electronic components manufacturing sector include component sales, licensing arrangements, maintenance offerings and tailored or customized solutions (Johnson et al., 2008; Teece, 2010; Wirtz et al., 2015). The revenue streams of electronic component manufacturing firms generally span several categories, reflecting the broad scope of their commercial activities. These revenue avenues include:

Sales of Components: The main revenue driver for electronic component producers is the sale of various electronic parts and modules to original equipment manufacturers (OEMs), contract manufacturers, distributors and other clients. These parts may consist of semiconductors, capacitors, resistors, connectors, printed circuit boards (PCBs), sensors and additional electronic items used in the manufacturing of consumer electronics, industrial machinery, automotive technologies, telecommunications equipment and numerous other electronic products (IBEF, 2023; Invest India, 2022; MeitY Annual Report, 2022).

Custom Manufacturing Services: Numerous electronic component manufacturers provide customised production services, where they create specialised components designed according to the precise specifications of their clients. These services may include design engineering, prototyping, testing and the fabrication of bespoke components, offering enhanced value to customers seeking tailored solutions for their products. Revenue from custom

manufacturing varies depending on the complexity, technical demands and order quantities involved (Skill India Newsletter, 2021; Whitepaper ESDM Sector; DPIIT, 2022).

Supply Chain Solutions: Certain electronic component manufacturers deliver supply chain and logistics services to improve the procurement, inventory control and distribution of components for their clients. Through value-added offerings such as inventory optimisation, vendor-managed inventory (VMI) and just-in-time (JIT) delivery, these firms earn income via service charges, warehousing fees and logistics management costs (NITI Aayog, 2021; Porter, 1980; Hills & Jones, 2001).

After-Sales Support and Maintenance: Additional revenue streams arise from after-sales support services, including technical guidance, repair and maintenance of electronic components and systems. Companies may generate income by providing extended warranties, long-term service agreements, sales of spare parts and repair solutions to ensure consistent performance and longevity of their products throughout their operational lifespan (IBEF, 2023; Invest India, 2022; Skill India Newsletter, 2021).

Licensing and Intellectual Property: Electronic component manufacturers that own proprietary technologies, patents or intellectual property rights can generate income through licensing arrangements, royalty payments or technology transfer agreements. By commercialising their innovations and intellectual assets, these companies can broaden their revenue base and utilise their technological capabilities to create additional streams of income (DPIIT, 2022; MeitY Annual Report, 2022; EB Bureau, 2020).

Research and Development Collaborations: Partnerships with research organisations, academic institutions and industry collaborators can also produce revenue for electronic component manufacturers. By engaging in joint research activities, technology development programmes and collaborative consortia, companies may secure funding from licensing deals

linked to the commercialisation of research findings and technological advancements (NITI Aayog, 2021; Whitepaper ESDM Sector; Sharma, 2021).

Beyond production and sales, electronic component manufacturers often provide value added offerings such as design assistance, product customisation, system integration and software development. Revenue from these services typically includes consultancy charges, service agreements and project-based fees, illustrating the specialised expertise and enhanced value the company delivers to its clients (Hills & Jones, 2001; Porter, 1980; Wirtz et al., 2015).

Overall, electronic component manufacturers earn revenue through product sales, customised manufacturing services, supply chain support, after sales maintenance, licensing activities, research partnerships and value-added solutions. This diversity of revenue sources reflects the multifaceted structure of their business operations and the wide ranging requirements of customers across multiple industry sectors (Johnson et al., 2008; Teece, 2010; Banerji, 2021; MeitY Annual Report, 2022).

Supply Chain Management

Effective management of the supply chain plays a central role in coordinating raw material procurement, production processes and the delivery of electronic components. As shown in figure 2.10, the core supply chain functions within the electronic components sector, including sourcing, manufacturing and distribution activities (Porter, 1980; NITI Aayog, 2021; Whitepaper ESDM Sector; Invest India, 2022).

Supply chain management in the electronic components manufacturing sector comprises an interconnected set of activities that coordinate the flow of materials, information and resources from raw material suppliers to final consumers. This process spans multiple stages, including product planning and sales coordination, sourcing and manufacturing, logistics, warehousing and final order fulfilment. Each stage plays a critical role in ensuring operational efficiency, supply continuity and the ability to meet customer requirements. An

examination of these elements enables deeper understanding of the key processes, challenges and established practices that shape supply chain performance within the electronic components industry (Porter, 1980; Hill & Jones, 2001; NITI Aayog, 2021; MeitY Annual Report, 2022).

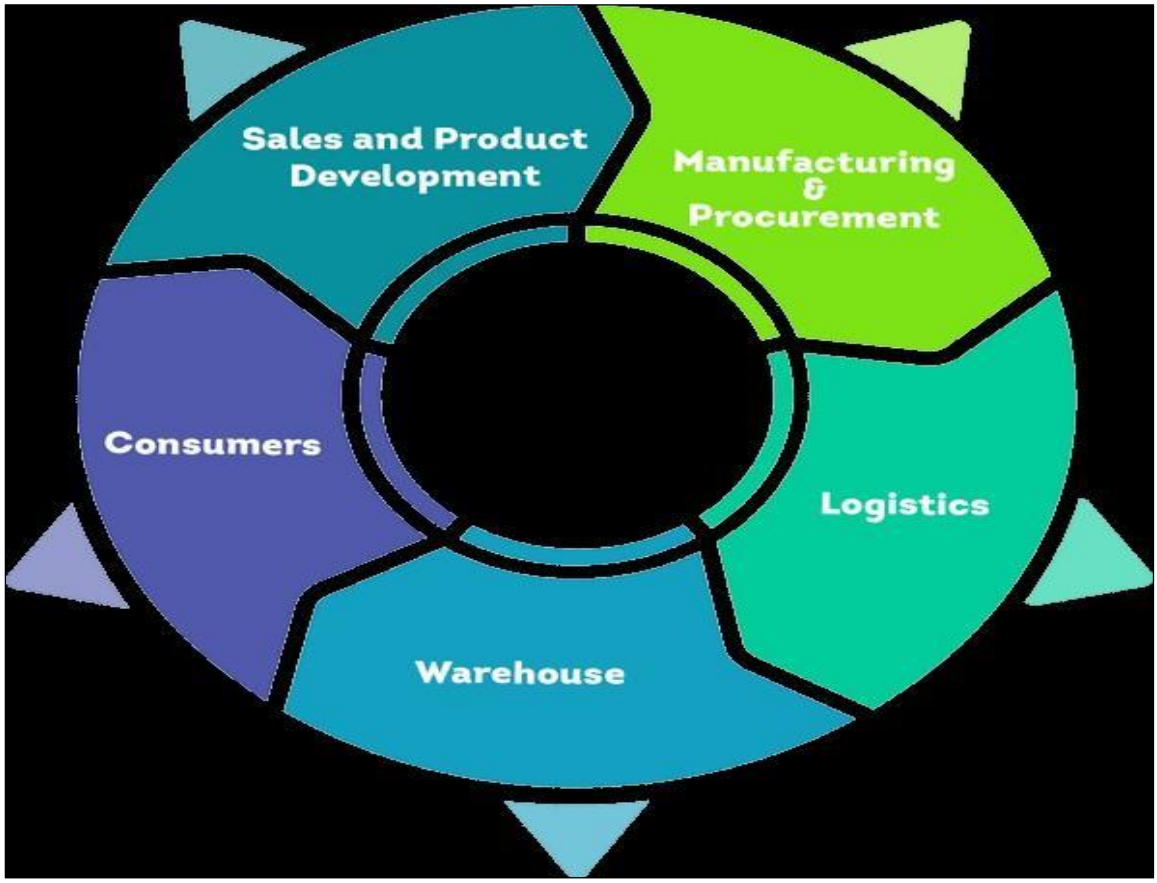

Figure 2.10 Core supply chain management elements in electronic component manufacturing
Source: Panna Technology website

Sales and Product Development:

Sales and product development play a central role within the supply chain by influencing product design choices, market positioning and customer engagement. In the electronic components manufacturing sector, these functions operate in close alignment to interpret shifts in market conditions, evolving customer requirements, and technological developments, thereby supporting innovation and product differentiation. Decisions related to

new component development, enhancement of existing products, and the creation of application specific solutions are informed by market research, customer feedback and competitive analysis (Johnson et al., 2008; Wirtz et al., 2015; IBEF, 2023).

Effective coordination across sales, marketing, engineering, and research and development (R&D) functions is essential to ensure that product portfolios remain aligned with customer expectations and industry demand. Ongoing interaction with customers and strategic partners enables manufacturers to anticipate future requirements, identify emerging opportunities and respond proactively to sectoral challenges. The adoption of advanced tools such as computer aided design (CAD), simulation technologies, and rapid prototyping further supports this process by accelerating product development cycles, reducing time to market, and strengthening overall competitive performance (Skill India Newsletter, 2021; DPIIT, 2022; Invest India, 2022).

Manufacturing and Procurement:

Manufacturing and procurement represent core functions within the supply chain, covering both the production of electronic components and the sourcing of raw materials, parts and subcomponents from external suppliers. Manufacturing effectiveness is closely linked to structured production processes, efficient planning mechanisms, and robust quality control systems that collectively support product consistency, reliability, and cost efficiency. To enhance operational performance, electronic component manufacturers increasingly employ automation, robotics, and advanced manufacturing technologies, which help improve productivity, minimise material waste, and enhance flexibility in response to changing production requirements (Whitepaper ESDM Sector; NITI Aayog, 2021).

Procurement plays an important role in ensuring the continuous availability of materials and components required for manufacturing operations, with effective sourcing strategies, supplier relationship management and regular performance evaluation helping to reduce supply

chain risks, control procurement costs, and maintain production continuity. Close collaboration with reliable suppliers, contract manufacturers and logistics partners allows firms to access specialised capabilities, achieve economies of scale, and respond more effectively to changing market conditions (MeitY Annual Report, 2022; EB Bureau, 2020). The growing adoption of digital technologies further strengthens coordination between procurement and manufacturing functions, as tools such as enterprise resource planning (ERP) systems, supply chain management (SCM) software and digital procurement platforms provide real time visibility into inventory levels, demand forecasts and supplier performance. These insights support more informed decision making, improve sourcing outcomes and enable proactive responses to potential supply chain disruptions (Sharma, 2021; Invest India, 2022).

Logistics:

Logistics within the electronic components manufacturing sector focuses on the coordinated movement, storage and distribution of components across the supply chain, connecting suppliers, manufacturers, distributors and end users. Effective logistics management requires careful planning and execution to ensure timely delivery while controlling transportation costs and inventory holding expenses. Decisions related to transport modes, routing and carrier selection are influenced by factors such as delivery lead times, shipment volumes, geographic coverage and service reliability (IBEF, 2023; Skill India Newsletter, 2021). Given the high value and time sensitive nature of electronic components, logistics operations frequently rely on practices such as just in time (JIT) delivery, cross docking and express transportation services to minimise delays and maintain optimal inventory levels. Collaboration with third party logistics providers (3PLs) and freight forwarders further supports international coordination, customs compliance and adherence to global trade regulations (NITI Aayog, 2021; DPIIT, 2022).

Warehouse Management:

Warehouse management plays a key role in controlling the storage, handling and flow of inventory within electronic component manufacturing facilities and distribution centres. Efficient warehouse operations depend on robust inventory management systems, barcode and tracking technologies, and automation solutions that enhance space utilisation, reduce stock imbalances and improve accuracy in order fulfilment. Warehouse layout design, storage configuration and material handling equipment are strategically optimised to streamline inbound and outbound logistics activities and improve operational efficiency (Whitepaper ESDM Sector; MeitY Annual Report, 2022). Advanced inventory management techniques and demand forecasting further enable manufacturers to optimise inventory levels, reduce carrying costs and improve inventory turnover. Integration of warehouse management systems (WMS) with enterprise platforms, supported by electronic data interchange (EDI) standards, facilitates real time visibility, efficient planning and seamless coordination across supply chain partners (Sharma, 2021; EB Bureau, 2020).

Consumers:

The effectiveness of the electronic components supply chain ultimately depends on the ability of manufacturers to meet the expectations and requirements of end consumers. A strong customer orientation, consistent product quality and reliable service delivery are essential for building brand trust, sustaining competitiveness, and supporting longterm growth. Electronic component manufacturers seek to differentiate themselves by offering compelling value propositions, innovative solutions and responsive customer engagement strategies that foster durable relationships (Porter, 1980; Hill & Jones, 2001). Understanding customer preferences, purchasing behaviour and emerging market trends is critical for shaping product development, pricing strategies and marketing approaches. Continuous interaction with customers through feedback systems, technical support and digital platforms allows firms to capture insights, address concerns, and adapt rapidly to market changes. In addition, after sales services,

warranty programmes and product assurance mechanisms contribute to higher customer satisfaction, repeat business and positive market reputation (Johnson et al., 2008; Wirtz et al., 2015; Banerji, 2021).

Summary

Effective supply chain management is essential for improving competitiveness, resilience, and profitability in the electronic components manufacturing sector. By aligning sales and product development with market needs, enhancing manufacturing and procurement efficiency, and reinforcing logistics and warehouse operations, firms can better address challenges and respond to changing market conditions. This approach supports sustainable growth in an increasingly competitive business environment (Teece, 2010; Invest India, 2022; IBEF, 2023).

Manufacturing Processes

Business models in the electronic components manufacturing sector influence key production decisions including the extent of internal manufacturing, automation and quality assurance practices. Figure 2.11 shows the core manufacturing stages involved in electronic component production namely design, sourcing, assembly, testing, and distribution (NITI Aayog, 2021; Whitepaper ESDM Sector; MeitY Annual Report, 2022; Invest India, 2022).

The manufacturing process begins with the design stage, where product concepts are translated into technical specifications that meet customer requirements, regulatory standards and performance expectations. The use of computer aided design (CAD), simulation tools and prototyping technologies supports iterative design improvement, design for manufacturability, and compliance with quality and sustainability considerations (Johnson et al., 2008; DPIIT, 2022). Sourcing follows, involving the procurement of raw materials and components through structured supplier relationships and digital procurement systems that support cost control, quality consistency and supply continuity (IBEF, 2023; MeitY Annual Report, 2022).

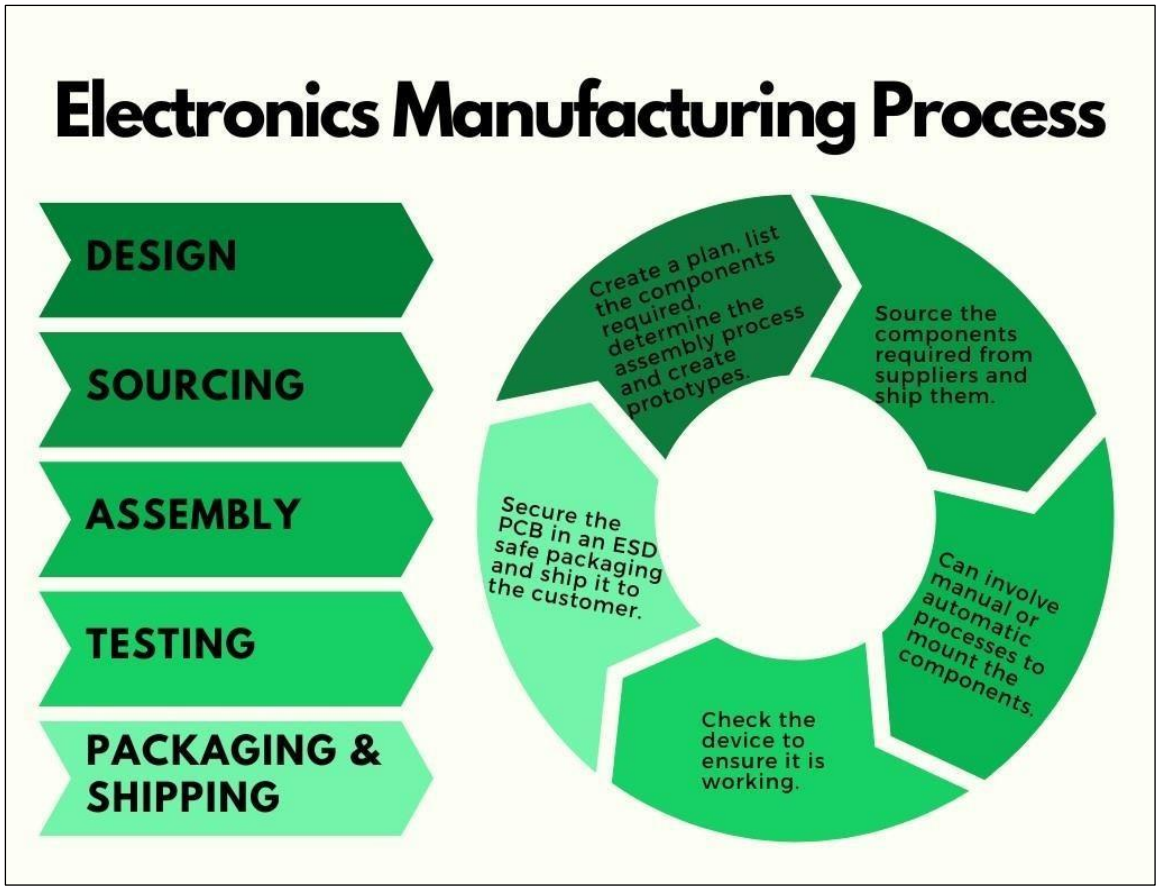

Figure 2.11 Stages of manufacturing process of electronic components

Source: arkcircuits.com

Assembly represents the core production phase, during which components are integrated into functional electronic products using automated manufacturing lines, surface mount technology (SMT) and precision inspection tools. Quality assurance mechanisms, including automated inspection and functional checks, are embedded throughout the assembly process to ensure reliability and regulatory compliance (NITI Aayog, 2021; IBEF, 2023). This is followed by comprehensive testing procedures designed to verify product functionality, durability and performance under operating and environmental conditions, supported by advanced testing platforms and analytics (Sharma, 2021; Invest India, 2022).

The final stage involves packaging and shipping, where products are protected, labelled and distributed through the networks. Effective packaging, traceability mechanisms and logistics planning support product safety, supply chain visibility and timely delivery to customers across domestic and international markets (DPIIT, 2022; EB Bureau, 2020). Overall, the electronic components manufacturing workflow reflects an integrated sequence of value creating activities. When supported by automation, digital systems and effective supply chain coordination, this process enables manufacturers to improve efficiency, maintain product quality and respond to evolving market demands within a highly competitive global environment (Porter, 1980; Hill & Jones, 2001; Wirtz et al., 2015; Invest India, 2022).

Distribution Channels

Distribution channels are necessary for ensuring that electronic components reach customers efficiently and reliably. Figure 2.12 shows the key distribution pathways used in the electronic components manufacturing sector, including direct sales models, distributor-based arrangements, online platforms, and international distribution networks (IBEF, 2023; Invest India, 2022; Skill India Newsletter, 2021; NITI Aayog, 2021). These channels form a structured network that facilitates the movement of components from manufacturers to end users, balancing cost efficiency, market reach and service responsiveness (Porter, 1980; Hill & Jones, 2001).

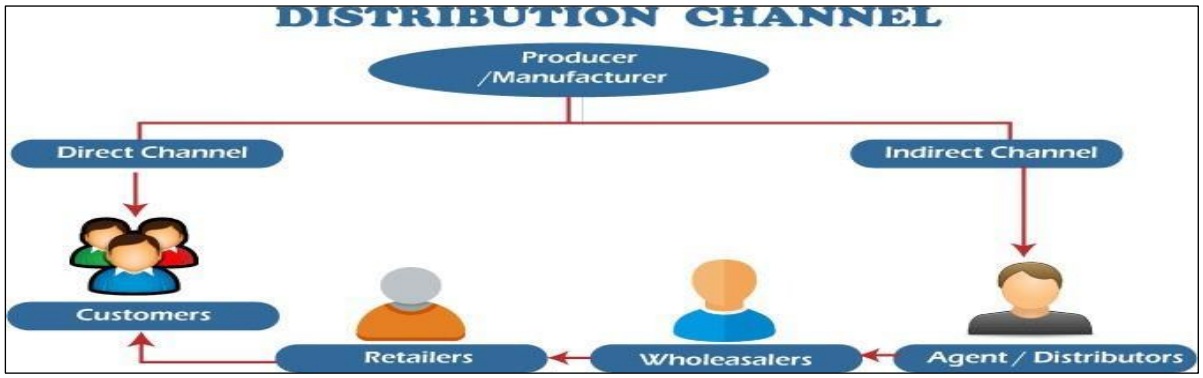

Figure 2.12 Distribution channels in the electronic components manufacturing industry
Source: Javatpoint

The distribution channel within the electronic components manufacturing sector consists of a network of organisations and intermediaries that manage the movement of components from producers to final customers. This complex system includes multiple pathways such as direct and indirect channels, distributors, wholesalers, retailers and end users. In this detailed overview, I will explore each element of the distribution channel and explain their respective roles, responsibilities and interactions within the broader electronic components supply chain (Porter, 1980; Hills & Jones, 2001; Invest India, 2022; IBEF, 2023).

Manufacturer:

Manufacturers occupy a central position within the distribution channel, as they are responsible for producing electronic components and defining product specifications, quality standards, pricing strategies and distribution policies. Electronic component manufacturers range from large multinational firms to producers and their strategic decisions strongly influence channel structure, partner selection and overall market positioning (MeitY Annual Report, 2022; Whitepaper ESDM Sector; Banerji, 2021).

Direct Channel:

In this channel, manufacturers sell electronic components directly to customers without relying on intermediaries. Direct channels provide great control over pricing, brand representation and customer relationship also enabling faster feedback and closer alignment with customer requirements. This approach enables them to customise offerings for market segments and react quickly to shifts in customer preferences (NITI Aayog, 2021; Skill India Newsletter, 2021; DPIIT, 2022).

Indirect Channel:

The indirect channel model uses intermediaries such as distributors, wholesalers and retailers to deliver electronic components to end users. Indirect channels provide manufacturers with wider market access, specialised distribution capabilities and cost efficiencies by utilising

the knowledge that intermediaries possess in sales, marketing and logistics. Manufacturers work with these partners to broaden market presence, enter new geographic territories and reach a wide range of customer groups more effectively
(EB Bureau, 2020; Sharma, 2021; Invest India, 2022).

Distributors:

Distributors operate as intermediaries between manufacturers and customers by collecting electronic components from various suppliers and providing them to retailers, OEMs, contract manufacturers and other end users. Distributors have an important role in managing inventory, completing orders and coordinating logistics and they offer customers a broad selection of products, technical assistance and additional value-based services. The electronic components sector includes authorized distributors, authorized resellers and independent distributors and each category focuses on different market segments and specific customer requirements (IBEF, 2023; NITI Aayog, 2021; Whitepaper ESDM Sector).

Wholesalers:

Wholesalers acquire electronic components in large quantities from manufacturers or distributors and sell them to retailers, contractors, system integrators and other purchasers. They generally operate within particular geographic areas or industry segments and function as major distribution centres and supply points for downstream clients. Wholesalers support bulk ordering, price discussions and inventory consolidation, providing customers with competitive prices, reliable availability and faster delivery choices (Skill India Newsletter, 2021; DPIIT, 2022; EB Bureau, 2020).

Retailers:

Retailers supply electronic components directly to end users, hobbyists, enthusiasts and businesses through physical outlets, online stores, catalogs and sales representatives. Many retailers focus on particular product ranges, brands or applications in order to meet varied

customer needs and preferences. Retailers deliver convenience, product variety and personalised service and they offer technical guidance, product demonstrations and after-sales assistance to improve the overall buying experience (Invest India, 2022; IBEF, 2023; Banerji, 2021).

Customers:

Customers are the final users of electronic components and may include individual consumers, businesses, OEMs, contractors and system integrators. They purchase electronic components for a wide range of applications such as consumer electronics, industrial machinery, automotive technologies, telecommunications equipment, healthcare devices and defense systems. Customer preferences, requirements and purchasing behaviour influence demand trends, product specifications and distribution approaches across the electronic components supply chain (Porter, 1980; Johnson et al., 2008; Wirtz et al., 2015).

Summary

In summary, the distribution channel within the electronic components manufacturing sector consists of an intricate network that includes manufacturers, intermediaries, distributors, wholesalers, retailers and end users. By using both direct and indirect channels, manufacturers can reach diverse customer groups, extend market coverage and improve overall distribution efficiency. Effective coordination among channel partners supported by inventory management and customer-oriented strategies which is essential for strengthening channel performance and sustaining competitiveness in a dynamic market environment (NITI Aayog, 2021; Whitepaper ESDM; MeitY Annual Report, 2022; Hill & Jones, 2001).

Technology Adoption

Business models shape how firms adopt, integrate and apply technology within their operations. The technologies used in electronic components manufacturing encompass IoT,

automation, AI and modern manufacturing techniques (Invest India, 2022; MeitY Annual Report, 2022; IBEF, 2023).

Design and Prototyping:

Design and prototyping mark the starting point of technology adoption, where electronic component manufacturers use advanced software tools, simulation platforms and prototyping methods to conceptualize, build and validate product designs. Computer aided design software supports engineers in generating detailed schematics, layouts and three-dimensional models of electronic components, which promotes visualisation, teamwork and continuous design improvement. Simulation tools such as SPICE and finite element analysis software help engineers study and evaluate electronic circuits, mechanical behaviour and thermal performance, allowing prediction of reliability, functionality and ease of manufacturing (Whitepaper ESDM Sector; Skill India Newsletter, 2021; NITI Aayog, 2021).

Prototyping methods such as 3D printing, rapid prototyping and additive manufacturing support quick iteration and verification of product designs, speeding up the development cycle and lowering time to market. Through the use of digital design and prototyping tools, electronic components manufacturers can enhance product performance, reduce design risks and meet customer needs more effectively (DPIIT, 2022; EB Bureau, 2020; Sharma, 2021).

Manufacturing Automation:

During the manufacturing stage technology is applied primarily through automation where robotics, machine vision systems and artificial intelligence are used to enhance efficiency, precision and production consistency. Automated assembly lines employing robotic arms, pick and place equipment and inspection tools enable high speed and accurate component production while reducing manual labour and error rates (MeitY Annual Report, 2022; Whitepaper ESDM Sector; IBEF, 2023). Machine vision technologies support quality assurance by verifying component placement, solder integrity and assembly accuracy while AI

driven systems analyse production data in real time to optimise process parameters and improve productivity and throughput (Invest India, 2022; Skill India Newsletter, 2021; Banerji, 2021). In addition, advanced manufacturing techniques such as surface mount technology, flip chip bonding and wafer packaging facilitate miniaturisation, integration and cost efficiency, enabling manufacturers to remain competitive in a rapidly evolving electronics market (NITI Aayog, 2021; DPIIT, 2022; EB Bureau, 2020).

Quality Control and Testing:

Quality control and testing are vital stages of the manufacturing workflow where technology plays a central role in ensuring product reliability, performance and compliance with industry standards. Automated testing systems such as automated optical inspection (AOI), incircuit testing and functional testing are widely used to detect defects, verify functionality and confirm sticking to technical specifications (Whitepaper ESDM Sector; MeitY Annual Report, 2022; Johnson et al., 2008). Environmental testing methods, including temperature cycling, vibration which enable manufacturers to assess product durability under real world operating conditions. Advanced inspection techniques such as x-ray analysis, acoustic microscopy and electron microscopy further support failure analysis and continuous quality improvement (Sharma, 2021; Invest India, 2022; Skill India Newsletter, 2021). The integration of data analytics, machine learning, and predictive maintenance tools allows early identification of anomalies, reduces downtime and strengthens overall quality outcomes, contributing to higher customer confidence and brand credibility (Wirtz et al., 2015; Hill & Jones, 2001; Porter, 1980).

Supply Chain Management:

Technology adoption has reshaped supply chain management in the electronic components sector by improving inventory control, procurement, logistics, and demand forecasting. Enterprise resource planning (ERP) systems integrate core business functions and

provide real time visibility across supply chain activities, enabling more informed and timely decision making (NITI Aayog, 2021; Invest India, 2022; MeitY Annual Report, 2022). Supply chain analytics tools further support demand analysis and inventory optimisation by applying predictive models and data driven insights, helping to reduce stock imbalances and carrying costs. In addition, electronic data interchange (EDI) standards enhance coordination and information sharing among suppliers, manufacturers, and customers, while emerging technologies such as blockchain offer opportunities to improve transparency and traceability. Collectively, these digital solutions strengthen supply chain responsiveness allowing manufacturers to adapt more effectively to evolving market conditions and customer expectations (Whitepaper ESDM Sector; Sharma, 2021; EB Bureau, 2020; IBEF, 2023).

Emerging Technologies and Future Trends:

In the future, several developing technologies are expected to transform the electronic components manufacturing sector. These include additive manufacturing, the Internet of Things, 5G connectivity and advanced materials. Additive manufacturing, also referred to as 3D printing, supports rapid prototyping, on demand manufacturing and the creation of complex shapes, which is changing product design, customization options and supply chain processes (Invest India, 2022; Skill India Newsletter, 2021; Whitepaper ESDM Sector).

The Internet of Things is converting standard electronic components into intelligent, connected devices that can gather, process and share data in real time. IoT based sensors, actuators and embedded systems support remote monitoring, predictive maintenance and autonomous functions, creating new possibilities for innovation in healthcare, automotive applications and industrial automation (NITI Aayog, 2021; MeitY Annual Report, 2022; IBEF, 2023).

In addition, 5G connectivity offers extremely fast, low latency communication networks that support real time data transfer, augmented reality, virtual reality and edge

computing applications. This technology enables smooth connectivity and interaction among electronic components, devices and systems, advancing digital transformation and creating new possibilities in smart city development, autonomous transportation and Industry 4.0 environments (DPIIT, 2022; Banerji, 2021; EB Bureau, 2020).

In addition, progress in materials science, nanotechnology and semiconductor fabrication is supporting the creation of next generation electronic components that provide higher performance, improved energy efficiency and greater functionality. Materials such as graphene, carbon nanotubes and other nanoscale structures offer exceptional electrical, thermal and mechanical characteristics, enabling the production of lightweight, flexible and durable components for new uses including wearable devices, flexible screens and advanced energy storage solutions (Sharma, 2021; Whitepaper ESDM Sector; NITI Aayog, 2021).

Summary

The adoption of technology plays an important role in strengthening the growth and competitiveness of the electronic components manufacturing sector. Through the use of advanced design tools, automated production systems, quality assurance technologies and digitally enabled supply chain solutions, manufacturers can respond effectively to changing market demands, support innovation and maintain a competitive position within the digital economy (Porter, 1980; Wirtz et al., 2015; Johnson et al., 2008; Hill & Jones, 2001).

Customer Relationships

Strong customer relationships are essential for success in the electronic components manufacturing sector, where long term partnerships support innovation, responsiveness and competitiveness. Manufacturers rely on customer engagement, support services, and collaborative relationships to understand evolving requirements and deliver value across diverse market segments (IBEF, 2023; Invest India, 2022; Hill & Jones, 2001). Effective customer relationship strategies help firms build trust, improve coordination and maintain a

stable market position in a competitive global environment (Teece, 2010; Wirtz et al., 2015; Porter, 1980).

Customer Segmentation:

Managing customer relationships begins with identifying and segmenting customers based on factors such as industry type, application requirements, purchasing behaviour, geographic location and organisational scale. Customer segmentation enables electronic component manufacturers to tailor product offerings, technical solutions, and service support to the specific needs of each segment, thereby enhancing customer value and satisfaction (NITI Aayog, 2021; MeitY Annual Report, 2022; Skill India Newsletter, 2021). Manufacturers often serve sectors such as automotive, consumer electronics, telecommunications, healthcare and industrial automation each with distinct regulatory, technical, and performance requirements that influence product design and service expectations (IBEF, 2023; Invest India, 2022; Whitepaper ESDM Sector).

Communication Channels:

Effective communication plays a key role in building and sustaining customer relationships within the electronic components manufacturing sector. Manufacturers engage with customers through multiple channels including direct sales teams, technical support services, digital platforms, online portals, and industry events. These channels facilitate information exchange, technical collaboration and issue resolution across different stages of the customer lifecycle, supporting stronger engagement and long term relationship development (Sharma, 2021; DPIIT, 2022; EB Bureau, 2020).

Direct sales teams and account managers serve a primary point of contact for important customers providing support, expertise and product guidance that match the customer specific requirements. Customer service representatives manage questions, complaints and order processing, ensuring quick issue resolution and timely product delivery. Technical support

engineers provide specialised help, troubleshooting support and application guidance to enable customers to enhance product performance and address technical problems effectively (Porter, 1980; Hills & Jones, 2001; Wirtz et al., 2015).

Online portals and self service platforms give customers access to product details, technical documents, training materials and online support tools, allowing them to locate answers to common questions, place orders and monitor shipments with ease. Social media channels, industry forums and user communities promote engagement, collaboration and knowledge sharing, helping customers exchange insights, best practices and feedback with peers and industry specialists (Whitepaper ESDM Sector; Skill India Newsletter, 2021; IBEF, 2023).

Value Proposition:

The value proposition forms the core of customer relationships in the electronic components manufacturing sector and reflects the distinct benefits, features and advantages that producers provide to customers. A strong value proposition explains how a manufacturer's products, services and solutions meet customer needs, resolve challenges and deliver clear value and benefits (Johnson et al., 2008; Teece, 2010; Wirtz et al., 2015).

Electronic component manufacturers differentiate themselves by delivering high quality products that meet performance standards, reliability requirements and industry certifications. Advances in system integrations and material technologies have enabled the development of components with enhanced functionality, energy efficiency, and durability supporting increasingly complex applications across end user industries (NITI Aayog, 2021; MeitY Annual Report, 2022; Banerji, 2021). Cost effectiveness also forms a central part of the value proposition as customers assess suppliers based on pricing competitiveness and total cost of ownership.

To address this, manufacturers optimise production processes, streamline supply chain operations and leverage economies of scale to remain cost competitive while ensuring long term sustainability (DPIIT, 2022; EB Bureau, 2020; Invest India, 2022). In addition, technical support, engineering assistance and after sales services strengthen customer confidence and foster long term partnerships, positioning manufacturers as trusted suppliers within the electronic components industry (IBEF, 2023; Whitepaper ESDM Sector; Skill India Newsletter, 2021).

Service Excellence:

Service excellence plays a key role in building positive customer experiences and strengthening relationships within the electronic components manufacturing sector. Manufacturers prioritise service quality, responsiveness and reliability through efficient order processing, accurate product documentation, timely delivery and transparent communication in order to meet customer expectations and industry standards (Porter, 1980; Hill & Jones, 2001; MeitY Annual Report, 2022). Technical support further contributes to customer satisfaction by providing prompt assistance, troubleshooting guidance and practical solutions when customers encounter integration, performance challenges thereby minimising disruption and supporting continued product use. By providing timely, skilled and proactive technical support, manufacturers can improve customer satisfaction and loyalty (EB Bureau, 2020; Sharma, 2021; Invest India, 2022).

Additionally, manufacturers invest in ongoing improvement programs, customer feedback systems and service performance indicators to track, evaluate and enhance service quality over time. Voice of the customer programs, customer satisfaction surveys and service level agreements help manufacturers collect insights, pinpoint improvement areas and prioritise service enhancements according to customer feedback and preferences (Whitepaper ESDM Sector; Skill India Newsletter, 2021; IBEF, 2023).

Long-Term Partnerships:

Developing long term partnerships with customers represents the primary objective of customer relationship management in the electronic components manufacturing sector. Such partnerships are defined by mutual trust, collaboration and shared objectives, where manufacturers and customers work together to promote innovation, overcome challenges and achieve business success. Manufacturers aim to become trusted advisors, strategic partners and preferred suppliers by providing outstanding value, reliable service and strong support to their customers (Johnson et al., 2008; Teece, 2010; Wirtz et al., 2015).

Long term partnerships are further strengthened through consistent communication, transparency and reliability which help build trust and reinforce customer loyalty. By maintaining a strong commitment to customer success and service quality, manufacturers can position themselves as dependable partners and preferred suppliers within the electronic components manufacturing sector (Invest India, 2022; MeitY Annual Report, 2022; Whitepaper ESDM Sector).

Overall, effective customer relationship management supports business growth by enabling manufacturers to deliver tailored solutions, sustain long term partnerships, and enhance competitive advantage in a dynamic market environment (Porter, 1980; IBEF, 2023; Invest India, 2022; Hill & Jones, 2001).

Risk Management

Business models in the electronic components manufacturing sector incorporate strategies to identify, manage and mitigate risks arising from complex operational and market environments. Key risks include supply chain disruptions, technological obsolescence, market volatility and regulatory change all of which can influence production continuity, profitability and long-term competitiveness (IBEF, 2023; Invest India, 2022; Teece, 2010; Porter, 1980).

Supply Chain Disruptions:

Supply chain disruptions represent a major risk due to the globalised and interdependent nature of electronic component production. Factors such as geopolitical tensions, natural disasters, trade restrictions and supplier failures can interrupt material availability and delay production schedules. Heavy reliance on single suppliers and long lead times further intensify vulnerability (Electronics B2B, 2020; Sharma, 2021). To mitigate these risks, manufacturers adopt supplier diversification, dual sourcing strategies, contingency planning and digital monitoring tools. Technologies such as predictive analytics, IOT enabled tracking, and blockchain enhance supply chain visibility and enable early detection of potential disruptions (IBEF, 2023; Invest India, 2022).

Technological Obsolescence:

Rapid technological change and short product life cycles expose electronic component manufacturers to the risk of technological obsolescence. Inability to adapt to evolving standards, materials or design requirements can result in inventory declining demand and loss of market relevance (Banerji, 2021; MeitY, 2022). Risk mitigation strategies include sustained investment in research and development, continuous product innovation and collaboration with technology partners and academic institutions. Strategic alliances, acquisitions and workforce skill development further support innovation capability and technological adaptability (Wirtz et al., 2015; Johnson et al., 2008; NITI Aayog, 2021).

Market Fluctuations:

Market fluctuations offer significant risks through fluctuating demand, pricing pressures and global competition. Shifts in consumer preferences, economic cycles and industry trends can lead to demand uncertainty and capacity imbalances, affecting revenue stability and profitability (EB Bureau, 2020; IANS, 2021). Manufacturers address these challenges through flexible production systems, demand forecasting, lean manufacturing practices, and diversification across products, customers and geographic markets.

Collaborative planning with customers and suppliers further improves responsiveness to changing market conditions (Hacklin & Johnson, 2018; Porter, 1980).

Regulatory Changes:

Regulatory risks arise from evolving legislation, environmental standards, trade policies and compliance requirements across different regions and markets. Failure to meet regulatory obligations can result in penalties, reputational damage and restricted market access (DPIIT, 2022; MeitY, 2022). To manage these risks, manufacturers implement structured compliance management systems supported by cross functional coordination, regulatory monitoring and regular audits. Engagement with industry bodies and investment in regulatory intelligence tools help firms anticipate policy changes and maintain compliance in dynamic regulatory environments (IBEF, 2023; Invest India, 2022; NITI Aayog, 2021).

Conclusion

By addressing supply chain, technological, market and regulatory risks through diversification, innovation, collaboration and digital capabilities, firms can strengthen operational resilience and sustain long term competitiveness. Robust risk management not only safeguards business continuity but also enables manufacturers to adapt strategically and capitalise on emerging opportunities (Teece, 2010; Porter, 1980; Wirtz et al., 2015; IBEF, 2023).

2.8 Challenges faced by electronic components manufacturing industries

The major challenges faced by the electronics industry followed by issues that are particularly relevant to electronic components manufacturing. The electronics sector, spanning consumer devices, industrial systems and advanced technologies, operates in a highly competitive and rapidly evolving environment shaped by technological change, regulatory demands and global economic forces. Understanding these challenges is essential for sustaining growth and longterm competitiveness across the industry (EB Bureau, 2020; IBEF, 2023; Invest India, 2022). High-Level Challenges Faced by Electronic Industries:

Rapid Technological Advancements

The electronics industry is characterised by continuous technological advancement, driven by developments such as artificial intelligence, the internet of things and 5G connectivity (Invest India, 2022; Sharma, 2021).

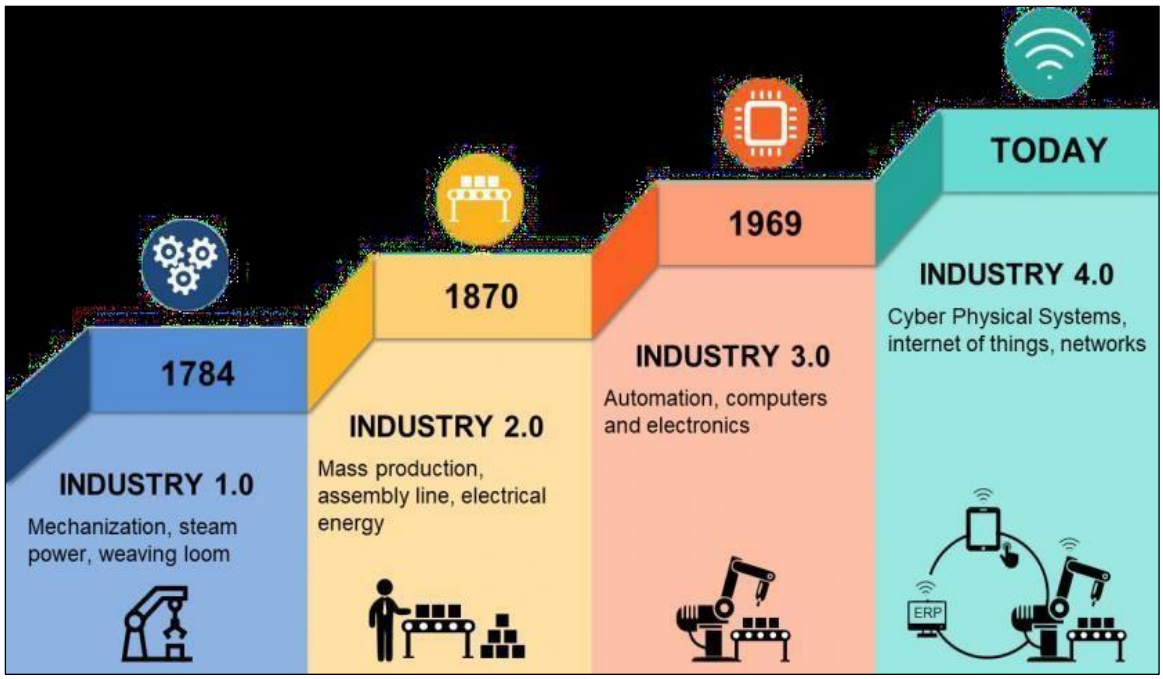

Figure 2.13 Technological Advancements

Source: Sciencedirect.com

Short Product Lifecycles

The innovations create new opportunities they also require manufacturers to upgrade products frequently, leading to shorter product lifecycles and increased pressure on research and development investment (Banerji, 2021; Wirtz et al., 2015).

Global Supply Chain Disruptions

Electronics manufacturing depends on globally interconnected supply chains involving multiple supplier tiers and logistics partners. This complexity exposes firms to risks arising from geopolitical tensions, trade restrictions, natural disasters and operational failures as highlighted during the covid pandemic. Disruptions can lead to production delays, component

shortages and increased costs, making supply chain resilience a critical concern (EB Bureau, 2020; NITI Aayog, 2021; Sharma, 2021).

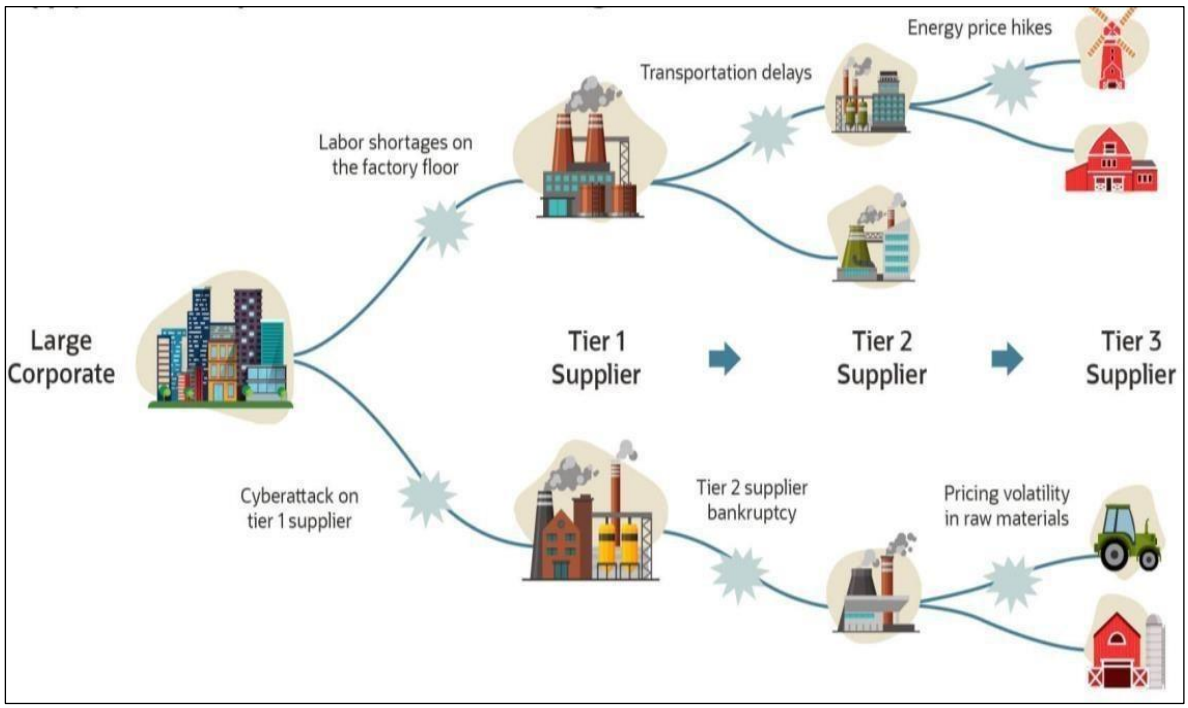

Figure 2.14 Market size of electronic components, 2022 to 2032 (USD BILLION)

Source: Oracle NetSuit.com

Intellectual Property Protection

Protecting intellectual property is a critical concern in the electronics sector, where innovation underpins competitive advantage. Risks such as piracy and unauthorised use of proprietary technologies can wear away returns on R&D investment and undermine firms market positions (EB Bureau, 2020; Sharma, 2021; Whitepaper ESDM Sector).

Regulatory Compliance

Electronic products are required to meet safety, environmental, and performance regulations across different markets, which adds complexity to product development and increases manufacturing costs (DPIIT, 2022; MeitY Annual Report, 2022; IBEF, 2023).

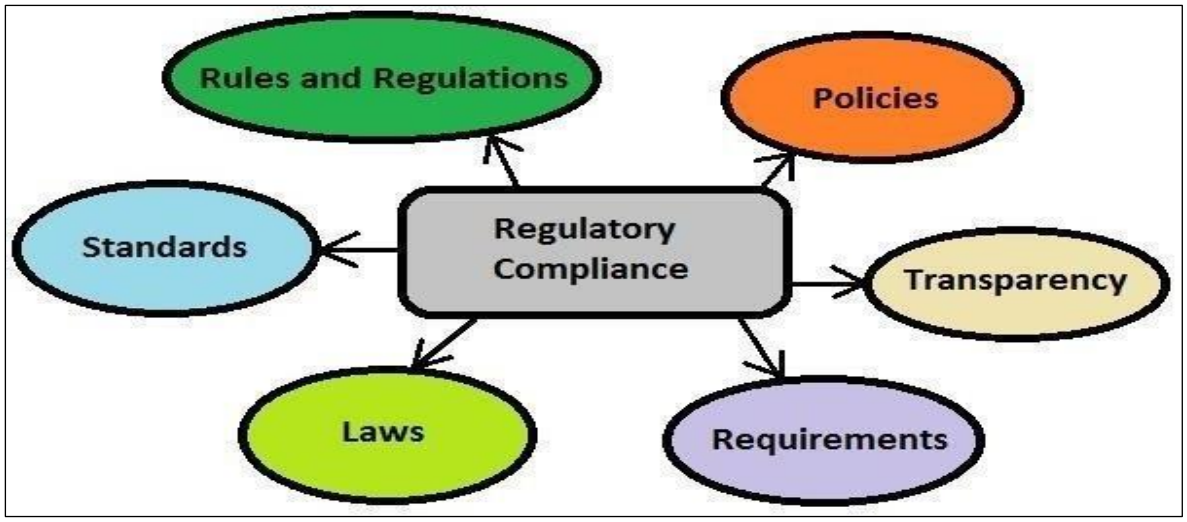

Figure 2.15 Regulatory Compliance

Source: powerelectronicstalks.com

Environmental Sustainability

Increasing emphasis on environmental sustainability requires electronics firms to address challenges such as e-waste management, energy efficiency and environmentally responsible manufacturing practices, with failure to do so posing reputational and regulatory risks (NITI Aayog, 2021; DPIIT, 2022; MeitY Annual Report, 2022).

Figure 2.16 Environmental Sustainability

Source: Forbes.com

Complex Supply Chain Management

Electronic components manufacturing relies on intricate global supply chains that include numerous supplier tiers, subcontractors and logistics partners. Coordinating this level of complexity while ensuring on-time delivery of components and consistently meeting quality requirements creates substantial operational challenges (Sharma, 2021; EB Bureau, 2020; Invest India, 2022).

Technological Obsolescence

Electronic components manufacturing depends on complex global supply chains involving multiple suppliers, subcontractors and logistics partners, making coordination, timely delivery and consistent quality assurance significant operational challenges (Sharma, 2021; EB Bureau, 2020; Invest India, 2022).

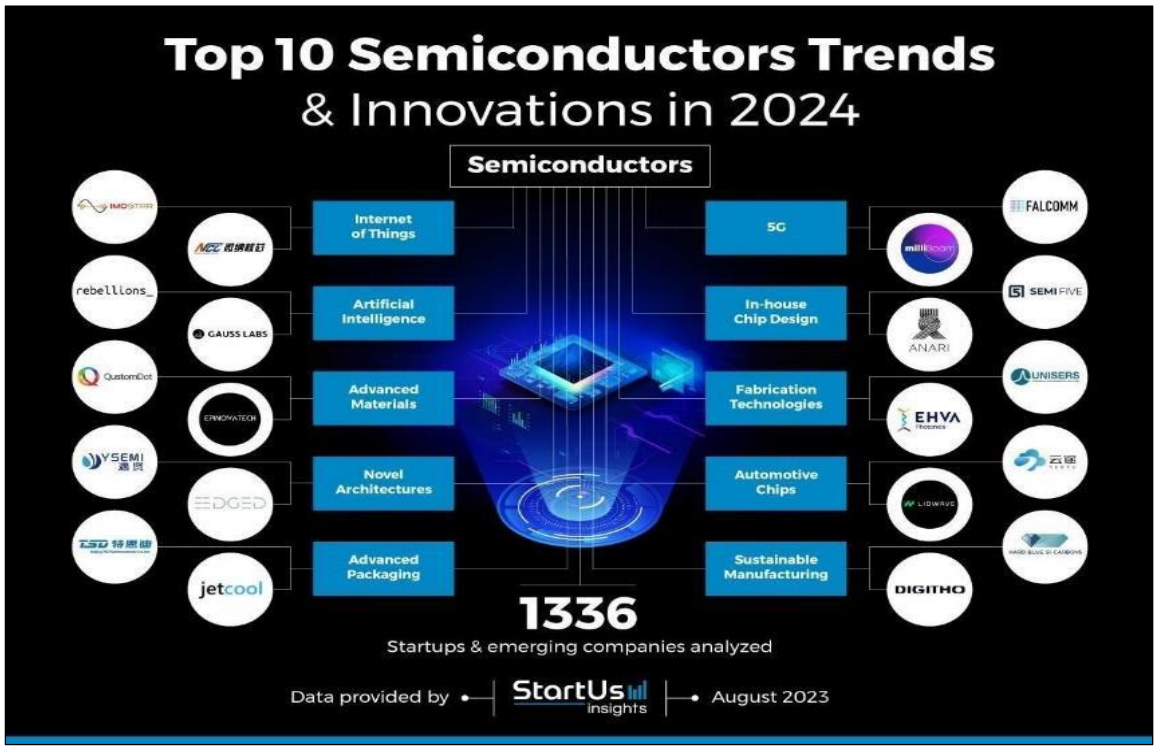

Figure 2.17 Advancements in semiconductor technology

Source: Startus insights.com

Quality Assurance and Testing

Ensuring the quality and reliability of electronic components is essential as these components are integral to the performance of a wide range of electronic devices. Manufacturers must comply with quality standards, manage complex testing requirements and continuously improve processes to meet evolving market and performance expectations (MeitY Annual Report, 2022; NITI Aayog, 2021; Whitepaper ESDM Sector).

Global Competition and Pricing Pressures

The electronic components manufacturing sector is highly competitive, requiring firms to balance competitive pricing with profitability. Intense competition from global manufacturers, particularly those operating in lower cost regions, increases pricing pressure and constrains margins making cost efficiency and differentiation critical for sustained competitiveness (IBEF, 2023; Invest India, 2022; EB Bureau, 2020).

Supply Chain Resilience

Building supply chain resilience is increasingly important for reducing risks arising from component shortages, geopolitical instability and natural disasters. Strategies such as supplier diversification, targeted risk mitigation measures and the use of digital technologies to enhance visibility and responsiveness support greater supply chain robustness (Invest India, 2022; NITI Aayog, 2021; MeitY Annual Report, 2022; Wirtz et al., 2015; Porter, 1980).

2.9 Summary

Development of India's electronics industry is reviewed in this chapter highlighting its rapid growth driven by rising consumer demand, increasing digital adoption, and supportive government initiatives. The analysis indicates that the Electronic System Design and Manufacturing (ESDM) sector is expected to expand significantly in the coming years, supported by advancements in areas such as electric vehicles, medical electronics, and telecommunications (EB Bureau, 2020; Invest India, 2022). Although percapita electronic consumption in India remains below the global average, improvements in affordability, rural

penetration and smartphone adoption continue to stimulate both domestic demand and production growth (IBEF, 2023).

The chapter also examined key industry segments including consumer electronics, industrial electronics and IT hardware with consumer electronics particularly smartphones emerging as a major driver of expansion. India's position as one of the world's largest smartphone markets has attracted both domestic and multinational manufacturers, supported further by policy initiatives such as the Production Linked Incentive (PLI) scheme aimed at strengthening domestic manufacturing capacity (IANS, 2021; Banerji, 2021; MeitY Annual Report, 2022).

Despite these positive trends, the industry faces persistent challenges including infrastructure gaps, skill shortages, supply chain vulnerabilities, regulatory complexity, and weak intellectual property protection. These constraints alongside intense global competition and limited semiconductor fabrication capability continue to restrict India's ability to scale high value manufacturing and expand its global market share (Sharma, 2021; Whitepaper ESDM Sector). Supported by favourable demographics, ongoing digital transformation and continued policy focus India's electronics industry retains strong potential. With sustained investment in infrastructure, skills and innovation, and closer collaboration between industry and government, the sector is well positioned to contribute to long term economic growth, employment generation and technological advancement (NITI Aayog, 2021; DPIIT, 2022).

In addition to outlining sectoral growth and structural constraints, the literature reviewed in this chapter underscores the importance of examining electronics manufacturing through an integrated ecosystem perspective. Prior studies consistently suggest that production outcomes in electronics are shaped not only by market demand or policy incentives, but also by the interaction between infrastructure readiness, supply-chain depth, technological capability and institutional coordination (Porter, 1980; Teece, 2010; NITI Aayog, 2021). This

reinforces the view that manufacturing performance must be understood as the result of cumulative system level factors rather than isolated firm-level decisions.

The review further highlights that India's electronics industry remains characterised by a strong assembly orientation, with relatively limited progression into advanced component manufacturing and high value design intensive activities. While policy initiatives have successfully attracted large-scale assembly operations, the literature indicates that deeper industrial upgrading requires sustained investment in research and development, skill formation, and domestic supplier capability, areas where gaps persist relative to established manufacturing hubs (Banerji, 2021; Whitepaper ESDM Sector; Invest India, 2022). These findings point to the need for a more balanced development approach that supports both volume growth and capability accumulation.

Finally, the synthesis of academic, industry and policy literature reveals clear gaps that justify the present study. While existing research documents India's electronics growth trajectory and policy landscape, fewer studies systematically examine why electronic component manufacturing has not scaled at the same pace as in economies such as China, Taiwan and South Korea. This gap highlights the need for focused analysis of component-level manufacturing constraints, comparative capability differences and ecosystem-level barriers, which the subsequent chapters of this dissertation seek to address.

CHAPTER III:

METHODOLOGY

3.1 Introduction

This chapter is proposed to outline the methodology adopted in this research to examine the challenges limiting to India's electronic components manufacturing sectors growth. This study tends to explain why India's electronic components manufacturing ecosystem has not upscaled comparable to established hubs like Taiwan, China and Vietnam. The approach has been designed to address the research problem in a structured way.

This study adopts a mixed method research design. A qualitative approach is appropriate because it allows for a detailed examination of industry level challenges, structural constraints and contextual factors shaping electronic components manufacturing in India (Flick, 2009). The research is based on an exploratory analysis of secondary data sources enabling key patterns from existing evidence rather than being imposed through predefined assumptions (Schreier, 2018; Ruggiano & Perry, 2019).

Research design serves as the framework that links research questions, data sources and analytical procedures. As noted by Trochim (2005), a clear research design ensures coherence across all stages of the study and enhances reliability and transparency. In line with this view, the present study employs a descriptive qualitative design to document existing conditions within the electronic components manufacturing sector and to support comparative analysis across countries using established secondary data sources (Wickham, 2019).

This chapter therefore presents the research design and methodological approach followed by a description of data sources, data collection and analysis procedures, ethical considerations and methodological limitations. The chapter concludes with a summary of the methods adopted to address the research questions.

3.2 Research Methods and Design

This study adopts mixed methods of research design combining qualitative content analysis of secondary data with quantitative comparative analysis across selected countries. This approach enables examination of the research problem by integrating qualitative insights from sources with descriptive numerical indicators drawn from datasets. The mixed methods design supports triangulation and enhances the robustness of the findings while remaining appropriate to the study's scope and timeframe (Flick, 2009; Wickham, 2019).

The research is qualitative dominant with quantitative analysis used to support cross country comparison. A qualitative approach is suitable given the study's objective of understanding structural, policy related and industry specific challenges influencing the growth of India's electronic components manufacturing sector (Flick, 2009).

Descriptive nature is in the study focusing on documenting existing conditions and observable patterns within the electronic components manufacturing industry. Descriptive research is appropriate for examining industry realities and comparative positioning using existing evidence (Wickham, 2019).

The research relies exclusively on secondary data sources. Academic literature, government policy documents, industry and market reports and international datasets are included. The use of secondary data enables longitudinal analysis, cross-country comparison and industry level assessment without direct engagement with research participants (Ruggiano & Perry, 2019; Wickham, 2019).

An inductive analytical approach is adopted for the qualitative component of the study. This approach involves identifying recurring patterns obtaining from the data. Inductive qualitative analysis is particularly suitable for exploratory studies that seek to explain complex sectoral challenges based on evidence derived from multiple sources (Schreier, 2018).

The study is guided by an interpretivist research philosophy which recognises that industry performance and outcomes are shaped by economic, institutional, and policy contexts. This perspective supports an understanding of the electronic components manufacturing sector and aligns with the qualitative and descriptive briefing of the research (Flick, 2009).

Together, these methodological choices provide a proper framework for examining why India's electronic components manufacturing sector has not expanded at the same pace as comparable global manufacturing hubs.

3.3 Population and Sample

Population

The population for this study covers the electronic components manufacturing sector in India examined withinn leading manufacturing economies such as China, Taiwan, South Korea and the United States. As the study is based entirely on secondary data, the population does not consist of individual respondents. Instead, it includes industryy level evidence drawn from policy documents, organizational and sectoral reports, trade and production statistics and relevant academic literature related to electronic components manufacturing.

This population is suitable for addressing the research problem as the study focuses on macro level structural, technological and policy related factors influencing India's electronic components manufacturing sector in comparison with established global hubs. Analyzing industry wide data enables the identification of gaps and comparative performance patterns aligned with the research objectives.

Sample

The sample for this study is obtained from the population through purposeful selection of secondary data sources relevant to electronic components manufacturing. The sampled materials include government policy publications, industry and market research reports, trade association documents, academic journal articles and internationally recognized statistical

datasets. These sources were selected based on their credibility, relevance and direct alignment with the research questions.

Purposeful sampling is suitable for qualitative and descriptive research where the objective is to draw insights from information rich sources that clear up key aspects of the facts under study (Suri, 2011). This approach allows focused examination of documents that address manufacturing challenges, technological capabilities, policy interventions and comparative industry outcomes.

The inclusion of data from multiple countries also supports cross country comparison enabling the study to situate India's performance within the global electronic components manufacturing area. The use of secondary data as the sample is consistent with qualitative research practice and appropriate for descriptive and comparative analysis at the industry level (Schreier, 2018; Ruggiano & Perry, 2019).

3.4 Data Collection, Processing, and Analysis

This study depends on secondary data to examine India's electronic components manufacturing sector. Data were sourced from credible publications including government reports, statistical databases, industry and market research reports, trade association documents, academic journals, patent databases, international trade records and reputable media sources. Secondary data are appropriate for analyzing industry level phenomena particularly where longitudinal trends and cross country comparisons are required (Wickham, 2019; Ruggiano & Perry, 2019).

The study adopts a mixed methods approach. The qualitative component involves content analysis of policy documents, industry reports and academic literature to identify recurring themes, structural constraints and contextual factors influencing sectoral development (Schreier, 2018). The quantitative component consists of descriptive and

comparative analysis using existing statistical indicators related to production trends, export performance, investment levels and industry capacity (Wickham, 2019; Hanckel et al., 2021).

Key data sources include publications from the Ministry of Electronics and Information Technology and comparable international datasets from countries such as China, Taiwan, South Korea and the United States, providing meaningful cross-country comparison. Industry reports from trade bodies and market research organizations provided sector specific insights while academic literature supported conceptual framing and contextual interpretation (Flick, 2009).

Data preparation involved systematic cleaning and organization to ensure consistency and comparability across sources. Missing or incomplete data were handled cautiously to preserve analytical integrity. The processed data were categorized according to the research questions to support structured analysis and comparison (Schreier, 2018).

Descriptive analysis was used to summarize key sectoral characteristics while comparative analysis shows up differences in manufacturing scale, innovation capacity and global integration across countries. Together, these methods ensure transparency and replicability providing a strong empirical foundation for addressing the research questions and supporting subsequent discussion.

3.5 Limitations

All research studies are subject to limitations that may influence the scope and interpretation of their findings. This study acknowledges several limitations arising from its qualitative descriptive design and its reliance on secondary data. Recognizing these constraints is important to ensure transparency and to appropriately contextualize the results (Wickham, 2019).

A primary limitation relates to the use of secondary data. While secondary sources enable cost effective analysis and support cross country comparisons. The researcher has no control over the original data collection methods. Differences in data quality, measurement

approaches and reporting standards therefore exist across sources (Ruggiano & Perry, 2019). This limitation was addressed by selecting data from credible sources and cross-checking information where possible.

Another limitation concerns data availability and consistency. Certain indicators relevant to electronic components manufacturing are not uniformly reported across countries or time periods which can restrict the depth of comparative analysis. Such gaps are an inherent challenge in secondary research and may limit the level of detail achievable in specific areas (Wickham, 2019).

The study is also limited by its descriptive and comparative analytical approach. While this approach is effective for identifying patterns, trends and differences across national contexts it does not establish causal relationships (Hanckel et al., 2021).

The electronic components manufacturing sector is shaped by dynamic economic, technological and policy factors that vary across regions and over time. As a result, the findings may not be universally applicable to all industry contexts or future conditions. To mitigate this the analysis carefully considers contextual differences when presenting results (Schreier, 2018).

Finally, time related limitations are acknowledged as secondary data may not fully capture the most recent developments due to publication lags. In a rapidly evolving industry such delays can affect the currency of available information. Ethical considerations related to the responsible use of secondary data were addressed through adherence to established research ethics guidelines (Tripathy, 2013).

Despite these limitations the methodological approach adopted is appropriate for addressing the research questions. By acknowledging these constraints transparently, the study maintains methodological accuracy and provides a balanced foundation for analysis and discussion.

3.6 Ethical Assurances

Ethical integrity is central to the credibility of this research. The study adheres to established ethical principles applicable to qualitative research and secondary data analysis. Although no direct interaction with human participants was involved, ethical responsibility remains important due to the use of secondary data obtained from public, institutional and online sources (Tripathy, 2013). All data used were publicly available or ethically accessible at the time of collection and were drawn from reputable organizations such as government bodies, academic institutions, industry associations and recognized research organizations (Ruggiano & Perry, 2019).

Ethical awareness was maintained throughout the data selection, analysis and reporting processes. The researcher assessed the transparency and reliability of original sources and consulted multiple datasets where appropriate to reduce bias and avoid misrepresentation (Wickham, 2019). No personal data were used, and all information was handled responsibly and solely for academic purposes. Data were interpreted cautiously with attention to contextual differences across national and institutional settings, and without attempting to distort findings or support predetermined conclusions (Schreier, 2018).

Proper acknowledgement of all original authors and data providers was ensured through accurate citation and referencing in line with academic conventions. This approach safeguards intellectual property rights, prevents plagiarism and supports transparency and traceability of the research process (Ruggiano & Perry, 2019). Overall, by adhering to recognised ethical guidelines for secondary research, maintaining transparency in data use and applying responsible interpretation this study upholds high standards of ethical conduct and reinforces the trustworthiness of its methodological approach.

3.7 Summary

This chapter outlined the methodological framework adopted to examine the challenges affecting India's electronic components manufacturing sector in comparison with countries such as China, Taiwan, the United States and South Korea. The study was designed to address the central research question concerning India's relatively slower sectoral growth through a qualitative, descriptive and inductive research approach supported by an interpretivist research philosophy (Flick, 2009; Wickham, 2019).

The methodology enabled a systematic examination of industry level challenges using secondary data analysis. A qualitative approach supported indepth exploration of structural, policy related and contextual factors shaping the sector while the descriptive design facilitated the examination of existing conditions, long term trends and cross country differences using published evidence (Schreier, 2018; Ruggiano & Perry, 2019). An inductive analytical process allowed themes and patterns to emerge directly from the data rather than being imposed through predefined theoretical constructs supporting an exploratory and context sensitive analysis.

The chapter also detailed the procedures for data collection, preparation and analysis including source verification, data organization and comparative assessment ensuring transparency and analytical rigor (Wickham, 2019). Methodological limitations related to secondary data reliance, descriptive analysis and generalizability were acknowledged and addressed through careful source selection and cautious interpretation. Ethical considerations relevant to secondary research were emphasized to ensure responsible data use and academic integrity (Tripathy, 2013). Overall, the methodological approach adopted provides a robust and coherent foundation for the analysis presented in the subsequent chapters.

CHAPTER IV:

RESULTS

4.1 Introduction

The findings of the study are presented in this chapter based on the analysis of secondary data relating to the electronic components manufacturing sector. In line with the research objectives, the chapter is limited to the presentation of results derived from data analysis and does not include interpretation, evaluation or discussion.

The findings reported in this chapter are drawn from a mixed method research design that combines qualitative content analysis of secondary documentary sources with quantitative summarisation of qualitative evidence and descriptive numerical indicators. The qualitative component involved systematic examination of documentary materials to identify recurring themes and patterns aligned with the research questions. This was complemented by quantitative techniques including frequency counts and descriptive indicators to provide structured numerical representation of the qualitative findings.

The secondary data sources used in this analysis include government policy documents, industry and market research reports, academic publications, international trade statistics, patent and bibliometric databases, and global development datasets. These sources were selected to capture policy, industry, technological, and international comparative dimensions relevant to electronic components manufacturing. The results presented reflect consistent patterns identified across these diverse data sources.

To maintain clarity and transparency the findings are organised according to the research questions guiding the study enabling direct alignment between research objectives and reported results. Section 4.2 presents the detailed findings and is divided into two parts: Section A reports result from the qualitative content analysis, including quantitative frequency analysis of qualitative data for each research question, while Section B presents descriptive quantitative

results based on secondary numerical indicators. Section 4.3 provides a consolidated summary of the key findings serving as a transition to the discussion in the following chapter.

4.2. Results

This section presents the results of the study derived from the content analysis of secondary data related to the electronic components manufacturing sector. In accordance with the study design, this chapter focuses exclusively on the presentation of results without interpretation or discussion. The findings reported in this section are based on qualitative content analysis and quantitative descriptive evidence obtained from government publications, industry and market research reports, statistical records, academic literature, patent databases and international trade records. The results are organized in alignment with the research questions and are presented systematically in the following sub-sections.

A. Content analysis of qualitative data

Table 4.1: Data sources utilised for content analysis of secondary data.

Data Sources	**Data type**	***Description***
Government publications	Policy documents, reports	Official policy documents, strategy papers and sectoral reports related to electronics manufacturing and industrial development, used to identify policy priorities, regulatory context and reported challenges.
Statistical records	Quantitative datasets	National and international statistical records providing data on manufacturing output, R&D expenditure, exports, and sector performance.
Industry and market research reports	Reports	Industry analyses and market research reports published by industry bodies and research organisations, used to identify sector-level trends, constraints and stakeholder perspectives.
Academic journals and scholarly articles	Peer-reviewed articles	Academic literature examining electronics manufacturing, industrial ecosystems, technology capability and comparative manufacturing performance.

Patent databases	Patent records	Patent data used to examine innovation activity and technological development related to electronic components manufacturing.
International trade records	Trade statistics	International trade data used to analyse export–import patterns and global integration of electronics manufacturing.

The qualitative content analysis of secondary data produced a set of recurring patterns and themes relevant to the research questions guiding this study. Through systematic coding and categorisation of documentary evidence, the analysis identified key issues reported across policy documents, industry reports, academic literature and trade-related sources. The findings derived from this analysis are presented in the following sub-sections, structured according to each research question.

Findings for RQ1

Research Question One (RQ1): What are the key quantitative differences in policy interventions, public investments, infrastructure, and global integration supporting electronic components manufacturing between India and established hubs like China, Taiwan, and Vietnam?

The findings for Research Question One are derived from the qualitative content analysis of secondary data sources. The results summarise the key barriers to scaling electronic component manufacturing in India as reported across government publications, industry and market research reports, academic literature and trade-related sources.

Table 4.2 Content analysis of secondary data for RQ1.

Data category	**Code**	**Emergent theme**	***Description***	**Freq. count**
Policy and regulation	1. Policy volatility and ambiguity	Policy and regulatory constraints	This theme captures recurring policy related barriers identified across the	15

	2. Regulatory burden and compliance complexity 3. Delays in regulatory and administrative approvals 4. Inconsistent policy implementation.		secondary data including regulatory uncertainty, delays in approvals and inconsistent implementation frameworks that were frequently observed in relation to electronic component manufacturing.	
Infrastructure	1. Inadequate manufacturing infrastructure 2. Logistics inefficiencies 3. Power and utilities reliability issues 4. Limited availability of industrial clusters	Infrastructure and logistics limitations	This theme captures evidence across secondary sources indicating that limitations in infrastructure of industries, logistics capacity and supporting utilities that were identified in relation to electronic component manufacturing operations.	12
Supply chain	1. Limited domestic supplier depth 2. Dependence on imported components 3. Weak integration across supply-chain tiers 4. Limited localization of	Fragmented supply chains	This theme reflects recurring evidence across secondary sources that weaknesses in domestic supplier depth, weak integration across supply chain tiers and continued reliance on imported inputs within the electronic component manufacturing area.	14

	high-value components			
Finance and investment	1. High capital intensity requirements 2. Limited access to long-term financing 3. Investment risk perceptions 4. Constraints in venture and institutional funding	Investment and financing constraints	This theme captures evidence reported across secondary sources indicating that high capital intensity, financing constraints and perceived investment risks limit capacity expansion and long-term scaling within electronic component manufacturing.	9
Skills and workforce	1. Shortages of specialised technical skills 2. Gaps in process engineering expertise 3. Limited advanced manufacturing capabilities 4. Insufficient industry-relevant training programmes	Skill shortages	This theme reflects consistent evidence across secondary sources identifying shortages in specialised technical skills, process engineering capabilities and advanced manufacturing expertise relevant to electronic component production.	11
Technology and innovation	1. Limited access to advanced manufacturing technology 2. Gaps in domestic R&D capability	Limited technological capability	This theme captures reported gaps in advanced manufacturing technologies, process maturity and domestic technological development that constrain the progression toward	8

	3. Reliance on foreign technology 4. Low technology process maturity		higher-value electronic component manufacturing.	
Market and scale	1. Insufficient production scale 2. Limited domestic demand for high-value components 3. Difficulty achieving economies of scale 4. Fragmented market demand	Scale and demand limitations	This theme shows evidence across secondary sources identifying limitations related to production scale, demand levels for higher value components and limited economies of scale within electronic component manufacturing.	10
Sustainability and compliance	1. Environmental compliance costs 2. Sustainability reporting requirements 3. Regulatory burden related to environmental standards 4. Compliance-driven operational complexity	Environmental and compliance challenges	This theme reflects recurring evidence across secondary sources that environmental regulations, compliance requirements and sustainability-related obligations increase operational complexity and cost burdens for electronic component manufacturers.	7

The Table 4.2 presents the qualitative coding derived from the content analysis of secondary sources relevant to Research Question One, focusing on barriers to scaling electronic component manufacturing. The table consolidates recurring barriers reported across the

reviewed documentary evidence, providing a structured representation of constraints affecting expansion and industrial scale-up.

The evidence summarised in Table 4.2 indicates that scaling barriers are reported across multiple domains of the manufacturing ecosystem. The coded results reflect constraints associated with the policy and regulatory environment, infrastructure readiness and industrial ecosystem support, supply-chain depth and localisation capacity, financing and investment conditions, and the availability of specialised skills required for advanced manufacturing. The table therefore captures how the barriers identified in the literature and stakeholder-relevant documents extend beyond a single factor and instead relate to multiple interdependent constraints reported across sources.

In addition, Table 4.2 captures barriers associated with technological capability and innovation conditions, market and scale dynamics, and compliance-related requirements that influence manufacturing expansion. Together, these coded results provide a structured overview of the qualitative evidence underpinning the identification of key barriers addressed under Research Question One.

Findings for RQ2

Research Question Two (RQ2):

How do differences in technological capabilities, R&D infrastructure, and skill availability between India and established hubs like China, Taiwan, and Vietnam constrain India's ability to produce advanced electronic components, as evidenced by qualitative themes and quantitative indicators?

The findings for Research Question Two are derived from the qualitative content analysis of secondary data and supported by quantitative descriptive indicators where applicable. The results summarise evidence related to technological capability, research and

development infrastructure, innovation activity and workforce skills as reported across government publications, industry and market research reports, academic literature and international datasets. The findings are presented as emergent themes identified through systematic analysis of the reviewed sources.

Table 4.3 Content analysis of secondary data for RQ2.

Data category	**Code**	**Emergent theme**	***Description***	**Freq. count**
Research and innovation	1. Limited industrial and applied R&D investment 2. Constraints in R&D funding for advanced component production	Limited R&D investment	This theme captures consistent evidence across secondary sources indicating that comparatively low levels of industrial and applied research and development investment limit technological advancement and the production of advanced electronic components.	13
Technology capability	1. Limited access to high-precision fabrication equipment 2. Gaps in advanced manufacturing tools and process technologies	Gaps in advanced manufacturing technology	This theme reflects reported gaps in access to advanced manufacturing equipment, fabrication processes and production technologies that restrict the development of high-precision and high-value electronic components.	11
Skills and workforce	1. Shortages of specialised technical skills 2. Gaps in process engineering and	Shortage of specialised technical skills	This theme represents recurring evidence across secondary sources of shortages in specialised technical skills, including process engineering,	14

	3.	semiconductor expertise Limited advanced manufacturing skill availability		semiconductor design and advanced manufacturing expertise, which limit capability development in component manufacturing.	
Innovation systems	1. 2.	Weak collaboration between industry and academic institutions Limited applied research and knowledge transfer	Weak industry–academia collaboration	This theme captures evidence indicating limited collaboration between academic institutions, research organisations and manufacturing firms, reducing knowledge transfer, applied research outcomes and innovation capacity within the sector.	9
Infrastructure	1. 2.	Limited availability of testing and prototyping facilities Inadequate certification and validation infrastructure	Limited R&D and testing infrastructure	This theme reflects reported constraints related to the availability and accessibility of research facilities, testing laboratories, prototyping infrastructure and certification mechanisms required for advanced electronic component development.	10
Knowledge and learning	1. 2.	Dependence on imported technologies Limited domestic technology development capability	Dependence on foreign technology	This theme represents evidence across secondary sources indicating continued reliance on imported technologies and external knowledge sources, limiting domestic technological self-reliance and innovation capability.	8

Workforce development	1. Insufficient continuous training mechanisms 2. Gaps in workforce upskilling and skill upgradation programmes	Insufficient upskilling mechanisms	This theme captures recurring references to gaps in workforce development, continuous training and learning programmes and skill development necessary to support progress in requirements of technology in electronic component manufacturing.	7

Table 4.3 shows the coding of qualitative data derived from secondary data analysis related to research question two focusing on technological capabilities, research and development infrastructure and skill availability linked with India's production of advanced electronic components. The table join recurring capability related constraints identified across policy documents, industry reports, academic literature and sectoral analyses showing consistent references to limitations in technological capability and research infrastructure.

In addition, Table 4.3 captures qualitative evidence related to skill availability and innovation systems. The coding reflects reported shortages in specialised technical skills, gaps in process engineering and advanced manufacturing expertise, and limited collaboration between research institutions and manufacturing firms. Together, the coded results provide an overview of capability-related factors shaping India's capacity to produce advanced electronic components under Research Question Two.

Findings for RQ3

Research Question Three (RQ3):

How does India compare with established manufacturing hubs (China, Taiwan, Vietnam) in technological capabilities, R&D infrastructure, skill availability, cost structures, quality, and innovation, as evidenced by qualitative themes from secondary sources and current quantitative indicators?

The findings for Research Question Three are derived from the comparative analysis of secondary data drawn from international trade statistics, industry and market research reports, policy publications and global datasets. The results present observable differences between India and selected manufacturing hubs with respect to manufacturing scale, cost structures, quality-related capabilities and innovation-related indicators. The findings are reported descriptively and are supported by quantitative indicators and comparative figures where applicable.

Table 4.4 Content analysis of secondary data for RQ3.

Data category	**Code**	**Emergent theme**	***Description***	**Freq. count**
Manufacturing scale and cost	1. Limited production scale relative to established hubs. 2. Reduced cost efficiencies due to lower throughput.	Economies of scale advantage	This theme reflects recurring evidence across secondary sources that established manufacturing hubs benefit from large-scale production capacity, enabling cost efficiencies and higher throughput levels compared to India's relatively lower scale of component manufacturing.	14
Cost structures	1. Higher logistics and input costs. 2. Reduced supplier proximity advantages.	Competitive cost structures in established hubs	This theme captures comparative reporting that cost competitiveness in established hubs is supported by production efficiencies, supplier proximity and logistics advantages, resulting in more favourable cost structures than those reported for India in the reviewed sources.	12

Quality and manufacturing capability	1. Lower process maturity levels. 2. Inconsistent quality standards. 3. Limited precision manufacturing capability.	Advanced precision manufacturing	This theme represents evidence that countries such as China and Taiwan demonstrate stronger precision manufacturing capability and quality consistency, supported by mature production processes and higher levels of manufacturing capability reported across sources.	13
Innovation and R&D	1. Lower R&D intensity. 2. Limited sustained innovation investment.	Higher R&D intensity in established hubs	This theme captures recurring evidence that established hubs demonstrate sustained and comparatively higher intensity of research and development investment, contributing to stronger innovation performance relative to India in the reviewed secondary sources.	11
Innovation systems	1. Less developed innovation ecosystems. 2. Weaker institutional coordination.	Strong innovation ecosystems	This theme reflects evidence of more developed innovation ecosystems in leading hubs, characterised by institutional support, research infrastructure and coordination across industry and research actors, which is reported as less developed in India.	10
Global value chains	1. Weaker integration into global	Deeper global value chain integration	This theme represents repeated reporting that established hubs show stronger integration into	15

	electronics value chains. 2. Limited supplier network depth.		global electronics value chains through higher export orientation, supplier network depth and embedded participation in international production systems compared to India.	
Export performance	1. Lower export orientation in high-value components. 2. Limited diversification of component exports.	Export-oriented manufacturing models	This theme captures evidence that export-led models in established hubs are supported by diversified component production and stronger global market linkages, with India reported as having comparatively lower export intensity in high-value components.	9
Market positioning	1. Concentration in assembly-focused activities. 2. Limited movement into advanced component manufacturing.	Assembly-focused positioning of India	This theme reflects recurring evidence across secondary sources that India's electronics manufacturing activity remains more concentrated in assembly and lower-value segments, with comparatively limited movement into advanced and high-value component manufacturing.	8

Table 4.4 presents the qualitative coding derived from the analysis of secondary sources related to research question three, focusing on India's comparative position relative to established electronic components manufacturing hubs. The table combine qualitative evidence

drawn from policy documents, industry analyses, trade publications and academic literature describing differences in cost structures, manufacturing quality and innovation performance.

In addition, this table captures differences related to innovation capacity and participation in global value chain with coding highlighting variation in research and development intensity, innovation output, supplier network and export orientation for high value electronic components.

Findings for RQ4

Research Question Four (RQ4):

Given India's comparative gaps with established manufacturing hubs (China, Taiwan, Vietnam) in cost structures, quality, and innovation, what strategies and policy interventions are reported in secondary sources to accelerate India's transition toward a globally competitive electronic components manufacturing hub?

The findings for Research Question Four are derived from the qualitative content analysis of secondary data sources, including government policy documents, industry and market research reports, academic literature and trade-related publications. The results summarise strategies and policy interventions reported across the reviewed sources in relation to strengthening domestic electronic components manufacturing capabilities. These findings are presented as emergent themes identified through systematic analysis of documentary evidence and are reported descriptively without interpretation.

Table 4.5 Content analysis of secondary data for RQ4.

Data category	**Code**	**Emergent theme**	***Description***	**Freq. count**
Industrial policy	1. Incentive-based manufacturing support mechanisms.	Production-linked incentives	This theme captures recurring evidence across secondary sources that incentive-based policy instruments, including	14

	2.	Policy measures promoting domestic localisation and scale.		production-linked mechanisms, are emphasised as a strategy to promote domestic manufacturing capacity, localisation and scale expansion in electronic components.	
Infrastructure development	1. 2.	Development of electronics manufacturing clusters. Expansion of industrial parks and shared facilities.	Manufacturing clusters and industrial parks	This theme reflects evidence that the development of manufacturing clusters, industrial parks and shared infrastructure facilities is consistently identified as necessary to strengthen ecosystem readiness and enable scalable component manufacturing.	11
Research and innovation	1. 2.	Investment in applied R&D and innovation ecosystems. Support for semiconductor and advanced component research.	Investment in R&D and innovation ecosystems	This theme represents repeated reporting that targeted investment in applied research, innovation ecosystems and technology development initiatives is required to strengthen domestic capability for advanced electronic component manufacturing.	12
Skills and workforce	1. 2.	Sector-specific skill development initiatives. Strengthening of technical education and workforce readiness.	Skill development and workforce readiness	This theme captures evidence that sector-specific skill development, technical education strengthening and workforce readiness initiatives are frequently highlighted as critical interventions to support	10

			capability development and industrial scaling.	
Regulatory environment	1. Regulatory simplification measures. 2. Approval streamlining and compliance reforms.	Ease of doing business reforms	This theme reflects recurring evidence that regulatory simplification, approval streamlining and administrative reforms are viewed as necessary to improve investment conditions and reduce operational constraints affecting manufacturing expansion.	9
Global integration	1. Strategies to attract foreign direct investment. 2. Strengthening export linkages and trade competitiveness.	Global value chain participation	This theme captures evidence across reviewed sources that strategies supporting global integration such as attracting foreign investment, strengthening export linkages and improving trade competitiveness are identified as important for accelerating India's transition toward higher-value component manufacturing.	13
Technology collaboration	1. International technology partnerships. 2. Joint ventures and technology transfer mechanisms.	International technology partnerships	This theme represents reporting that international collaborations, joint ventures and technology transfer mechanisms are consistently identified as approaches to accelerate capability development and reduce reliance on external technology sources.	8

Sustainability and standards	1. Adoption of environmental and quality standards. 2. Promotion of sustainable manufacturing practices.	Sustainability and quality standards	This theme reflects evidence that strengthening sustainability practices and compliance with quality standards is increasingly highlighted as necessary to support competitiveness, market access and long-term industrial development in electronic components manufacturing.	7

Table 4.5 presents the qualitative coding derived from the analysis of secondary sources related to research question four, focusing on strategies and policy interventions reported as relevant to strengthening India's electronic components manufacturing ecosystem. The table brings together qualitative evidence from policy documents, industry reports, academic studies and trade publications that refer to actions and measures linked to manufacturing competitiveness and ecosystem development. The coded results show recurring references to industrial policy initiatives, infrastructure development, investment measure, and regulatory changes related to manufacturing activities.

The findings also include references to initiatives supporting innovation, research and development, and skills development within the electronic components sector. The table reflects evidence related to global integration and sustainability, including participation in global value chains, export related measures, technology collaboration and the adoption of quality and sustainability standards.

B. Quantitative analysis of the qualitative data

This part provides the quantitative results obtained from used secondary data sources in the study. The findings reported in this section complement the qualitative content analysis

by providing numerical and comparative indicators related to research and development investment, innovation performance, manufacturing output and market size within the electronics manufacturing sector. The results are presented descriptively using figures and published statistical evidence without interpretation.

Table 4.6 Data sources utilised for content analysis of secondary data.

Data Sources	**Data type**	***Description***
World Bank databases	Quantitative indicators	Numerical data on research and development expenditure, innovation metrics and macro-level manufacturing indicators
International trade statistics	Quantitative datasets	Data on electronics manufacturing output, exports, imports and global trade participation
Patent databases (e.g., OpenAlex)	Quantitative records	Bibliometric and patent-related indicators used to assess innovation activity and research productivity
Industry and market research reports	Statistical reports	Quantitative industry-level data on electronics manufacturing performance, market size and growth
Government statistical publications	Official statistics	National-level statistics related to electronics manufacturing, investment and sector performance

Findings for RQ1

Research Question One (RQ1): What are the key quantitative differences in policy interventions, public investments, infrastructure, and global integration supporting electronic components manufacturing between India and established hubs like China, Taiwan, and Vietnam?

Table 4.7 Quantitative analysis of the qualitative data for RQ1.

Indicator	**India**	**China**	**Taiwan**	**Vietnam**
Electronics manufacturing value added (% of GDP)	2.3%	5.8%	6.2%	4.1%
High-technology exports (% of manufactured exports)	10-12%	30%	55-60%	40%
Electronics exports (USD, billions)	25-30	>700	150	115

Number of electronics-related patents (annual)	3,000-4,000	>200,000	40,000	2,000
R&D expenditure (% of GDP)	0.7%	2.4%	3.5%	0.9%
Domestic component supplier depth	Limited	Extensive	Highly specialized	Moderate

Source: Author's work based on data from World Bank Development Indicators; International Trade Statistics; OpenAlex patent database; government and industry reports.

The quantitative indicators reported in Table 4.7 describe observable differences between India and established manufacturing hubs in relation to manufacturing scale, innovation intensity, research and development investment, export performance, and domestic supplier depth. India records a lower share of electronics manufacturing value compared to China, Taiwan and Vietnam as a percentage of GDP showing limitations in production. Measures related to high technology exports and total electronics export value also show that India's participation in global electronics markets is lower.

In addition, qualitative assessments of supplier ecosystems indicate that the depth of domestic component suppliers in India is more limited when compared with the highly specialised supplier networks observed in established manufacturing hubs. .

Findings for RQ2

Research Question Two (RQ2): How do differences in technological capabilities, R&D infrastructure and skill availability between India and established hubs like China, Taiwan and Vietnam constrain India's ability to produce advanced electronic components as evidenced by qualitative themes and quantitative indicators?

Table 4.8 Cross-Country Comparison of Quantitative Indicators Related to Technological Capability, R&D Infrastructure, and Skills

Indicator	India	China	Taiwan	Vietnam
Gross domestic expenditure on R&D (% of GDP)	0.7%	2.4%	3.5%	0.9%
Business enterprise R&D expenditure (% of total R&D)	37%	76%	80%	45%
Electronics-related patent applications (annual)	3,000-4,000	>200,000	40,000	2,000
Patent intensity (patents per million population)	3	140	1,700	20
Availability of advanced fabrication facilities	Limited	Extensive	Highly advanced	Moderate
Number of researchers per million people	260	1,300	4,900	350
Tertiary STEM graduates (% of total graduates)	32%	41%	46%	38%
Presence of specialised semiconductor R&D centres	Emerging	Extensive	Highly concentrated	Developing

Source: Author's work based on data from World Bank Development Indicators, OpenAlex patent database, UNESCO Institute for Statistics, government and industry reports

The quantitative indicators showed in Table 4.8 highlight observable cross-country differences in research and development investment, innovation output and skill related capacity. A lower level of gross domestic expenditure on research and development as a percentage of GDP is recorded in India compared to China and Taiwan. Business enterprise expenditure on R&D constitutes a smaller share of total R&D activity in India relative to established manufacturing hubs.

Patent-related indicators show substantial variation across countries, with India registering a lower volume of electronics-related patent applications and lower patent intensity

per million population. Indicators related to research capacity, including the number of researchers per million people, also differ markedly across countries. Data on skill-related proxies indicate variation in the proportion of tertiary STEM graduates and the availability of specialised semiconductor and electronics-focused research centres. These indicators provide descriptive numerical evidence of differences in technological capability, R&D infrastructure, and workforce skill capacity across the selected countries.

Findings for RQ3

Research Question Three (RQ3): How does India compare with established manufacturing hubs (China, Taiwan, Vietnam) in technological capabilities, R&D infrastructure, skill availability, cost structures, quality, and innovation, as evidenced by qualitative themes from secondary sources and current quantitative indicators?

Table 4.9 Quantitative Indicators Related to Technological Capability, R&D Infrastructure, and Skills in India

Indicator	**India**
Gross domestic expenditure on R&D (% of GDP)	0.7%
Business enterprise expenditure on R&D (% of total R&D)	37%
Public R&D institutions focused on electronics / semiconductors (number)	25-30
Electronics-related patent applications (annual)	3,000-4,000
Patent intensity (patents per million population)	3
Availability of advanced fabrication and testing facilities	Limited / emerging
Researchers per million population	260
Engineering and technology graduates per year (millions)	1.5
Share of STEM graduates (%)	32%
Formal skill development programmes in electronics manufacturing	Moderate

Source: Author's work based on data from World Bank Development Indicators; OpenAlex patent database; UNESCO Institute for Statistics; Government of India publications; industry reports

The workforce development data on engineering and STEM graduate output along with the availability of formal skill development programme is shown related to electronics manufacturing. Measures associated with technological infastructure show the presence of advanced fabrication, testing and certification.

Findings for RQ4

Research Question Four (RQ4): Given India's comparative gaps with established manufacturing hubs (China, Taiwan, Vietnam) in cost structures, quality, and innovation, what strategies and policy interventions are reported in secondary sources to accelerate India's transition toward a globally competitive electronic components manufacturing hub?

Table 4.10 Quantitative Indicators of Policy and Strategic Interventions Supporting Electronic Components Manufacturing in India

Policy / Strategy Indicator	**India**	**China**	**Taiwan**	**Vietnam**
Public investment in electronics manufacturing (USD, billions)	10-12	>150	20-25	15
National incentive schemes for electronics manufacturing	Yes (PLI schemes)	Yes (multiple national programmes)	Yes (targeted semiconductor incentives)	Yes (FDI-linked incentives)
Number of dedicated electronics manufacturing clusters / parks	25-30	>200	15-20	50
Public R&D funding for electronics and semiconductors (% of GDP)	0.15%	0.9%	1.2%	0.25%
Formal skill development programmes for electronics manufacturing	Moderate	Extensive	Extensive	Moderate
FDI inflows into electronics manufacturing (USD, billions)	8-10	>100	10-12	18
Participation in international technology partnerships	Emerging	Extensive	Extensive	Moderate

Adoption of international quality and sustainability standards	Increasing	High	High	Moderate-High

Source: Author's work based on data from World Bank Development Indicators, Government of India policy documents, international trade statistics, industry and market research reports

The indicators which are quantitative shown in the table present differences across countries in relation to policy driven investment level, infrastructure development, research and development support, workforce readiness initiatives and mechanisms of global integration. Public investments in electronics manufacturing and R&D funding as a percentage of GDP is recorded low in India compared to China and Taiwan.

Measures associated with workforce development and technology collaboration reflect variation in the availability of formal skill development programmes and international technology partnerships. In addition, indicators related to the adoption of quality and sustainability standards vary across countries.

4.3 Summary

This chapter reported the findings of the study based on the analysis of secondary data related to the electronic components manufacturing sector with specific attention to India's position in comparison with manufacturing hubs established. The results were organised in line with the research questions and presented observable patterns, trends, and comparative outcomes identified across policy documents, industry reports, academic literature and international datasets.

The findings for research question one showed that multiple barriers to scaling electronic component manufacturing in India were repeatedly reported across secondary sources. The quantitative analysis of qualitative data identified policy and regulatory constraints, infrastructure and logistics limitations, fragmented supply chains, investment and

financing challenges, skill shortages, technological capability gaps, scale related limitations and sustainability related compliance issues.

Results addressing rresearch qquestion two showed that technological capabilities, research and development infrastructure and skill availability were reported as key factors influencing India's ability to produce advanced electronic components. The evidence showed consistent reporting of constraints linked to technological capabilities, research and development infrastructure and skill availability including limited R&D investment, gaps in advanced manufacturing technologies and shortages of specialized technical skills.

The research question three's findings reported comparative differences between India and established manufacturing hubs such as China, Taiwan and Vietnam across production scale, cost structures, manufacturing quality, innovation activity and global value chain integration.

And research question four indicated that sources reported a range of strategies and policy interventions related to production linked incentives, infrastructure and cluster development, investment in research and innovation, skill development initiatives, regulatory reforms, global value chain participation, international technology collaboration, and quality and sustainability standards. All together the findings presented in this chapter provide a structured account of the patterns identified through secondary data analysis.

CHAPTER V:

DISCUSSION, IMPLICATIONS, RECOMENDATIONS AND CONCLUSIONS

5.1 Introduction

This chapter discusses the findings of the study in relation to the research problem and objectives established in chapter one. The study examines the challenges limiting India's transition from a component assembly base to a globally competitive electronic components manufacturing hub with particular attention to structural, policy, infrastructure, technological, investment and capability related constraints.

The primary purpose of the research was to analyze the barriers restricting India's ability to scale electronic component manufacturing and to assess India's relative position compared with established manufacturing hubs such as China, Taiwan and Vietnam. Through this analysis the study sought to generate evidence-based insights that can inform policy formulation and strategic interventions aimed at strengthening India's electronic components manufacturing ecosystem.

The study adopted a mixed method secondary research design, combining qualitative content analysis of documentary sources with descriptive and comparative quantitative indicators to support different country assessments. This approach enabled the identification of recurring patterns and themes across government publications, industry and market research reports, trade statistics and academic literature, while remaining consistent with the scope and feasibility of the research.

The study acknowledges limitations associated with reliance on secondary data including variations in data availability consistency and reporting practices across sources and countries. Ethical considerations were addressed using publicly available materials and by ensuring transparent, accurate and properly attributed analysis and reporting.

Building on the results presented in chapter four, this chapter interprets the findings in relation to the research questions and the theoretical and conceptual foundations established in the literature review. Section 5.2 discusses the findings for each research question. Section 5.3 outlines theoretical and research implications. Section 5.4 presents practical recommendations and directions for future research and ssection 5.5 concludes by summarizing how the study addresses the research aim and contributes to understanding India's pathway towards enhanced global competitiveness in electronic components manufacturing area.

5.2 Discussion of Results

This section presents findings shown in chapter four by explaining significance in relation to the research questions. The discussion situates the findings within relevant academic and policy literature to clarify how the identified patterns contribute to understanding India's challenges in building a globally competitive electronic components manufacturing sector.

Discussion of Research Question One

The findings for first research question indicate that India's ability to scale electronic component manufacturing is constrained by a systemic combination of policy, infrastructure, supply chain, investment and capability related factors, rather than isolated weaknesses. When the qualitative themes and comparative indicators are interpreted together, they suggest that these interrelated constraints collectively weaken India's competitiveness relative to established manufacturing hubs and limit deeper integration into global electronics value chains.

From a policy perspective, the results indicate that regulatory complexity, procedural delays and inconsistent policy execution continue to create uncertainty for manufacturers. Although multiple initiatives have been introduced to promote electronics manufacturing, fragmented implementation and limited longterm predictability appear to reduce their effectiveness. Comparative indicators show that established hubs benefit from more stable and

coordinated policy frameworks that support manufacturing investments whereas India's policy environment is less effective in enabling such commitments.

The findings highlight persistent gaps in manufacturing infrastructure, logistics efficiency and supporting utilities which raise operational costs and restrict expansion. Comparative evidence suggests that countries such as China and Taiwan benefit from dense industrial clusters and integrated infrastructure ecosystems that facilitate economies of scale while India's infrastructure constraints continue to slow scaleup in electronic component manufacturing.

Supply chain structure also emerges as a critical constraint. The results indicate limited domestic supplier depth and continued reliance on imported high value components weakening India's position within global value chains. Comparative indicators reinforce this finding showing lower localisation levels and weaker backward linkages than those observed in established hubs where highly integrated supplier networks support cost efficiency, resilience and rapid scaling.

Investment conditions and capability gaps further influence scale outcomes. High capital intensity, constrained access to long term financing and skill shortages in advanced manufacturing limit productivity and expansion. Comparative indicators show that established hubs benefit from sustained public investment, stronger financing mechanisms and closer alignment between technical education and industry needs supporting higher manufacturing sophistication and output efficiency.

Overall, the evidence from tables 4.2 and 4.7 demonstrates that India's difficulty in scaling electronic component manufacturing results from the interaction of regulatory uncertainty, infrastructure gaps, fragmented supply chains, constrained investment environments and capability limitations. These systemic challenges help explain why India

continues to lag established manufacturing hubs in achieving scale and global integration despite growing domestic demand and policy emphasis on electronics manufacturing.

Discussion of Research Question Two

The second research question's findings indicate that India's limited ability to produce advanced electronic components is primarily constrained by gaps in technological capability, underdeveloped research and development (R&D) infrastructure and shortages of specialised skills. When the qualitative themes and comparative indicators are interpreted together, they suggest that these constraints prevent India from transitioning beyond lower value manufacturing activities into technologically sophisticated and high precision component production placing it at a disadvantage relative to established hubs such as China, Taiwan and Vietnam.

The results highlight restricted access to advanced fabrication technologies, precision manufacturing tools and mature production processes alongside limited industrial and applied R&D investment. Insufficient availability of testing, prototyping and validation facilities further weakens India's ability to convert research outputs into commercially viable manufacturing processes. Comparative indicators show that established hubs benefit from sustained investment in high precision fabrication infrastructure and stronger integration between research institutions and manufacturing ecosystems, supporting continuous process innovation, higher yields and consistent quality in advanced component production.

Skill availability and innovation linkages further constrain India's progress in advanced manufacturing. The findings reveal persistent shortages of specialised technical skills in areas such as semiconductor process engineering and technology production roles alongside weak alignment between skill development systems and industry requirements. Limited collaboration between industry and academic or research institutions reduces opportunities for applied research, technology diffusion and incremental process improvement. In contrast,

established hubs benefit from long term investment in industry aligned technical education and strong industry academia linkages, enabling higher productivity, sustained innovation and long-term technological competitiveness. Overall, the integrated evidence from Tables 4.3 and 4.8 explains why India remains concentrated in lower value segments of electronics manufacturing and highlights the need for coordinated capability development across technology, R&D and workforce domains to support advanced electronic component production.

Discussion of Research Question Three

The research question three found that India's comparative position in electronic component manufacturing remains weaker than that of established hubs such as China, Taiwan and Vietnam across multiple dimensions. When the qualitative themes and comparative indicators are interpreted together, they suggest that India's manufacturing ecosystem remains largely oriented toward lower value and assembly focused activities, limiting its ability to compete effectively in advanced and high precision component manufacturing.

Differences in manufacturing scale, cost efficiency and quality emerge as key determinants of India's relative competitiveness. The findings indicate that India operates at a lower production scale, constraining economies of scale and contributing to higher unit costs. Comparative indicators show that established hubs benefit from higher throughput, dense supplier networks and efficient logistics systems, enabling more competitive cost structures and consistent quality outcomes. Investment in automation, process control and advanced manufacturing systems in these hubs supports higher yields and production reliability whereas India's lower process maturity and fragmented production environment limit its movement into higher value component segments.

Innovation capacity and global value chain integration further distinguish India from established manufacturing hubs. The findings indicate lower R&D intensity, weaker innovation

ecosystems and limited development of proprietary technologies in India, reinforcing dependence on imported technologies. Comparative indicators show that leading hubs benefit from long term investment in research infrastructure, strong industry linked innovation systems and deeper integration into global production networks. India's relatively shallow participation in global value chains characterised by limited supplier depth and lower export orientation in high value components restricts opportunities for learning, upgrading and expansion. Overall, the evidence from tables 4.4 and 4.9 explains why India continues to lag established hubs in competitiveness across cost, quality and innovation dimensions, despite growing domestic demand and policy emphasis on electronics manufacturing.

Discussion of Research Question Four

The findings of the research question four show that India's progress towards becoming a globally competitive electronic components manufacturing hub is closely tied policy weaknesses. These weaknesses cut across cost competitiveness, manufacturing quality, innovation capability and coordination within the broader industrial ecosystem. Although a range of policy initiatives has been introduced to support electronics manufacturing the evidence suggests that these measures have not yet produced outcomes comparable to those observed in established hubs such as China, Taiwan and Vietnam.

A recurring issue identified in the findings concerns the way in which policy measures are designed and implemented. While several programmes aim to promote manufacturing growth their impact appears to be limited by fragmented execution, overlapping institutional responsibilities and delays in implementation. This weakens confidence among manufacturers and reduces the long-term predictability required for capital intensive investments. Comparative indicators reinforce this observation as established hubs consistently demonstrate more stable and coordinated industrial strategies where policy instruments, investment incentives and capability development efforts are aligned over extended periods.

Cost competitiveness remains a major constraint on India's ability to attract advanced electronic component manufacturing. The findings indicate that higher production and logistics costs continue to reduce India's appeal for large scale and high value manufacturing activities. But established hubs benefit from economies of scale, closer supplier networks and more efficient infrastructure which together enable lower unit costs and stronger price competitiveness. India's difficulty in achieving similar cost advantages limits its participation in high volume global supply chains and reinforces its focus on lower value manufacturing segments.

Manufacturing quality and process maturity also influence India's competitive position. The results suggest that gaps in precision manufacturing, process standardisation and quality assurance systems make it challenging for Indian manufacturers to consistently meet the stringent requirements of global electronics markets. Comparative indicators show that leading manufacturing economies have embedded quality and process excellence into their industrial development strategies, resulting in reliable output and sustained market trust. India's relatively weaker quality capabilities therefore restrict its ability to move into higher value component segments.

Innovation capacity emerges as another critical factor shaping India's long-term competitiveness. The findings highlight limited R&D intensity, underdeveloped innovation ecosystems and continued dependence on imported technologies. Quantitative indicators confirm that innovation output and technology development remain lower than in established hubs. But countries such as Taiwan and China have prioritised innovation led industrial growth through sustained investment in R&D infrastructure, strong industry academia collaboration and indigenous technology development, which has supported long term upgrading within the electronics value chain.

Taken together, the evidence from tables 4.5 and 4.10 indicates that India's pathway to global competitiveness in electronic component manufacturing requires more than isolated policy interventions. Progress depends on long term strategies that address cost efficiency, manufacturing quality, innovation capability and ecosystem coordination simultaneously. The findings explain why existing measures have not yet closed the competitiveness gap with established hubs and provide a clear basis for the recommendations discussed in the following sections.

5.3 Implications

Theoretical Implications

The findings of this study offer several insights into how electronic component manufacturing develops in emerging economies and why some countries struggle to move beyond assembly-based production. Rather than pointing to a single dominant constraint the results show that competitiveness in electronic components manufacturing is shaped by the interaction of policy frameworks, infrastructure readiness, technological capability, skills and innovation systems. What becomes evident is that these factors do not operate independently, weaknesses in one area tend to amplify limitations in others slowing industrial upgrading even when selective interventions are in place.

From a manufacturing ecosystem perspective the results underline the importance of coordination across system level dimensions. Existing literature often highlights individual enablers such as infrastructure investment, skills development or policy incentives. However, the findings here suggest that improvements in one dimension are unlikely to produce sustained upgrading unless complementary capabilities are developed in parallel. Fragmented progress across policy, infrastructure and supply chains appears insufficient to support a transition towards advanced component production. This reinforces a more integrated view of ecosystem dependency within technology-intensive manufacturing sectors.

The findings also offer refinement to capability based and dynamic capability perspectives. Competitiveness in electronic component manufacturing appears closely linked to long term accumulation of technological capability rather than short term firm level innovation alone. Applied research capacity, process engineering expertise and the availability of testing and validation infrastructure emerge as critical but underdeveloped elements in emerging economies. Where industry academia linkages and applied R&D systems are weak, firms face structural barriers in scaling advanced manufacturing activities even when capital investment is available.

Insights from the study further align with and extend global value chain theory. The results indicate that shallow participation in global electronics value chains limits opportunities for learning, upgrading and value capture. Limited supplier depth, weak localisation and dependence on imported high value components restrict movement into higher value segments. This suggests that integration into global production networks depends not only on market access, but also on the presence of domestic technological, institutional and infrastructural capabilities that allow sustained participation at advanced levels of production.

By examining India alongside established manufacturing hubs, the study also contributes to broader debates on industrial development in emerging economies. The findings indicate that policy led manufacturing strategies are unlikely to generate durable competitiveness unless they are supported by longterm capability accumulation and ecosystem coordination. This insight extends beyond the Indian case and provides a useful analytical lens for other emerging economies seeking to move beyond assembly driven manufacturing models.

Implications of Research Question One

The research question one's results highlight that manufacturing scale is constrained by the combined effects of regulatory uncertainty, infrastructure gaps, fragmented supply chains and capability limitations. This reinforces the view that scale in technology intensive

manufacturing cannot be explained through isolated constraints. Instead, scaling outcomes reflect the degree of alignment across regulatory systems, infrastructure readiness and ecosystem coordination. The findings suggest that partial interventions are unlikely to support large scale manufacturing when system level weaknesses occur.

Implications of Research Question Two

Findings from research question two point that technological capability, R&D infrastructure and specialised skills form the foundation of advanced electronic component manufacturing. The theoretical implication is that capital investment alone is insufficient to enable upgrading in electronics manufacturing. Where applied research systems, industry aligned skills and continuous technological upgrading are weak, emerging economies face persistent barriers to entering higher value segments. This reinforces capability-based theory by highlighting the structural role of innovation systems and workforce alignment in advanced manufacturing contexts.

Implications of Research Question Three

The analysis for third research question shows that cost competitiveness, quality, innovation intensity and global integration are closely connected. Improvements in one dimension appear constrained by weaknesses in others. This supports a multidimensional understanding of manufacturing competitiveness, where scale, process maturity, innovation capability and value chain integration must progress together. The findings extend comparative manufacturing literature by demonstrating that sustained competitiveness in electronics manufacturing cannot be achieved through cost-based advantages alone.

Implications of Research Question Four

The research question four findings suggest that policy effectiveness in manufacturing led development should be assessed by outcomes rather than the number of initiatives introduced. Strategic interventions that lack coherence, continuity or alignment with capability

development objectives are unlikely to close competitiveness gaps with established hubs. From a theoretical perspective, this reinforces the argument that longterm industrial upgrading depends on coordinated policy design, sustained investment and ecosystem wide capability development rather than fragmented or short term measures.

5.4 Recommendations

Recommendations for practical Applications

The findings of this study point to several practical actions that could support the development of a more competitive electronic components manufacturing ecosystem in India. These recommendations are grounded in the structural and capability related constraints identified in the analysis and are directed at policymakers, industry stakeholders and supporting institutions involved in the sector.

Policy and Governance

A key implication of the findings is the need for greater policy stability and longterm orientation. Rather than relying on short term initiatives industrial policy for electronic component manufacturing would benefit from clearer long range objectives, consistent regulatory frameworks and predictable incentive structures. Such stability is particularly important in a capital-intensive sector where investment decisions depend on confidence in future policy direction. Improved coordination between central and state level authorities could also help reduce procedural delays and uneven implementation, which currently weaken the effectiveness of existing measures.

Infrastructure and Industrial Clusters

The results highlight the importance of manufacturing infrastructure in enabling scale and cost efficiency. Focused investment in specialised industrial clusters, supported by reliable utilities, efficient logistics and shared facilities could lower operating costs and improve productivity for component manufacturers. Cluster based development may also encourage the

geographic concentration of suppliers enabling closer coordination across supply chain tiers and supporting faster scaleup. Strengthening these physical ecosystems would help reduce the infrastructure related disadvantages identified in the study.

Supply Chain Development and Localisation

The study indicates that limited domestic supplier depth remains a major constraint on scalability and resilience. Strengthening local supply chains through targeted supplier development programmes could reduce dependence on imported components and improve integration across production stages. Collaboration between large manufacturers and smaller domestic suppliers supported by incentives and capability building initiatives may help develop tier two and tier three supplier networks. Over time, this could support greater localisation, cost efficiency and participation in higher value segments of global electronics value chains.

Investment and Financing Mechanisms

Access to long term financing emerged as a recurring challenge in the findings. Advanced electronic component manufacturing requires substantial upfront investment and carries higher perceived risk which can discourage private capital. The development of tailored financing mechanisms such as public private funding models or risk sharing instruments could help address these barriers. Easier access to patient capital may encourage firms to invest in advanced technologies, process upgrades and capacity expansion necessary for long term competitiveness.

Skills Development and Workforce Alignment

Skill availability plays a central role in manufacturing capability. The findings suggest that closer alignment between education systems and industry needs is required particularly for specialised roles in process engineering and advanced manufacturing. Stronger collaboration between educational institutions, industry bodies and government agencies could support the expansion of applied training programmes and continuous upskilling initiatives. Such

alignment would help address skill shortages while improving productivity and process sophistication within the sector.

Innovation and R&D Ecosystems

Longterm competitiveness in electronic component manufacturing depends on stronger applied research and innovation capacity. The study points to the need for closer collaboration between industry, research institutions and academia to support technology development and diffusion. Investment in shared testing, prototyping and certification facilities could help firms move beyond reliance on imported technologies and accelerate innovation led upgrading. Strengthening these innovation ecosystems would support sustained capability development rather than incremental or isolated improvements.

Recommendations for Future Research

While this study provides a broad understanding of the constraints facing India's electronic components manufacturing sector, it also highlights several areas where further research would be valuable. Future studies could incorporate primary data collection methods, such as interviews or surveys with manufacturers, policymakers and industry experts. Such approaches would allow deeper insight into firm level decision making, policy implementation challenges and operational constraints that are difficult to capture through secondary data alone.

Longitudinal research designs could also be used to assess how recent policy initiatives and industrial investments influence manufacturing outcomes over time. Tracking changes in scale, capability and global integration would help determine whether current strategies lead to sustained improvements or only short-term gains.

Comparative research involving a wider range of countries may further enrich understanding of alternative development pathways. Examining emerging manufacturing economies beyond the current comparison group could reveal different policy and ecosystem configurations that support successful upgrading.

In addition, firm level studies focusing on innovation practices, technology adoption and skill formation could complement the ecosystem level perspective adopted here. Such micro level analysis would help bridge the gap between policy frameworks and operational realities within firms.

Finally, future research could explore the growing importance of sustainability and environmental regulation in electronics manufacturing. As global supply chains increasingly emphasise green compliance, understanding how environmental requirements interact with cost, quality and innovation would provide timely and relevant insights for both policymakers and industry.

5.5 Conclusions

This study set out to explore the factors that have limited India's movement from a predominantly assembly-oriented base toward becoming a globally competitive electronic components manufacturing hub. Using a mixed method secondary research approach, the analysis drew on both qualitative themes and descriptive quantitative indicators to examine the structural, policy related, technological, and capability driven constraints shaping India's manufacturing ecosystem. The research was organised around four research questions addressing issues of scale, capability development, comparative performance and strategic policy direction.

The findings indicate that the challenges facing India's electronic components manufacturing sector are not isolated but instead arise from the interaction of multiple constraints operating simultaneously. The analysis related to research question one showed that regulatory uncertainty, gaps in infrastructure, fragmented supply chains, limited access to long-term investment, and skill shortages together restrict India's ability to scale manufacturing and integrate more deeply into global value chains. These constraints remain evident despite

increasing domestic demand and the introduction of various policy initiatives intended to support the electronics sector.

Findings linked to research question two highlighted the role of technological capability, research and development infrastructure, and specialised skills in shaping India's capacity to produce advanced electronic components. The results suggest that progress in higher value manufacturing depends not only on financial investment, but also on the availability of applied research environments, effective links between industry and skills development systems and sustained efforts to upgrade production technologies.

The comparative analysis under research question three demonstrated that India continues to trail established manufacturing hubs such as China, Taiwan and Vietnam across several key dimensions including cost competitiveness, manufacturing quality, innovation activity, and participation in global value chains. These gaps help explain why India remains concentrated in lower value and assembly focused segments of electronics manufacturing with limited ability to capture greater value within global production networks.

Finally, the findings for research question four indicate that although India has introduced a range of policy measures aimed at promoting electronics manufacturing, these interventions have yet to deliver outcomes comparable with those observed in leading hubs. Issues related to fragmented implementation and weak alignment with longterm capability development appear to reduce the overall effectiveness of existing policies. This points to the need for more coherent and sustained strategies that prioritise ecosystem-wide development rather than isolated or short-term initiatives.

Taken together, this study contributes to the academic understanding of manufacturing development in emerging economies by offering an integrated assessment of scale, capability, and competitiveness in the electronic components sector. By bringing together qualitative and

quantitative evidence, the research provides a clearer explanation of why India's manufacturing ambitions remain constrained and highlights the areas where coordinated action is most needed.

REFERENCES

Banerji, S., 2021. The FAB Challenge. Business Today. Available at: https://www.businesstoday.in/magazine/industry/story/the-fab-challenge-283688-2021-01-06

Business Today., 2024. India's semiconductor ambitions are drawing giants like Micron, but profitability and scalability pose hurdles. Business Today. Available at: https://www.businesstoday.in/magazine/deep-dive/story/indias-semiconductor-ambitions-are-drawing-giants-like-micron-but-profitability-and-scalability-pose-hurdles-445471-2024-09-11

Department for Promotion of Industry and Internal Trade (DPIIT)., 2022. Electronics Manufacturing Sector Report. Government of India. Available at: https://dpiit.gov.in/

EB Bureau., 2020. Why is the Indian electronic components industry not growing faster? ElectronicsB2B. Available at: https://www.electronicsb2b.com/electronics-manufacturing-india-new-and-features/why-is-the-indian-electronic-components-industry-not-growing-faster/

ELCINA. (2022). Electronics manufacturing industry analysis and policy perspectives. Electronic Industries Association of India. Available at: https://www.elcina.com

Flick, U., 2022. An Introduction to Qualitative Research. 4th ed. London: Sage Publications. Available at: https://www.torrossa.com/en/resources/an/5409482

Hanckel, B., Petticrew, M., Thomas, J. and Green, J., 2021. The use of Qualitative Comparative Analysis (QCA) to address causality in complex systems: a systematic review of research on public health interventions. BMC public health, 21(1), p.877. Available at: https://doi.org/10.1186/s12889-021-10926-2

IANS., 2021. No Atmanirbhar Bharat without electronics manufacturing: ELCINA. The Economic Times – Telecom. Available at: https://telecom.economictimes.indiatimes.com/news/no-atmanirbhar-bharat-without-electronics-manufacturing-elcina/83837982/

India Brand Equity Foundation (IBEF)., 2023. Electronics System Design & Manufacturing (ESDM) Industry Report. Available at: https://ibef.org/

Invest India., 2022. Electronics System Design & Manufacturing Sector Overview. Available at: https://www.investindia.gov.in/

Jasim, A. and Hailan, M., 2021 Causal Comparative Research. Available at: https://www.researchgate.net/publication/352748969

Johnson, M.W., Christensen, C.M. and Kagermann, H., 2008. Reinventing your business model. Harvard business review, 86(12), pp.50-59. Available at: https://scholar.google.com/scholar_lookup?&title=Reinventing%20your%20business%20model&journal=Harvard%20Bus%20Rev&volume=86&issue=12&pages=50-

59&publication_year=2008&author=Johnson%2CMW&author=Christensen%2CCM&author=Kagermann%2CH

MeitY., 2022. Annual Report 2021–22. Ministry of Electronics & Information Technology. Available at: https://www.meity.gov.in/

Ministry of Electronics and Information Technology (MeitY). (2023). Annual report and electronics sector initiatives. Available at: https://www.meity.gov.in/documents/reports/annual-report-QM1YTNtQWa

NITI Aayog., 2021. Manufacturing in India: Opportunities & Challenges. Government of India. Available at: https://www.niti.gov.in/

Porter, M.E. and Strategy, C., 1980. Techniques for analyzing industries and competitors. Competitive Strategy. New York: Free, 1, p.76. Available at: https://scholar.google.co.uk/scholar?hl=en&as_sdt=0%2C5&as_vis=1&q=Techniques+for+Analyzing+Industries+and+Competitors+porter+1980&btnG=

Rawat, M., Raj, R. and Agarwal, T., 2020. A critical review of Make in India as an import substitute. Available at: https://dx.doi.org/10.2139/ssrn.3569655

Ruggiano, N. and Perry, T.E., 2019. Conducting secondary analysis of qualitative data: Should we, can we, and how?. Qualitative social work, 18(1), pp.81-97. Available at: https://www.researchgate.net/publication/316142398

Saxenian, A., 2005. From brain drain to brain circulation: Transnational communities and regional upgrading in India and China. Studies in comparative international development, 40(2), pp.35-61. Available at: https://doi.org/10.1007/BF02686293

Schreier, M., 2018. Sampling and generalization. The SAGE handbook of qualitative data collection, pp.84-97. Available at: https://www.torrossa.com/en/resources/an/5018779#page=113

Sharma, M., 2021. Moving From Assembly to Manufacturing Base. Business Today. Available at: https://www.businesstoday.in/magazine/cover-story/story/moving-from-assembly-to-manufacturing-base-285113-2021-01-21

Suri, H., 2011. Purposeful sampling in qualitative research synthesis. Qualitative research journal, 11(2), pp.63-75. Available at: https://www.emerald.com/insight/content/doi/10.3316/QRJ1102063/full/html/

Teece, D.J., 2010. Business models, business strategy and innovation. Long range planning, 43(2-3), pp.172-194. Available at: https://doi.org/10.1016/j.lrp.2009.07.003

Tripathy, J.P., 2013. Secondary data analysis: Ethical issues and challenges. Iranian journal of public health, 42(12), p.1478. Available at: https://www.researchgate.net/publication/278044529

United Nations Conference on Trade and Development (UNCTAD). (2022). World investment report: International production and digital economy. United Nations. Available at: https://unctad.org/publication/world-investment-report-2022

Whitepaper: ESDM Sector. (2021). India's Electronics System Design & Manufacturing Landscape. Ministry of Electronics (MeitY) & Industry Partners. Available at: https://www.meity.gov.in/ministry/our-groups/details/electronics-system-design-manufacturing-esdm-wM5kTNtQWa

Wickham, R.J., 2019. Secondary analysis research. Journal of the advanced practitioner in oncology, 10(4), p.395. Available at: https://www.researchgate.net/publication/333441568

Wirtz, B.W., Pistoia, A., Ullrich, S. and Göttel, V., 2016. Business models: Origin, development and future research perspectives. Long range planning, 49(1), pp.36-54. Available at: https://doi.org/10.1016/j.lrp.2015.04.001

World Bank., 2018. Research and development expenditure (% of GDP). World Bank Data. Available at: https://data.worldbank.org

APPENDIX A

MANUFACTURING CLUSTERS

Electronic Manufacturing Clusters (EMCs) are dedicated industrial zones or areas specifically designed and developed to promote and facilitate electronics manufacturing activities. These clusters provide a range of infrastructure, facilities and services tailored to the needs of electronic manufacturing companies, with the aim of fostering growth, innovation and competitiveness in the electronics industry. Several clusters have been identified and selected for development under the EMC scheme, including:

- ELCINA Electronics Manufacturing Cluster in Bhiwadi, Rajasthan
- Adityapur Industrial Area Development Authority in Jharkhand
- West Bengal Electronics Industry Development Corporation
- Odisha Industrial Development Corporation
- Chhattisgarh State Industrial Development Corporation
- Siri City in Andhra Pradesh
- ELCINA Raaga Mayuri Electronics Park in Andhra Pradesh
- Kerala Industrial Infrastructure Development
- Department of Information Technology in Goa
- Madhya Pradesh State Electronics Development
- Mundra Solar Techno Park in Gujarat
- Mysore ESDM Cluster
- Info Valley Electronics Manufacturing Cluster in Bhubaneswar
- Deogiri Electronic Cluster Private Limited in Aurangabad