Unlocking Industry 4.0 Technologies: The JSW Steel Case

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ABSTRACT

Steel is a vital material due to its strength, durability and wide-ranging applications across many industries. Its conventionally complex, labour-intensive and unsustainable manufacturing process is now evolving to reduce its carbon footprint, support global development and shape the modern world. This paper explores how JSW Steel, one of the largest steel-producing companies in the world, is deploying Industry 4.0 technologies (I4.0) to achieve economic, social and productivity goals. The paper contributes to the growing discourse on how the use of intelligent technologies is transforming pioneering and early-adopting firms, while reducing uncertainty and costs for others.

KEYWORDS

Industry 4.0, steel manufacturing, productivity, sustainability, transformation

INTRODUCTION

The Government of India aims to establish that country as a global manufacturing and design hub (Make in India, n.d.). India is also the third largest country in terms of economy-wide digitalisation (Press Information Bureau, 2025). JSW Steel is an Indian multinational company based in Mumbai. Its adoption and use of Industry 4.0 (I4.0) technologies is an inspiring model for other legacy manufacturers and provides academics with concrete examples of how digital technologies can be leveraged to transform industries and drive sustainable growth.

BACKGROUND AND AIMS

Industry 4.0 – synonymous with smart manufacturing – is often seen as a panacea for sustainable growth (Lekan et al., 2021). It is a complex concept with four key dimensions, including digital transformation, organisation, strategy and human resources, yet it is paving the way for growth in many economies (Rocchi & Brissaud, 2023), including India. There are some concerns about I4.0's tenets relating to environmental and social sustainability, with I5.0 being seen as a better manufacturing concept (Dieste et al., 2023; Wan et al., 2020). The objectives of this research are to explore JSW Steel's adoption and use of I4.0 technologies to enhance productivity, support sustainability and enable social progress. Opportunities for enhancing implementation are identified.

METHODS AND RESEARCH DESIGN

As the scope of the research question is quite broad, the research methods applied combined case-study analysis (using secondary data) with a non-systematic literature review. Key search terms such as 'Industry 4.0' and 'JSW' were used to retrieve relevant results from Google Scholar, EBSCOhost, and Google. The inclusion criteria included conceptual papers, case studies, industry publications, annual reports, company websites and videos. Preference was given to content published during the last six to seven years. Scholarly articles that were unclear or not relevant to the research topic, or focused on mathematical models and simulation, were excluded. Some of the techniques adopted for

bias mitigation were use of multiple information sources for a wider perspective, data triangulation to validate findings, multiple lenses for a nuanced understanding, and self-reflection.

FINDINGS, ANALYSIS AND DISCUSSION

Intelligent products and factory automation are central to the concept of I4.0 (Wan et al., 2020). Many conceptual frameworks on digital transformation recommend a multi-dimensional approach for implementing I4.0 technologies (Hajoary et al., 2023), and emphasise the strategic, cultural and structural integration of these domains (Imran et al., 2021). Using this understanding and its digital maturity evaluation, JSW has been applying a strategically planned and staged programme of resource optimisation and digitalisation (JSW Steel, 2024; JSW Steel, 2022). It has reported having initiated over 200 projects since 2017 and has made strong strides towards its smart factories' milestones (JSW Steel, 2024; ABB, n.d.). The firm's digitalisation strategy focuses on driving revenue and market growth, increasing profitability, attaining excellence in environmental, social and governance (ESG) practices, and creating an excellent workplace environment (JSW Steel, 2023; 2024). Figure 1 provides a simple representation of the firm's adoption of I4.0 from a value chain perspective. The four 'smart' dimensions reflect operational and market needs with an end application principle along the value chain as shown by the big arrow. The colour depth of the 'smart' boxes is based on the author's interpretation and qualitative assessment of JSW's progress, with a darker shade implying more progress.

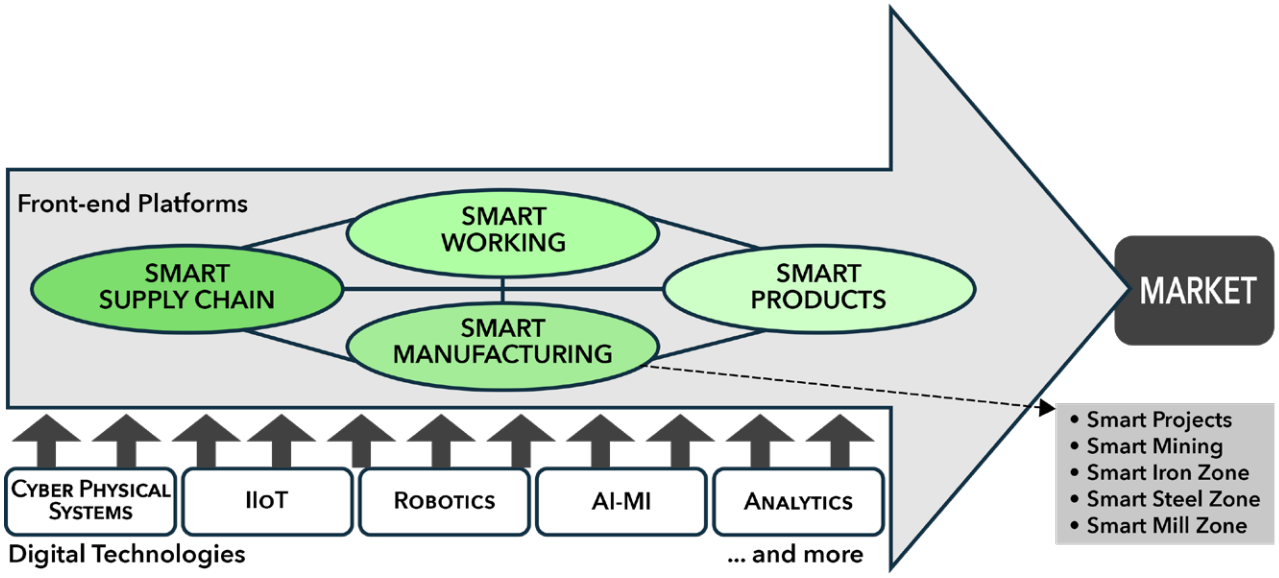

Figure 1. JSW's I4.0 technologies, adapted from Frank et al. (2019).

Major specific application areas and benefits of I4.0 for JSW have included real-time remote monitoring and management of production processes, enabling predictive maintenance and averting downtime, thereby enabling yield prediction. This has helped optimise steel production, minimise productivity loss, reduce costs, achieve plant efficiency and improve quality (Asia Growth Partners, n.d; JSW Steel, 2021; 2023; 2024). Using AI-enabled coal gasification and decarbonisation technologies has reduced energy consumption and carbon footprint, and has enabled the development of green products from recyclable steel (SteelOrbis, 2025; Carbon Clean, 2024). End-to-end operations, including mining, raw material processing and steelmaking, have been integrated; value-added product and brand management has enhanced efficiency, reduced costs, and improved customer satisfaction and retention; HR digitalisation and upskilling staff using virtual and augmented reality technologies have modified workplace safety practices (Manufacturing Today, 2024).

Solutions-focused products have been created; for example, providing high corrosion resistance and heat reflection (JSW Steel, 2025). During 2023–24, value-added special products made up 62% of JSW's sales, and the firm trained 7,182 employees in digital technologies, ensuring future readiness of its workforce (JSW Steel, 2024). So far, the firm has avoided over 25,000 hours of unplanned downtime using AI-enabled real-time monitoring, contributing to operational efficiency (JSW Steel, 2025).

JSW is also involved in several social transformation initiatives, such as health education and waste management. The company once partnered with Datamatics, an Indian technology company providing digital solutions to overseas clients for getting AI-related jobs for the women of its mill workers' families, opening upskilling opportunities and fostering their economic independence and future career prospects (Columbia Business School, 2024).

JSW's new abilities in the digital space have empowered the wider JSW group to develop a tech-led B2B e-commerce platform to cater to India's construction and manufacturing companies and thus expand into other value-generating territories. This platform offers end-to-end services to buy steel and other products, including procurement, fulfillment and credit, and aims to become a leading e-commerce platform for B2B companies and builders, saving their time and enhancing customer satisfaction (JSW One MSME, n.d.; TNN, 2025). This initiative also enables market penetration and sales growth of its core steel business.

Factors such as long-term vision, large size, high risk-tolerance, a big training infrastructure, managerial capabilities and experience, and ambitious yet adaptive strategic planning are supporting JSW's digitalisation and resource optimisation journey, while also progressively embracing the Industry 5.0 (I5.0) landscape. However, despite several awards, impressive progress and sustainability-linked remuneration of senior management, conventional steel manufacturing remains a polluting business overall. JSW is exploring greener technologies, such as hydrogen injection and electric arc furnaces (Hydrogen GenTech, 2024; JSW S.A., 2021), but blast furnaces are still a big part of its current operations. Unless major investments are made, this could impact the achievement of JSW's carbon-neutral goal (by 2050) and no net loss of biodiversity (by 2030). Its short-term objective to reduce its carbon footprint by 50% by 2030 (using 2020 baseline) could be particularly challenging to meet.

RECOMMENDATIONS AND FUTURE RESEARCH

More in-depth research is required for a more accurate assessment of the success of JSW's digitalisation activities and its benefits to the firm and its ecosystem; however, JSW should benefit from a comprehensive review of its initiatives, using a 360-degree feedback loop. Greater focus on green production, more afforestation, and biodiversity conservation projects may better support the I5.0 principles of sustainability. There are also opportunities to align further with the I5.0 tenets of human centricity and resilience (Bucci et al., 2024). With an evolving and complex ecosystem, JSW would benefit from continually integrating its ecosystem with those of its supply-chain members. The firm should also benefit from improving gender balance at work and gender-balanced leadership, as it is still a male-dominated workplace. Investment in human–machine collaboration technologies should improve productivity, safety and alignment with India's national strategy on robotics (MyGov, 2025).

CONCLUSION AND IMPACT

JSW's progress with I4.0 technologies and award-winning achievements are in strong harmony with India's and the firm's growth priorities, particularly in the domains of infrastructure development and technological advancement. This paper fills a research gap by exploring the implementation of I4.0 in the Indian steel-manufacturing context and the benefits of I4.0 for legacy firms, and informs decision making. JSW should

gain from a 360-degree review of its progress and taking appropriate actions to develop a stronger base for I5.0. There is much for other legacy manufacturers to learn from JSW's digital transformation and growth using 14.0 technologies, to enhance their readiness and reduce uncertainty.

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