Supply Chain Insider

Volume 17, Issue 01, 65-92. 10-10-25
Article Received: 25-08-2025
Accepted: 15-09-2025
Available Online: 10-10-2025
ISSN: 2617-7420 (Print), 2617-7420 (Online)
DOI: **10.5281/zenodo.17285008**
supplychaininsider.org

Addressing Bottlenecks in Bangladesh's Light Engineering Industry: A Comprehensive Analysis

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ARTICLE INFO

Key word:

Light Engineering Industry, operational inefficiencies, workforce shortage, raw material supply, transportation delays, quality assurance, industry modernization, skill development, SMEs, economic contribution.

ABSTRACT

The Light Engineering Industry (LEI) of Bangladesh, a sector also important to the agricultural, transportation, and construction sectors, is encountering serious operational problems affecting the level of productivity and the level of competitiveness. LEIs have a significant role to play in the rising national industry development and employment. However, they still have labor shortage, backward technology, lack of raw materials, delay in transportation, and ineffective quality control system. Based on primary data provided by 50 LEI enterprises, supplemented by secondary data from the national industry study reports, this study also examines the key restrictions and studies interrelationships among them. Results indicate that there is a significant constraint of man power shortages, which triggers other inefficiencies like those due to poor ergonomics, reactivity in problem solving, and acceptance of the technology. Then again, the supplementary material suggests the broader implications of these problems for the future of the business. This paper concludes that the removal of these systemic deficiencies will require specific policy measures, including the upgrading of vocational training, more visible technology intensification, strengthening of the systems of quality assurance, and increased formalisation of the informal firms. The paper highlights the importance of policy measures to facilitate process of modernization of the industry to be in line with national development priorities, including the attainment of Sustainable Development Goals (SDGs).

1. Introduction

The Light Engineering Industry (LEI) of Bangladesh which is sometimes known as the "mother of all industries" is very much fundamental to the core sectors of manufacturing, transportation, agriculture, cloth, and construction as it specialized to produce spare parts, essential components of machineries and repair work (Majumder & Dey, 2020). Its significant contribution is believed to be more than 600,000 direct jobs and potential of 2 million indirect jobs, but it is still an under recognized and unsupported industrial sector (Talukder & Jahan, 2017).

The business has encountered a number of operational roadblocks in the recent past such as absence of skilled labor, outdated technology, inadequate quality check systems and ineffective infrastructure. These constraints are imposing serious challenges on the competitive edge, export potential and productivity of Bangladesh as it is moving towards industrial modernization. Based on the primary data collected from 50 LEI enterprises in several districts and secondary data collected from the national bureau of labor and industry records, the current situation is measured in the study (SEIP, 2023).

Based on descriptive statistical analysis, approximately 80% of the companies surveyed experience worker shortage, approximately 74%–76% are confronted with raw materials, transportation, and quality control–related challenges, and approximately 24% have not invested in new technologies. Significant relationships were discovered by cross-tabulation between personnel problems and other inefficiencies such as reactive-approach to problem solving, ergonomic shortcomings and outdated testing methods. In addition, the approximate secondary data revealed that the majority of specialists and engineers experience functional restrictions, heavy task load, product delay and allocation that often lead to outsourcing and service discontinuance (SEIP, 2023).

As per the literature currently in print, these challenges are not merely due to insufficient resources, but are exacerbated by uncoordinated policy, inconsistent institutional backing, and mismatch between worker skills and employment demand (Barai, 2020; Talukder & Jahan, 2017). In view of these concerns, this study aims to (i) identify key operational challenges facing the LEI sector; (ii) analyze the inter-relationship between these challenges using empirical data, and (iii) proffer policy recommendations to strengthen the resilience and capacity of the sector to contribute effectively to national development goals.

Objective:

The overall objective of this study is to explore the operational and structural problems encountered by the Light Engineering Industry (LEI) sub-sector of Bangladesh based on empirical data analysis and secondary sources.

- To investigate major operation bottlenecks including lack of manpower, no sufficient quality tests, raw material problems, and delay in transportation side ring the potential to enhance the productivity of LEI companies.
- Check if there is some interrelationship among various problem domains, correlation between Manpower shortage and areas as raw, material, transportation, poor ergonomics, reactive problem solving and technology adoption.

2. Literature review:

2.1 Industrial Importance and Sector Overview:

Bangladesh's Light Engineering Industry (LEI) plays a key role in the country's industrial economy. It supplies essential machinery, spare parts, fasteners, and tools to important sectors like agriculture, textiles, construction, shipbuilding, and automotive. The industry produces over 3,800 types of machinery and accessories (BIDA, 2024). With a robust network of over 80,000 small and medium-sized enterprises (SMEs) and almost one million skilled and semi-skilled workers, the LEI contributes around 3% to the national GDP and fulfills about half of the local demand, reducing the need for imports and encouraging self-sufficiency (Banglaseh, 2025; LightCastle, 2025). In the 2023-2024 fiscal year, the domestic market for the sector was worth USD 8.2 billion. While exports are still a smaller part of the picture, they're steadily growing. Export earnings from the Light Engineering Industry (LEI) reached about USD 796 million, with big goals set for the future—aiming for USD 12.56 billion by 2030 (Banglaseh, 2025; LightCastle, 2025; Tribune, 2025a). Often referred to as the "mother of all industries" in Bangladesh, LEI plays a vital role in making locally-produced machinery, offering tailored production solutions, and supporting jobs and livelihoods in both cities and rural areas (Talukder & Jahan, 2016). The industry has strong backing from the government, which provides benefits like tax holidays, export incentives, and exemptions on raw materials and machinery. Additionally, the Light Engineering Industry Development Policy 2022 is focused on helping the sector grow by encouraging cluster development and enhancing skills, which will ultimately boost productivity, modernization, and competitiveness on the global (TFE, 2025a).

2.2 Technological Limitations and Production Challenges:

Although the Bangladesh Engineering Industry Owners' Association (BEIOA) claims the light engineering industry (LEI) sector as ‘the mother of all sectors, this sector still faces numerous technological and production constraints. BEIOA President classified the challenges into five major heads - access to finance, backdated technology, lack of policy support, lack of skills and lack of infrastructure (Talukder & Jahan, 2016). Banik et al. Mentioned several problems associated with Bangladesh’s Light Engineering, including the non-existence of Common Facility Centre (CFC), lack of metal and heat treatment facilities, constraints related to finance, old and manual technology, unfair competition in the domestic market, inadequate accreditation of standards, etc (Banik & Swarna, 2018).

2.2.1 Backdated Technology:

From Bangladesh’s industrial viewpoint, it is very difficult to implement sustainable circular supply chain practices due to backdated technology and utilization inefficiencies(Affan et al., 2024). This is very evident in the Light Engineering (LE) sector that relies mostly on the traditional and outdated production technologies and has a significant shortage in terms of advanced manufacturing machinery needed to produce high-quality goods(BBF, 2024). The gap between these technologies leads to high resource waste, poor product quality, and low production capacity. According to studies on the subject, manual labor and outdated technology account for 30% to 40% of resource inefficiencies per unit (BIDA, 2024). Despite these difficulties, the industry supports more than 80,000 businesses, employs more than 1 million people, adds around 3% to the national GDP, and meets almost half of the USD 8.2 billion in domestic demand in the nation (Bizbd, 2025). Though compared to domestic needs, exports are still small, estimated at USD 486–797 million in recent fiscal years, indicating unrealized potential

(Bangladesh, 2025). The lack of advanced machinery such as automated inspection systems, CNC machines, and precision tools reduces scalability, increases defect rates, and hampers productivity. For example, in industries like agricultural machinery and electrical goods, local production with traditional machinery only satisfies 50% of demand, increasing dependencies on imports. It is critically necessary to combine focused investment in cutting-edge technology, workforce upskilling, and strong industry-academia collaboration to modernize the sector and realize its full potential both domestically and globally.

2.2.2 Poor Infrastructure Facilities:

Bangladesh's Light Engineering Sector mostly faces poor infrastructure facilities where utilities are generally unavailable, hindering its growth and efficiency. They face problems such as narrow roads, unreliable electricity, and inadequate gas and water supplies. These problems result in reduced productivity, higher operating costs, quality issues, and transportation bottlenecks (LightCastle, 2025).

Inadequate Quality Standards: Poor product quality is one of the major problems in Bangladesh's Light Engineering Industry. A large number of buyers in this industry demand high-quality products. Still, this sector often fails to meet their requirements due to poor quality raw materials, old technology and unskilled staff and weak designs (BBF, 2024). For raw materials, they mostly use recycled ship-breaking metals without proper testing or certification. As a result, most enterprises prefer importing Chinese products over Bangladeshi LE products.

Bangladesh's Light Engineering Sector faces several operational challenges that hamper its progress and development. One significant issue is the inflow of cheap foreign products, which are often preferred by customers due to their lower price points(Lisan, 2018). Additionally, many factories struggle with a shortage of skilled workers, poor working conditions, and a stagnation in local demand. On top of that, the sector also struggles with weak government support, issues with public agencies, and outdated machinery. Many factory owners started as workers and don't have the business skills to manage effectively. All of this makes it hard for the sector to grow and compete(Talukder & Jahan, 2017).

2.3 HR and skill gap:

Implementation of Green Supply Chain Management (GSCM) in Bangladesh is confronted with various challenges including skill deficiencies in human resources(Rahman et al., 2020). The Light Engineering (LE) (LightCastle) industry faces significant problems due to these constraints in particular since there is no synchronism between the demand for skills, required for contemporary industrial practices and the supply of qualified workers. This knowledge gap is not only an obstacle to the uptake of sustainable practices, it also impacts the over all competitiveness and potential growth of this sector.According to Hossain and Arefin (2025), a major barrier to the sector's growth is the gap between academic qualifications and the practical skills required in the workplace (Hossain & Arefin, 2025). Approximately 75% of the workforce experiences skill mismatches, leading to underemployment and inefficiency (TBS, 2023b). Furthermore, the National Skills Development Authority-NSDA (2023) highlights that the LE sector suffers from a shortage of skilled workers, particularly in specialized roles such as CNC machine operators, welders, and fitters, which limits productivity and technological advancement (Northern, 2018). The educational system, as noted by (Hossain & Arefin, 2025), does not adequately prepare students for the specific demands of the LE sector, with outdated curricula and limited practical exposure. Inadequate training opportunities, as pointed out by the NSDA (2023), further exacerbate this issue, as many technical programs do not align with industry needs. To address these challenges (Hossain & Arefin, 2025) recommend reforms in educational curricula to include industry-relevant skills and improve employability (Hossain & Arefin, 2025). The NSDA (2023) also

advocates for strengthening TVET institutions and promoting competency-based training. Additionally (Hossain & Arefin, 2025) suggest that closer collaboration between industry stakeholders and educational institutions is necessary to ensure that training programs are closely aligned with the sector's needs. These strategies, when implemented, could help bridge the skill gaps, enhance productivity, and contribute to the long-term competitiveness of the LE sector in Bangladesh (Markes, 2006; RMG, 2023).

"The shortage of skilled workers in the light engineering sector and the inability of unskilled labor to perform tasks effectively results in higher wages for workers compared to those in other sectors, which hinders the growth and profitability of firms in the industry"

Shiraj Khan, vice president of Jashore Light engineering association.

2.4 Policy Gaps and Institutional Fragmentation:

Despite its critical role in fostering industrial diversification and employment generation, it faces serious challenges because of scattered policies and weak institutions that limit its competitiveness and export potential. Though LEI is recognized as a key sector, there is still a lack of integrated frameworks and coordinated governance, which weakens policy execution (Mishra & Satapathy, 2021). Research conducted on Bangladesh's Light Engineering shows that export growth is slow because businesses face structural obstacles and barriers like limited access to finance, inadequate quality control, and a shortage of skilled workers. As a result, a gap exists between the aimed policies and the implemented policy at the operational level (Banik & Swarna, 2018). Studies further highlight that the sector suffers from institutional gaps, such as weak value-chain integration, fragmented support services like testing and certification, and the duplication of programs across different (Tribune, 2025b).

2.5 Contribution to Sustainable Development Goals (SDGs):

Sustainability is that triangle of the triple bottom line: people, planet, profit. The more it benefits all three of those areas, the more sustainable the business(Pulok et al., 2022). Likewise, the Light Engineering Industry (LEI) in Bangladesh is a driving force to achieve different Sustainable Development Goals (SDGs), particularly contributing to the SDGs such as poverty reduction, gender equality, economic development, and sustainable environment. By performing the practices accordingly to these core sustainability values, the LEI sector can indeed generate positive impact both socially and environmentally .According to the study by Sacchidanand Majumder (Majumder, 2022), the LEI sector contributes to:

1. LEIs Sector and SDG 1 (No Poverty)
   SDG1 is poverty eradication, which SDG1 defines as reduce by half by 2030 the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions. Industrialization under conditions of decent job opportunities and health and safety works wonders in alleviating poverty. Industrialization has been the reason hundreds of millions have climbed out of poverty through the bedside and jobs from wages(UN, 2020). In Bangladesh, poverty reduction has been a major focus of the country's national plans, with each Five-Year Plan (FYPs) from 1973- 2020 emphasizing job creation, investing in people, and empowering women. These efforts have helped reduce poverty, falling from 56.7% in 1991 to 24.3% by 2016 (UN, 2025). The Light Engineering Industry

(LEI) sector plays a vital role by generating direct and indirect jobs. With around 40,000 LEIs across the country employing about 0.8 million people, the demand for skilled workers is expected to grow by 76.95% by 2025-26 (TFE, 2025b). Also, Bangladesh's LEI sector includes over 40,000 industries, generating approximately 300,000 direct jobs and around 3 million indirect jobs in related sectors(Choudhury, 2020).

2. LEIs Sector and SDG 4 (Quality Education)
   Education is so vital for development as it powers economic growth and productivity. SDG 4 is focused on all people having quality education, including vocational and technical training. The expansion of industry creates a need for trained workers, and the economy and education are interconnected(UN, 2020). In Bangladesh education and training for youth are among the priorities for the government in two years earlier, 2.4 million youths received training in the last decade(UN, 2025). The National Skills Development Authority (NSDA) supports various programs like STEP, B-SEP, and SEIP to improve skill development. In light engineering, the Bangladesh Engineering Industry Owners' Association (BEIOA) has trained over 13,000 people, including 559 girls (Devex, 2022).

3. LEIs Sector and SDG 5 (Gender Equality)
   Women are disproportionately affected by poverty due to restricted access to paid employment, education, and property. Gender equality and women's economic empowerment are fundamental challenges of the 2030 Agenda(UN, 2020).
   Participation of women in the workforce is critical for economic growth, and addressing poverty. According to the latest Labor Force Survey (LFS) 2016–2017, female participation rose by 4.6% between 2015 and 2016–2017 in Bangladesh(BBS, 2018). The LEI sector contributes significantly towards ameliorating the gender disparity by creating employment for women, particularly in rural areas, where more than 70 % workers are reported female(Choudhury, 2020).

4. LEIs Sector and SDG 8 (Decent Work and Economic Growth)
   For a sustained growth of the economy, structural reorientation of the economy to more efficient sectors are needed. Industrialization generates employment, competitiveness, productivity and worker safety(UN, 2020).
   SDG 8 seeks to achieve sustainable economic growth and income growth for all, particularly in developing countries (Bangladesh, 2020). Bangladesh has made great headway, recording an 8.15% growth in GDP in 2018-19, powered by industries such as the LEI segment, which accounts for around 20% of GDP. This sector also contributes to the reduction of the dependence upon import with products valued $200 million substituting imports(Choudhury, 2020). The government has made substantial investments in economic zones and offers cash incentives to boost exports. The LEI sector employs over 0.8 million people and creates millions of indirect jobs, contributing significantly to employment growth(Tribune, 2025b). Demand for skilled labor in the sector is expected to grow by 76.95% by 2025-26(SEIP, 2017).

5. LEIs Sector and SDG 9 (Industry, Innovation and Infrastructure)
   SDG 9 focuses on developing infrastructure and advancing a sustainable industrialization and innovation. in Bangladesh the government gives preference for small and medium enterprise (SME) in order to accomplish on industrialization where 33 percent of industrial share is coming from SME which contribute up to 25 percent of GDP(Bangladesh, 2020). The LEI is

composed of approximately 40,000 industries that manufacture a diversity of goods, some of which are domestically distributed and some are not. Yet, the industry also has problems such as outdated technology, no room for modern equipment, and lack of finance(Majumder, 2022).

6. LEIs Sector and SDG 10 (Reduced Inequalities)

   Poverty can't be eradicated without addressing deep inequalities in income and opportunities(UNIDO, 2016). SDG 10 focuses on reducing these disparities within and between countries by tackling marginalization and ensuring the needs of the poorest are met. Industrial development plays a key role in reducing inequality by creating jobs, raising incomes, and offering social mobility. The LEI sector in Bangladesh, with 40,000 industries across urban and rural areas, contributes to regional and gender equality by providing employment opportunities, especially for women and vulnerable communities(Choudhury, 2020; Majumder, 2022). Demand for skilled workers in this sector is expected to rise significantly, further reducing inequalities(SEIP, 2017).

7. LEIs Sector and SDG 11 (Sustainable Cities and Communities)

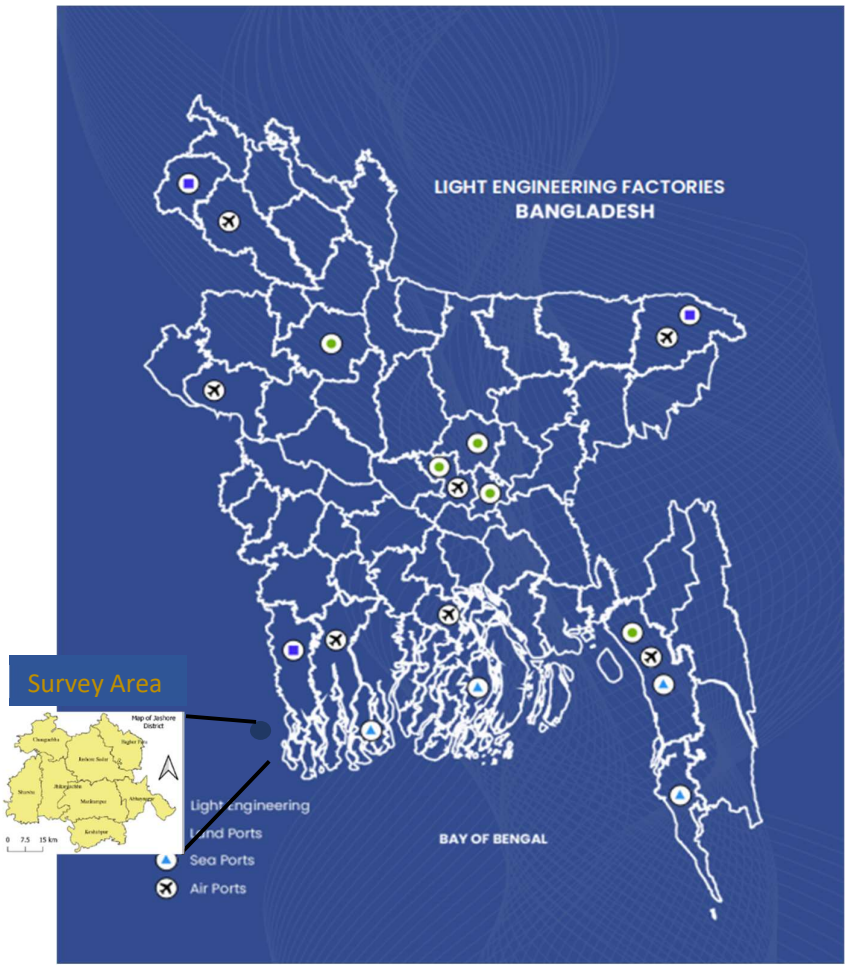
   Urbanization and industrialization go hand in hand, helping societies benefit from economies of scale(UNIDO, 2016). In Bangladesh, urban centers face challenges with waste management due to rapid urban growth(Bangladesh, 2020). The LEI sector contributes to SDG 11 by promoting industrial clusters in urban areas, helping small firms overcome growth barriers through efficient resource use(Schmitz, 1999). These clusters, located across 18 districts, offer opportunities for modernization and support through infrastructure, training, and funding (Talukder & Jahan, 2016). LEIs are classified as "smart industries" under environmental regulations, producing recyclable waste without harmful chemicals (Talukder & Jahan, 2017).

8. LEIs Sector and SDG 12 (Responsible Production and Consumption)

   SDG 12 focuses on decoupling economic growth from environmental damage. Bangladesh has adopted policies to promote sustainability in production and waste management(Bangladesh, 2020). LEIs in Bangladesh produce only solid waste and are considered "green industries." While these industries are generally safe, waste management and working conditions need improvement. Positive changes are occurring, with LEI owners and associations working on better waste handling and safer environments (Talukder & Jahan, 2017).

9. LEIs Sector and Goal 13 (Climate Action)
   SDG 13 focuses on boosting resilience to climate-related disasters, integrating climate measures into policies, and raising awareness on mitigation and adaptation. Bangladesh has been proactive in addressing climate change, becoming a global model in disaster management. The country has reduced disaster impact by training volunteers and preparing communities for better risk management(Bangladesh, 2020). The LEI sector in Bangladesh plays a key role in climate change mitigation by reusing scrap metal from shipbreaking, which reduces mining and lowers energy use and CO2 emissions in steel production (Neşer et al., 2008; Zakaria et al., 2012).

3. Overview of Bangladesh's Light Engineering Industry:



Source: [BIDA]

Light Engineering Industry (LEI) is a manufacturing sub-sector which produces small and light weight products in relatively low capital investment and utilizing low scale of technology and machinery. It is an area of manual or semi-automated production and is the main backward linkage industry in various large sectors including garment, agriculture, construction and transportation (Majumder & Dey, 2020; Talukder & Jahan, 2017).

LEI sector of Bangladesh contribute significantly to support the industrial base of the country by producing spare parts, tools, small machinery and repair & maintenance to garments, textiles, agriculture, construction & transport etc., core sectors (Majumder & Dey, 2020). Known otherwise as the "mother of all industries", the industry mostly comprises micro, small and medium enterprises (MSMEs) located in the industrial clusters - Dholaikhal, Jinjira, Bogura and Syedpur.

It is believed that the LEI segment employs over 800,000 under direct and indirect employment and contributes about 2% to the country's GDP (Talukder & Jahan, 2017). Yet this is a socially and economically important sector that is still largely informal and under-institutionalized. Most of firms

being ranked with the technology obsolesce, limited financially escalated, a large unskilled people or marginal skilled work force is sailing under the boat (Majumder, 2022).

3.1 Domestic market size and production

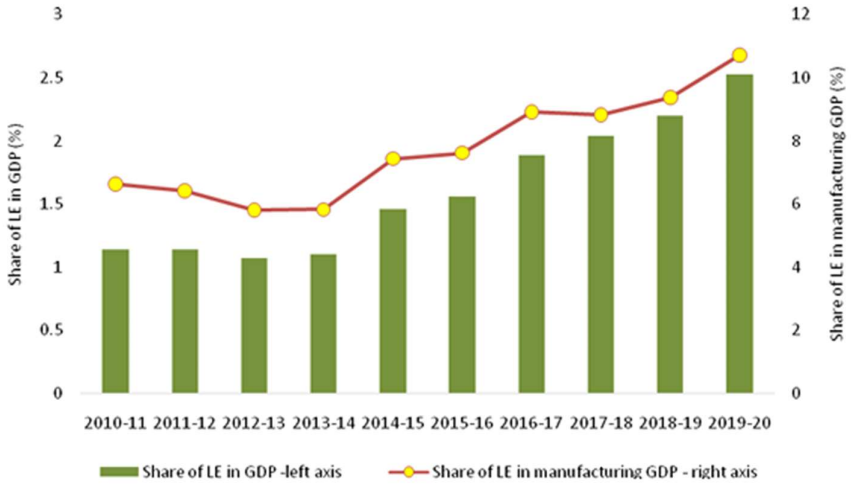


Fig. 1. Light Engineering GDP

Source: Authors' computation based on Bangladesh bureau of statistics data.

The light engineering sector is a key driver of economic growth in Bangladesh, supporting industrial development and providing significant employment opportunities. The National Board of Revenue (NBR) collected Tk 27,247 crore in July, the first month of fiscal year 2025-26(TDS, 2025). The draft policy targets increasing the contribution of industries to the country's gross domestic product (GDP) to 40 per cent by 2025 by developing light engineering industries(TDS, 2021).Predominantly composed of micro, small, and medium-sized enterprises, it manufactures and repairs metallic components for industrial, agricultural, and vehicular machinery. The sector has vast potential for further economic development and job creation, with around 10 million people employed, offering opportunities to reduce poverty and enhance labor market efficiency (Hoque, 2016). Despite the increase in collection, NBR fell short of its July target by 9.5 percent. The target was Tk 30,110 crore for the month. For the entire fiscal year, the NBR has set a revenue collection goal of Tk 499,000 crore (TDS, 2025).Manufacturing sector in Bangladesh growing at a Compound annual growth rate (CAGR) of 14%. The light engineering road map projected that export earnings from the sector would stand at $12.56 billion in 2030 (BIDA, 2024).

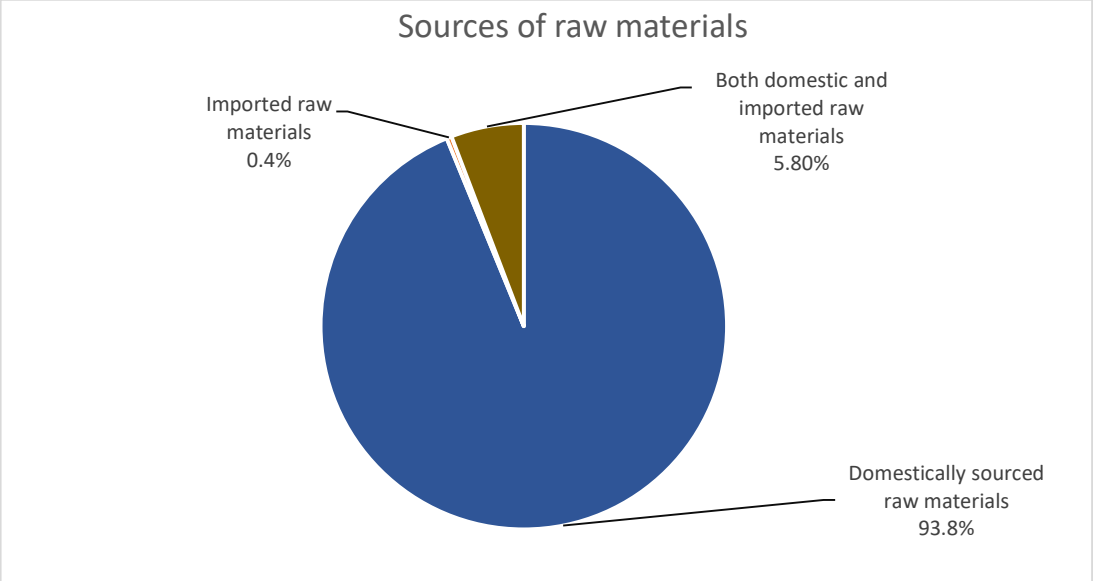


Fig. 2. Sources of raw materials.

Source: RAPID firm-level survey of LE sector, 2022.

In Bangladesh, light engineering firms predominantly rely on domestic raw materials for production. Approximately 94% of these firms use locally sourced materials, with only 6% utilizing some imported inputs. For those using imported materials, these account for about 40% of their total inputs. Key domestic sources for light engineering products include scrap materials from ships, aluminum, brass, iron, rods, various types of sheets, coke, limestone, ferrosilicon, and ferromanganese. Around 90% of the raw materials are sourced from the shipbreaking industry (TBS, 2023a).Surveyed firms mainly procure scrap metal from shipbreaking, along with aluminum, brass, pig iron, and cast iron from domestic sources. Not only does it affects the quality of the product, but also it limits the competitive capability in domestic and international markets (Talukder & Jahan, 2017). In addition, firms cite vast raw material procurement barriers as well as quality control, ergonomics and troubleshooting (Banglaseh) on top of reactive problem solving (RPS)—all signifying that the production environment is not very effective.

The various national political initiatives to support the sector have been narrow but increasing in number. The "Product of the Year" in 2020 announced by the Government of Bangladesh was meant to raise visibility and attract investment in light engineering products (Majumder & Dey, 2020). However, structural impediments such as the absence of policy for the sector, poor institutional coordination, and insufficient skills development programs will continue to constrain long-term growth.

Recent literature has also alluded to the role of the LEI sector through Sustainable Development Goals (SDGs), specifically SDG 1 – poverty eradication, SDG 8 – decent work and economic growth, SDG 9 – industry innovation including infrastructure and SDG 12 sustainable production practices (Majumder, 2022). Given appropriate policy initiatives, technological upgrading and financial inclusion, the LEI can be an important agent for promoting inclusive industrial growth in Bangladesh.

3.2 Value chain of Light Engineering:

From the procurement of raw materials to product delivery and after-sales support, the Light Engineering sector's value chain summarizes the sequential flow of operations that together define the sector's efficiency, competitiveness, and contribution to industrial progress.

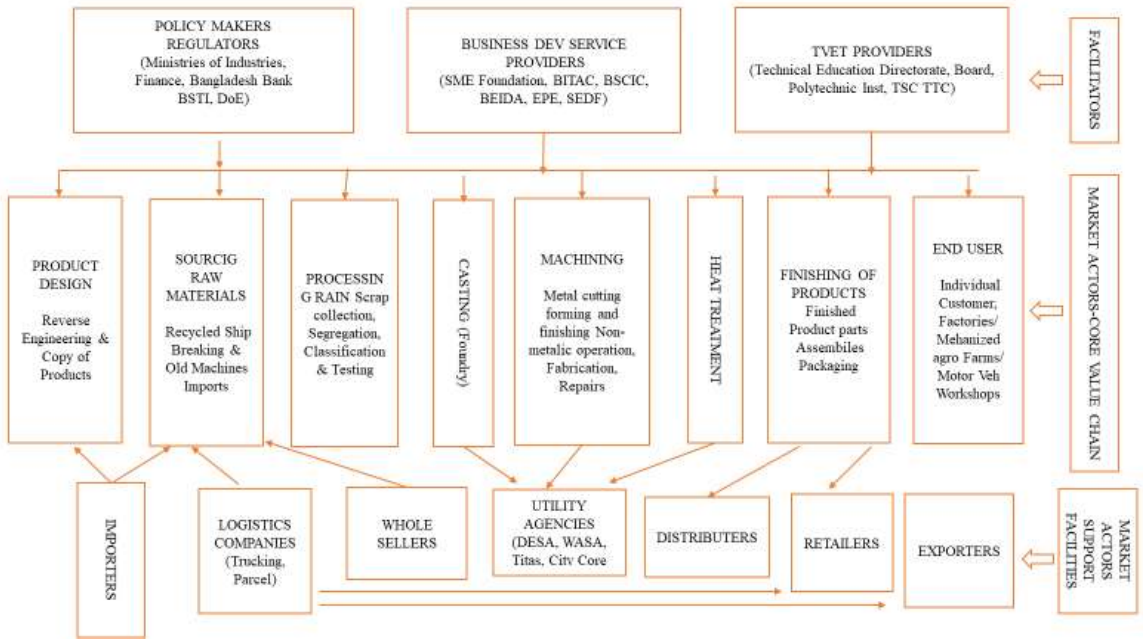


Fig. 3. Value Chain of the Light Engineering Sector in Bangladesh (Talukder & Jahan, 2016)

4. Challenges and Opportunities of the Light Engineering Industry:

In a highly competitive, complex and volatile nature of today's global marketplace, supply chains are continuously impacted by various incidents that can potentially jeopardize their capacity to function and their ability to be cost-effective(Mostafa et al., 2020). In the same region, the Light Engineering Industry (LEI) in Bangladesh has to deal with several critical challenges. Such as, due to lack of professional knowledge and skills of most laborer, there exists the lack of skilled workers as a serious problem. In addition, the people who work in this sector are mostly low educated and unskilled, and they work based on their human measurements and judgments instead of any computer-aided designs(Ahmad & Jahan, 2017). A recent study conducted by International Finance Corporation (IFC) in partnership with UK Department for International Development and Norwegian government showed that the light engineering sector in Bangladesh has employed around 600,000 people in its 50,000 micro-enterprises and 10,000 small and medium enterprises (Ahmad & Jahan, 2017).A dedicated talent pool of 1 million skilled workers, representing 7% of the national workforce (BIDA, 2024).

Light engineering enterprises in Bangladesh primarily use outdated conventional machinery, such as lathes, boring, milling, shaping, drilling, and grinding machines (INSPIRED, 2024; Talukder & Jahan, 2016).They lack access to advanced technologies like Computer-Aided Numerically Controlled (CNC) machines, Computer-Aided Design (CAD), heat treatment facilities, and testing equipment, which are essential for producing high-quality products. The majority of raw materials used are sourced from

shipbreaking (INSPIRED, 2024). Due to the inability to assess the strength of raw materials, the products often suffer from either excessive strength or weakness. The owners refrain from investing in new technologies because of uncertain demand, high financing costs, narrow profit margins, and a shortage of skilled labor. The use of outdated technology leads to poor product quality, limited product variety, and smaller operational scales (Talukder & Jahan, 2016).In addition, the unrestrained standardization & un-monitored testing facilities are also affecting product reliability. Because businesses are so dependent on imports, getting hold of raw materials is particularly difficult. Most businesses in Nigeria are informal and financing or institutional support may be difficult to come by. There are also issues stemming from broken organizational coordination and the dearth of government focus in the industry (Majumder & Dey, 2020; Talukder & Jahan, 2017).

4.1 Policy challenges (lack):

Due to the small size of the industry, light engineering (LightCastle) firm owners feel sidelined in the formation of incentives for the manufacturing sector. Industry stakeholders believe the government's policies overlook the LE sector's role in job creation and providing alternatives to imports. Raw materials for LE machines face customs charges of 32-35%, while tariffs on imported LE items are around 1% (Eusuf, 2022).Steel products are set to become more expensive as the government has announced raising the Advance Income Tax (Pasupuleti et al.) and value-added tax (VAT) by over 40% at the import and production stages 20-23% at import and 20% at production while scrapping the existing fixed import tariffs (TBS, 2025).There are some other noticeable impediments in the light engineering sector of Bangladesh, which are mentioned in (Haque, 2013).These are: (i) the absence of cluster development projects including common facility center, (ii) absence of basic steel industry, (iii) absence of international standard laboratory for testing the quality of light engineering products, (iv) insufficient marketing ability for export promotion, and (Devex) little care taken to address environmental hazards and human safety aspect, especially in shipbreaking yards from where raw materials are being procured.

With these challenges notwithstanding, there is much promise in the industry. It contributes significantly to import substitution, by supplying machinery and components to local firms. Market growth is attributed to increasing demand from the construction, agriculture and textile sectors. Also having significant export potential, the LEI industry boasts annual export value of over USD 500 million. It can also create many jobs, particularly for young people who have had technical training. The sector can play a very crucial role in sustainable industrial expansion and achieving the SDGs if it is enabled through policy, technology and cluster based approach to development (Majumder, 2022).

5. Methodology

Through a combination of primary, secondary research and adoption of mixed-method research design, this paper offers a comprehensive analysis of the problems encountered by Bangladesh's Light Engineering (Lele) sub-sector. In particular, the issues of labor shortages, raw-material constraints, and transportation delays are emphasized, as they are important impediments to competitiveness and efficiency.

5.1 The Collection and Analysis of Primary Data

Fifty questionnaires were administered to the sample of SMEs in the LE sector, prescribing the use of the standard questionnaires for the collection of data from the respondents. Responding men included managers, technicians, skilled and unskilled workers, salesmen and craftsmen. To find out whether certain operational issues (i.e. In the first place, the data was obtained in a dichotomous way

(Present/Absent) concerning specific operational problems the company was facing, viz. disruptive client demand, lack of quality control, slow reaction toward IT innovation, being reacting to instead of proacting on client problems, bad ergonomics) were or were not present, the data were dichotomously collected (yes/no).

Statistical Analysis The collected data was analyzed practically using different statistical procedures (Python14 emphasis on descriptive statistical methods for determining the most common problems: frequency, mean, and standard deviation for the investigated parameters. Associations between perceived barriers to advance and professional role were examined with cross-tabulation; patterns of variables and group themes were examined using factor analysis.

5.2 Secondary Data Integration

Secondary data from credible sources such as the SEIP-FD 2023 report and other government and industry publications were used to reinforce and confirm initial findings. Such resources offer a wide-angle view of the labor market situation in the LE sector, its labor shortage, supply chain in-coherences and demand-supply misalignments. Utilizations of the Likert scale description for measurements about workload increase, dependency increase of outsourcing, limitation of quality improvement, arranged customer loss under competitive condition and exiting services.

In order to ensure consistency and discover systemic issues within the industry the primary survey was compared with secondary reports. The secondary data also gave the national level background for firm-level observations and gave support to the findings by triangulation.

5.3 Ethical Considerations and Limitations

Ethical principles were followed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all subjects and anonymity and confidentiality of the data were protected in processing and reporting the data. While the findings provide crucial new data, the study's small sample size and regional focus may limit the applicability of the findings.

6. Result and discussion:

Based on the analysis of survey information of 50 respondents (workers, managers, and owners), the main problem of a light engineering industry is the absence of workforce. Raw material problems, shipping delays, ergonomic issues and holes in quality testing are not far behind. Results including factor analysis, cross-tabulation, and descriptive statistics demonstrate that these matters are related, often with shortages of labor engendering further operational inefficiencies. These two inferences are further corroborated by supplementary evidence showing more general industry-wide restrictions.

6.1. Characteristics statistics Analysis:

Descriptive statistics were generated for the eight key problem variables on the survey by response category (1 = problem, 0 = no problem). The results shed light on the incidence and the severity of the firms in the Light Engineering industry.

Mean, Median, Mode, Standard Deviation:

1. Mean= $\frac{\sum X}{N}$

- $\sum X$ is the sum of all values.
- N is the number of values.

2.The median is the middle value in a sorted list of numbers.

3.The mode is the value that appears most frequently in the dataset.

4. Standard Deviation = $\sqrt{\frac{\sum(x_i-\mu)^2}{N}}$

- X_i is each individual value.
- μ is the mean of the dataset.
- N is the number of values.

Table 1: Summary Statistics of Various Operational Issues: Mean, Median, Mode, and Standard Deviation Values.

Variable	Manpower Problem	Technology Adaptation	Raw Materials Issue	Reactive Problem Solving	Irregular Customer Order	Transportation Cost/Delay	No Quality Testing Method	No Ergonomics Applied
Mean	0.8	0.3	0.74	0.72	0.48	0.76	0.74	0.76
Median	1	0	1	1	0	1	1	1
Mode	1	0	1	1	0	1	1	1
Standard Deviation	0.404	0.463	0.443	0.454	0.505	0.431	0.443	0.431

Table 2: Frequency and Percentage Distribution

Variable	Frequency (Problem present)	Frequency (No Problem)	Percentage (Problem present)	Percentage (No Problem)
Manpower Problem	40	10	80%	20%
Technology Adaptation	15	35	30%	70%
Raw Materials Issue	37	13	74%	26%
Reactive Problem Solving	36	14	72%	28%

Irregular Customer Order	24	26	48%	52%
Transportation Cost/Delay	38	12	76%	24%
No Quality Testing Method	37	13	74%	26%
No Ergonomics Applied	38	12	76%	24%

Frequency Analysis:

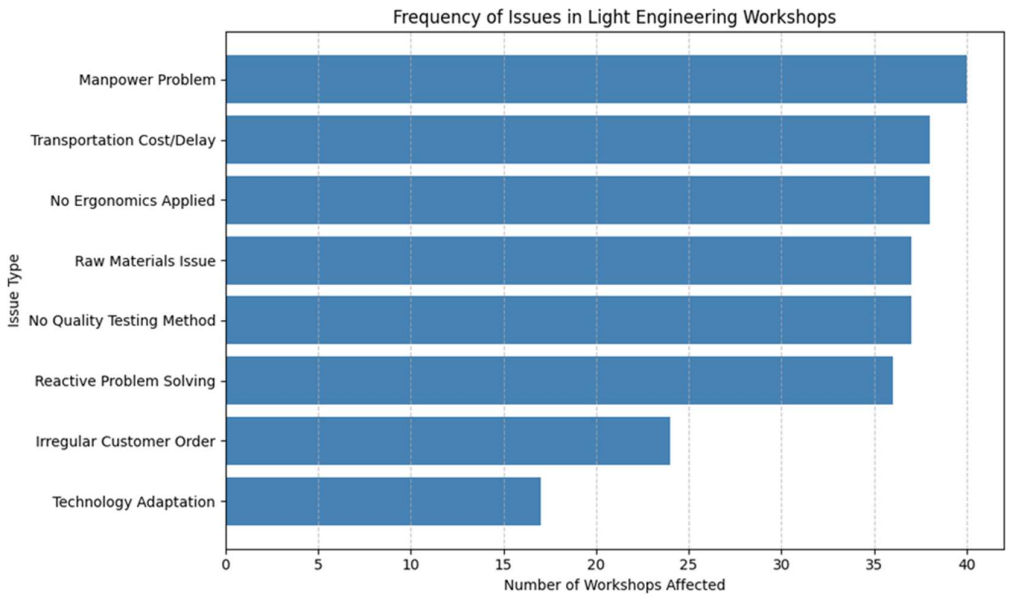


Fig. 4. Frequency of Operational Issues in Light Engineering Workshops.

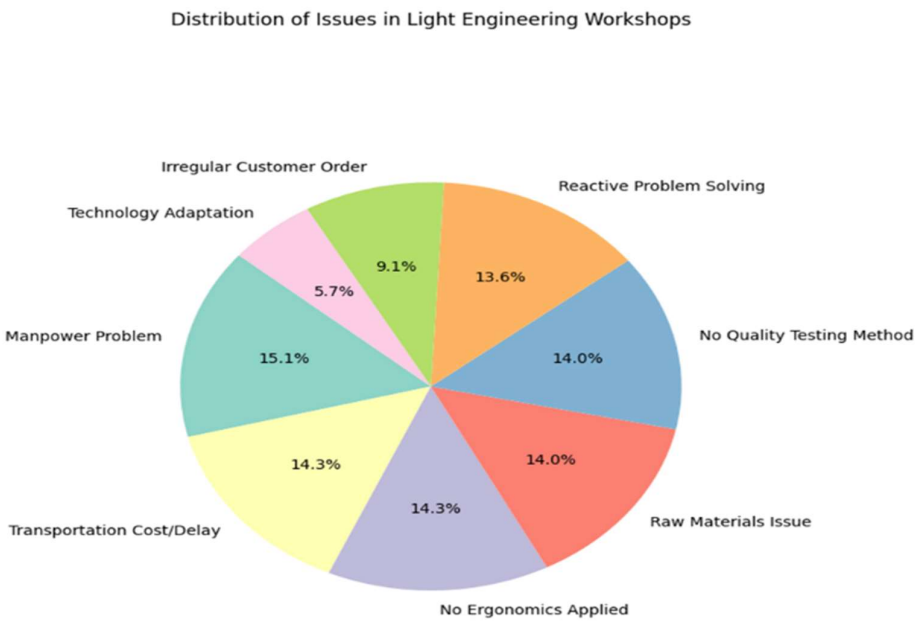


Fig. 5. Prevalence of Operational Issues in Light Engineering Workshops.

6.2 Cross Tabulation:

Cross-tabulation was performed to assess the relationship of the respondents' definitions of obstacles and their employment status. This research helped show that problems such as not enough people, quality control problems, raw material delays, etc., vary across technicians, managers and craftspeople. Consistent with the research aim of detecting deficiencies in occupation-oriented operations of the Light Engineering sector, it enabled a more delicate analysis of survey findings.

1.Raw Materials Issue vs Manpower Problem

Manpower Problem	**No (0)**	**Delay**	**Delay (1)**
No (0)	4		6
Yes (1)	8		32

2.Transportation Delay vs Manpower Problem

Manpower Problem	No Raw Issue (0)	Raw Issue (1)
No (0)	4	6
Yes (1)	9	31

3.No Quality Testing Method vs Manpower Problem

Manpower Problem	Has Testing (0)	No Testing (1)
No (0)	5	5
Yes (1)	8	32

4.No Ergonomics Applied vs Manpower Problem

Manpower Problem	Ergonomics Applied (0)	Not Applied (1)
No (0)	5	5
Yes (1)	7	33

5.Technology Adaptation vs Manpower Problem

Manpower Problem	Tech Not Used (0)	Tech Used (1)
No (0)	5	5
Yes (1)	30	10

6.Manpower Problem × Reactive Problem Solving

Man power Problem	Not Reactive (0)	Reactive (1)
No (0)	6	4
Yes (1)	8	32

7.Manpower Problem × Irregular Customer Order

Manpower Problem	No Irregularity (0)	Irregularity (1)
No (0)	6	4
Yes (1)	20	20

6.3 Correlation Analysis

The Phi coefficient (Φ) was calculated for each combination of binary variables (1: problems exist, 0: problems do not exist) so as to identify relationships between commonly occurring major operation problems, such as transit delays, raw material accidents, and human resource deficits. This was done with the Chi-Square Test of Independence. Phi was chosen as a standardized measure of relationship strength that is suitable for binary correlation. In order to focus on moderate to strong dependences, a cut of $\Phi \geq 0.2$ was used.

As the data show, the cause with the highest cause of the difficulty is inadequate human resources, which is closely correlated with a series of factors damaging the efficiency, such as inadequate testing methods ($\Phi = 0.42$), transport delay ($\Phi = 0.41$), reactive problem solving ($\Phi = 0.39$) and raw material problems ($\Phi = 0.36$). Together, these relationships indicate that firms that have labor problems are more likely to have other operational inefficiencies.

These associations are visually represented in the causal loop diagram (Figure 2), illustrating the interconnectedness of workforce constraints to other, systemic issues, and not existing in isolation. It indicates that adding labor capacity could be a tactical option to decrease the inefficiencies in the light metals industry.

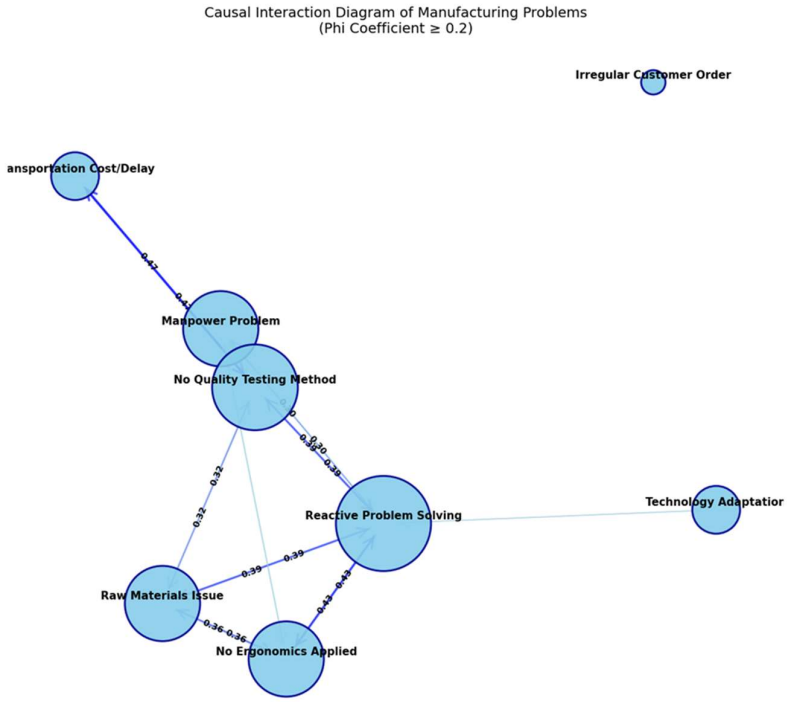


Fig. 6. Causal Interaction Network of Key Manufacturing Problems.

This Causal Interaction Diagram illustrates the relationships among significant process problems (Phi coefficient 0.2 or larger). It focuses on important aspects like Manpower Problem, Raw Materials Issue, and Quality Testing Method, which affect Reactive Problem Solving. Directed arrows are used to express causality and the circles are scaled according to the severity of the issue. There are some problems, such as Transportation Cost/Delay and Irregular Customer Order have relatively low connectivity but generate operational losses.

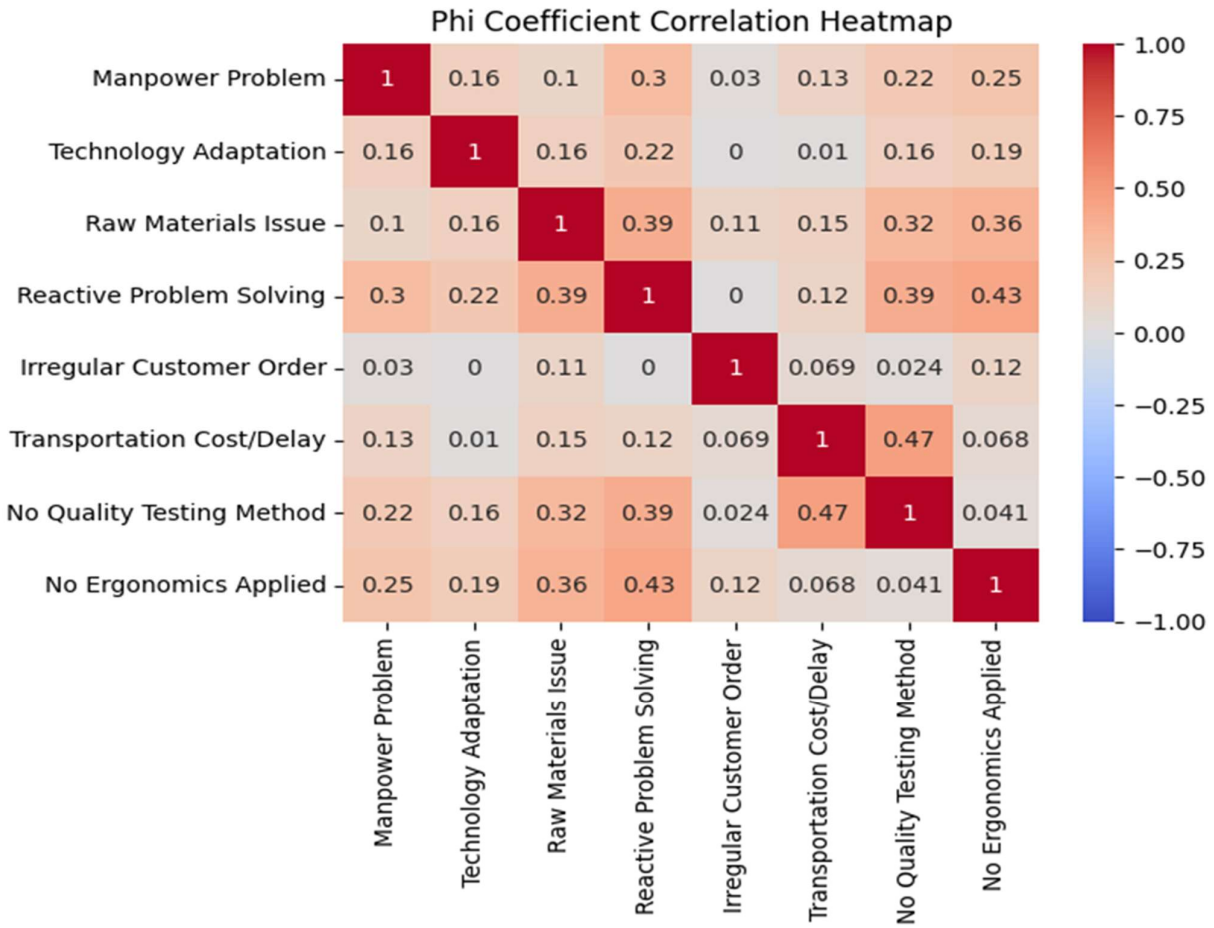


Fig. 7. Correlation Analysis of Operational Problems in Manufacturing

This is an image which depicts a heatmap of the Phi Coefficient correlation in the operational goals of the Light Engineering Industry. The matrix presents low to moderate correlations for factors such as manpower concerns, technology change, raw-materials-associated problems, and reactive problem resolution. The column "No Ergonomics Applied" is interesting that of any other columns it correlates most positively with "Reactive Problem Solving" and "Raw Materials Issue ". The interrelations between the listed issues are given by the heatmap.

Table 3: Impact of skill shortage on enterprise.

Occupation	Have difficulties introducing new work practice						Increased workload on other workers				
	No Impact (%)	Some Impact (%)	Moderate Impact (%)	High Impact (%)	Very High Impact (%)		No Impact (%)	Some Impact (%)	Moderate Impact (%)	High Impact (%)	Very High Impact (%)
Manager	9.21	38.16	43.42	7.89	1.32		22.37	40.79	31.58	5.26	–
Professional	6.25	21.88	40.63	25.0	6.25		21.88	15.63	46.88	12.5	3.13
Technician	5.1	25.95	45.92	12.24	7.14		15.31	17.35	36.73	28.57	2.04
Sales and Clerk	8.33	58.33	8.33	25			58.33	16.67	8.33	8.33	8.33

Source: Skills for Employment Investment Program (SEIP)

Table 4: Impact of skill shortage on enterprises.

Occupation	Obs.	Faced loss in sales or order due to competition (Domestic/International)				Delay in developing the quality of product			
		No Impact (%)	Some Impact (%)	Moderate Impact (%)	High Impact (%)	No Impact (%)	Some Impact (%)	Moderate Impact (%)	High Impact (%)
Manager	62	22.37	51.32	18.42	6.58	13	48.68	23.68	2.63
Professional	28	15.63	34.38	28.81	21.88	15.63	28.13	21.88	31.25
Technician	71.5	1.21	28.57	46.94	15.31	1.24	25.51	44.89	16.33
Sales and Clerk	11	16.67	58.33	25.00	0.00	83.3	25.00	66.67	0.00
Crafts and other	119	7.98	23.69	45.64	16.46	9.73	28.68	34.91	21.7
Total	120	9.85	29.08	40.87	15.02	12.28	30.53	35.06	18.58

Source: Skills for Employment Investment Program (SEIP)

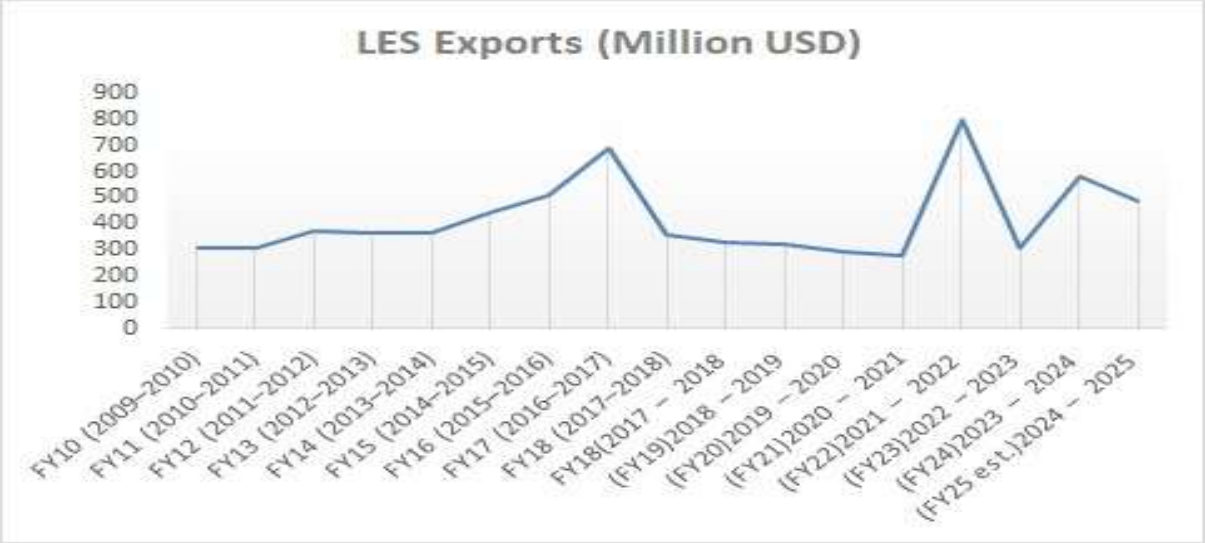


Fig. 8. Export performance of LES in Bangladesh (Export Promotion Bureau)

Table 5: Export of light Engineering sector in Bangladesh (Million USD).

Products (HS Code)	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Iron and steel (72, 73)	60.42	69.79	59.73	56.81	54.33	57.90	48.56	58.83	48.55
Copper wire (74)	110.86	99.83	50.93	66.38	49.17	27.88	24.47	36.09	53.18
Stainless steel ware (82)	26.11	36.03	3.20	1.58	5.36	3.89	9.22	7.82	4.37
Engineering equipment (84)	23.20	26.07	49.54	48.73	63.06	83.03	174.80	271.09	41.38
Electric products (85)	49.23	65.04	88.53	63.09	54.63	90.11	65.00	68.94	61.96
Bicycle (8712)	2.67	2.43	105.59	105.08	112.89	126.06	99.15	82.46	85.73
Others	38.60	10.36	17.97	25.80	27.19	58.17	88.88	163.61	60.79

Total	311.09	309.55	375.49	367.47	366.63	447.04	510.08	688.84	355.96

Source: Export promotion Bureau

7. Recommendations:

This paper provides the following pragmatic options for addressing structural shortfalls in the light engineering sector of Bangladesh in light of the major findings of the statistical analysis:

7.1 Skilled Workforce Training and Certification:

The sector's chronic manpower shortage could be addressed by expanding vocational and technical training programs relevant to LEI needs. Quality control, welding standards, CAD/CAM, CNC operation: all of these are where attention really need be directed. Government and industry partnerships can assist and promote certification-based initiatives to formally recognize skills.

7.2 Implementation of ERP and Digital Management Software:

SMEs need to be incentivized to deploy Enterprise Resource Planning (ERP) systems to enhance cooperation and output. This will reduce some manufacturing holdups and simplify the monitoring of client orders, procurement and inventory. Government or donor digitalization grants could also bolster early ERP uptake.

7.3 Improvement of Quality Assurance Mechanisms:

Infrastructure for high quality testing shall be invested Product reliability, marketability shall be strengthened by building standard testing facility within the industrial clusters and imparting ISO/ASTM standards.

7.4 Ergonomics and Occupational Safety Promotion:

Low- cost ergonomic interventions and education should be provided, especially in high technician workloads. This could potentially increase worker productivity and decrease injury risk.

7.5 Logistics And Supply Chain Hubs:

Best practice logistics facilities in and around key cities enable quicker access to raw materials and final markets. These hub locations should enable improved transport access, faster last-mile delivery, and bulk material storage.

7.6 Procedures Normalization and Financial Reward to Informal Firms:

Informal businesses could potentially be enticed into the formal sector through simplified registration processes and financial incentives such as equipment subsidies or cheap credit. This will enable training and support services to be more available.

7.7 Cluster-Based Industrial Growth:

Light Engineering Clusters will enable cost effectiveness, creativity and competition as it will facilitate the development of CFCs compromising shared equipment, management system supported by ERP and training center.

7.8 Policy Development and Institutional Coordination:

A country policy must be for the light engineering. It should have clear targets for technology adaptation, training, export promotion and environmental sustainability and also cascade down objectives for BSCIC, BITAC, SME Foundation and the private sector players.

POLICIES & INCENTIVES

- 10-year tax holiday for new industries (Applicable until 30 June 2030; SRO No. 166 Law/Income Tax/2021).
- Duty exemptions on capital machinery imports (118-AIN/2022/66/Customs).
- 10% Export Subsidy on export of light engineering products (Applicable until 31 December 2025; FEPD Circular No. 28).
- 50% tax exemption on income from exports (Applicable until 30 June 2028; SRO No. 170-Law/Income Tax/2023).
- Priority export diversification sector under Industry Policy 2022.
- Agricultural machineries (SR0 164/Law/Income tax/2021).
- Institutes providing technical/vocational training for engineering skills development (SRO 168/Law/Income Tax/2021)
- Reduced import duties on raw materials, tools and equipment used for LE industries (SRO 133 AIN/2017/19/Customs).

Source: BIDA

8. Conclusion:

According to the results and analyses of the study, it is evident that Bangladesh Light Engineering Industry (LEI) faces several serious constraints in their operation and the most important one is labor shortage. The sector's inefficiencies are compounded by other issues: raw material is scarce, shipping delayed, quality control insufficient, and technology unused. The interrelatedness of these problems highlights the need for a systemic approach to address the underlying pathologies in the industry.

"Improving availability of skilled labor and utilization of state of practice tools (e.g., CAD and CNC systems) could be key strategies to enhance competitiveness and productivity if such industry-wide innovative efforts are adopted concurrently." Officialization of the informal businesses is a drive-in long-term development and for effective planning, as well as for the provision-uptake of high-quality testing facilities and distributional logistics. In order to encourage these advance we need to see the emergence of national policies that are sympathetic to the requirements of the LEI sector and vocational training systems.

In summary, the LEI sector in Bangladesh has great potential to enhance the nation's economy in helping key sectors like construction, agriculture, clothing, etc. But there is a need for substantial investment in upgrading technology, strengthening institutional support, and developing skills in order to fulfill this promise. In addition to strengthening the resilience of the LEI sector, addressing these operational concerns will align the sector with the Sustainable Development Goals (SDGs) and broader national development objectives.

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