The use of “Industry 4.0 technology and practices” in Manufacturing Companies - A Case Study Research Approach

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To

Abstract

In recent periods, researchers (Buer et al., 2020; Dalenogare et al., 2018) have been discussing Industry 4.0 as an essential strategic concept for developing competitiveness and improving the productivity of manufacturing companies. Industry 4.0 is not only expected to strengthen operational performance (Chiarini and Kumar, 2021) but also facilitate real-time support and decentralized decision-making (Wiech et al., 2022; Zheng et al., 2021) in the value chain. The real context of these emerging technologies is to improve digitization and automation.

Even though there is no perfect agreement among researchers on the complete comprehensive list of tools that are discussed under Industry 4.0, it comprises several digital technologies with some recurring appearances. The commonly cited and explored elements of these technologies include Collaborative robots (CR), the Internet of Things (IoT), Big data, Cloud computing, Visualization technologies, Additive manufacturing, Machine learning, and Artificial intelligence.

The requirement and implementation pattern of Industry 4.0 and the subsequent performance in the organization may differ for individual technology (Ghobakhloo, 2018). As a result, it is very pertinent to refer to and deeply evaluate the applications of a particular technology being used in the manufacturing company. Although there is a wide scope of Industry 4.0 to impact and transform manufacturing (Ghadimi et al., 2022), academic research is infancy and mostly limited to a literature review, perception-based survey, or theoretical in nature. This provides a new scope for probing the practical implementation using case studies of the companies that implemented these (Yilmaz et al., 2022).

To understand the wide-ranging emerging phenomenon in the specific context of technology and manufacturing function, case research is considered the most powerful methodology due to the study done in real-life settings (Eisenhardt, 1989; Meredith, 1998). In this research, first,

we study the implementation journey of industry 4.0 practices in manufacturing firm second detailed study of one of industry 4.0 practices i.e. BDA and CC. The research also evaluates the impact of BDA and CC implementations on the performance of the company.

Case study 1: A road map to implement Industry 4.0 practices

Currently, many organizations are in the process of implementing Industry 4.0 practices. Industry 4.0 is a bunch of many practices however most of the studies were conducted around one practice/technology. In this study, our goal is to develop the roadmap of industry 4.0 implementation in manufacturing organizations. Our study will set directions to practitioners in multiple facets such as where to deploy industry 4.0 practices, Which industry 4.0 technology would be most appropriate based on the problem, how to surface the problem in communication flow, which is proactive in nature, and how to simultaneously be applied all these practices.

In the era of the lean world, researchers and practitioners utilized the concept of value stream mapping to some extent for the identification of waste in the supply chain but with advancements in technology that call for real-time decision-making. We also propose the concept of Digital Mapping (One of the steps in a complete road map) so that practitioners can map the current state of information flow and prepare the future state of information flow. Mapping Digital information flow will help to identify the projects in the supply chain, their value, and their priorities.

Keywords: Artificial intelligence, Computer vision machine learning, Internet of Things, Virtual reality, Collaborative Robots, Big Data analytics, Cloud computing, and digital mapping

Case-study 2: Integrating Big Data and Cloud Computing into the Existing System and Performance Impact: A Case Study in Manufacturing

Manufacturing companies generate vast but underutilized business data in ERP systems. Big data analytics is expected to drive valuable insights from unexplored data, enabling managers to make well-informed decisions. Cloud computing, with its cost-effective resources, offers access to hosting and facilitating such access. Despite extensive literature, real-life applications illustrating how manufacturing companies can derive value from available data through the integration of big data and cloud are still lacking.

The study, based on a single manufacturing case study, investigates the process of integrating big data and cloud computing into the existing business ERP system. Literature argued that big data benefits would be limited without aligning the established culture and resources in the implementation process, known as big data capability. The paper explores the company's journey, evaluating the importance and overall development of preexisting capability during adoption. The work also assesses the impact on operational performance. The several insights obtained from the real-life case serve as a valuable guide for managers before embarking on big data projects. The findings establish the importance of big data capability and illustrate how manufacturing companies can seamlessly integrate these technologies and improve performance without compromising the alignment of business.

Keywords: Case studies, Big data, Cloud computing, Industry 4.0, Manufacturing performance

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Case study:1

The current study bridges the gap of existing literature by two major contributions, first, we shared the complete roadmap to implement industry 4.0 practices. OEMs and MSMEs can benchmark the current study to implement it in a structured way. Our study set the example of inclusivity and teamwork, and how team engagement resulted in great results. We discussed most of Industry 4.0 practices individually. It gives direction to practitioners on which technology would be most suitable based on the nature of the problem.

The current approach is proactive in nature, it suggests surfacing the problem in the current communication flow of the supply chain and then solving the problem using best industry 4.0 technologies rather than reacting once the problem is observed. The success story of the transformation journey is the best example of teamwork, active engagement of stakeholders, skill enhancement, and innovation in the organization. The current study suggests how existing infrastructure and Oracle capabilities can be utilized for the implementation of I-4.0 practices, not necessarily to invest in solving problems through I-4.0 practices. Most importantly, we observed tangible and Intangible benefits of each practice deployment.

We propose an OEE optimizer model in case of higher absenteeism, this could be input for exclusive research on OEE in manufacturing environments. For collaborative For Collaborative robots, we suggested some insights such as when to purchase, where to deploy, and its other selection criteria. Extensive research can be performed in the domain of selection, and deployment with respect to different layouts and manufacturing environments. We shared the application of CVML technology i.e., packaging applications, footfall counting, and inspection processes. Practitioners can figure out similar nature of applications and utilize the technology. Best of our knowledge, application VR technology was limited to

training medical professionals, we shared how this technology can be used for imparting training in manufacturing environments.

Case study:2

Our second contribution is the impact of BDA and CC implementation in the supply chain. It is recommended that practitioners identify weak areas of the supply chain and then deploy industry 4.0 practices such as BDA and CC. We covered all the components of BDA, CC, and its impact on performance measures both tangible and intangible. A similar framework can be applied to other practices for future research.

The integration of big data analytics and cloud computing, using diverse manufacturing data, enables the creation of user-friendly dashboards presenting real-time operational measures. This visual real-time information assists the various stakeholders in comprehending the actual status of the system, facilitating quick decision-making and further enhancing overall performance. Moreover, the cloud enables access to the system on any device, including mobile, from any location.

The insights obtained from the case study apply not only to real-time inventory control but also offer applicability to various domains of manufacturing companies. The theoretical implication of this study lies in an empirical demonstration of how various capabilities of the company can be aligned for the successful adoption of big data and cloud computing. The study contributes to both researchers and practitioners with certain limitations. The validation of findings can be done by conducting a similar kind of case studies in different manufacturing sectors, especially in small and medium-sized companies. Additionally, the study may explore external performance parameters for manufacturing companies to broaden the contributions of the study.

The findings resulting from the real-life case offer crucial insights for managers to seek business value while venturing into big data analytics. The implementation of big data projects

should initiate with identifying needs, resulting benefits, and subsequently locating the source of appropriate data in the company. An important takeaway from this study is that the existing ERP system can serve as a robust foundation for data to extract value from big data analytics. This particularly opens several avenues for manufacturing companies to conceptualize and integrate big data analytics into traditional ERP systems effectively.

The in-depth case study indicates the willingness of the traditional company to accept the cloud concept but with a confidentiality mindset (Ogbuke et al., 2022). However, with rapid technological changes, cloud computing has become cost-efficient rather than owning expensive infrastructure. This provides an opportunity for companies to leverage present business data and align it with such emerging technologies. This presents a practical roadmap for companies to incorporate big data and cloud solutions into the existing system while addressing privacy and security concerns. This finding could be limited to the companies interested in using internal data for generating insight rather than those related to external data such as customer information.

Overall, the company can realize the large benefits of big data projects by establishing an organizational culture addressing both the human and technical aspects. Top management plays a pivotal role in initiating a data-driven attitude and fostering a learning culture among the employees. The study identified that such an organizational culture required for this project was not developed overnight or initiated for the given project but shaped over time through various initiatives, training, and improvement programs inducted by top management. Further, managing such a project may necessitate employees to upgrade specific technical skills while requiring an effective project management approach. Undertaking small and uncomplicated projects can enhance these skills and develop confidence among the employees for large and complex projects. It is observed that improvement programs such as Lean and Six Sigma, while not direct prerequisites, contribute to the favorable culture for big data by developing soft

practices referring to people, relationships, and processes. This is the significant finding from the case study, not adequately addressed in prior literature (Bittencourt et al., 2021; Buer et al., 2019; Kolberg et al., 2017; Yilmaz et al., 2022).

The findings emphasize that employee participation is an integral part of the big data project to identify and implement with the ability to collaborate and coordinate. This requires the top management to consider setting up the right organizational structure to initiate and execute such projects. The findings suggest that the organizational structure comprising a central team with cross-functional representation, including an IT person, is conducive to successful implementation. Furthermore, the study suggests that employees engaged in big data projects should possess managerial skills and knowledge across various business functions to maximize the value generated. This is a crucial outcome of the case study as earlier work did not seem to have a consensus on the appropriate organizational structure (Ghobakhloo, 2018; Sun et al., 2018; Wiech et al., 2022).

Initially, we studied all Industry 4.0 practices implementation in manufacturing environments, later on, detailed studies were conducted for BDA and CC. We proposed a framework in the first study, now detailed study can be conducted for the remaining practices other than BDA and CC. In the first study, we covered mostly technical aspects of I-4.0 practices implementation such as tangible and intangible benefits, transformation journey, challenges of technology selection, etc. A few aspects are still not covered such as skill development of employees over a while without any structured training program. The status of old improvement programs such as Lean or TOC, now it has been cannibalized by the I-4.0 program or have been merged with the I-4.0 program or both are running parallel.

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