An Evaluation of the Industry 4.0 Framework: Insights from a Survey-Based Analysis

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***Abstract*—The industry 4.0 (I4.0) architype is regarded as one of the most prominent topics within both academic and industrial spheres, encompassing emerging technologies that enhance process integration and offer digital solutions to assist companies in achieving the increased flexibility demanded by the market. Up to this point, the scientific literature has extensively focused on the development of enabling technologies and the evaluation of their effects across various industrial settings. Nevertheless, there is a notable deficiency in studies that provide empirical evidence regarding how manufacturing firms are navigating the digital transformation, particularly among smaller industrial entities. Subsequently, this paper pursues to examine the awareness, preparedness, and distribution levels of the I4.0 paradigm and its empowering technologies within Micro, Small, and Medium Enterprises (MSMEs) in Pune. A web-based survey was executed, resulting in interviews with companies. The findings from the survey indicate that MSMEs possess limited understanding of I4.0 and are inadequately prepared for its implementation.**

***Index Terms*—smart factory, I4.0, cyber-physical production system technological enablers, Implementation, Deployment readiness, maturity level, survey.**

I. INTRODUCTION

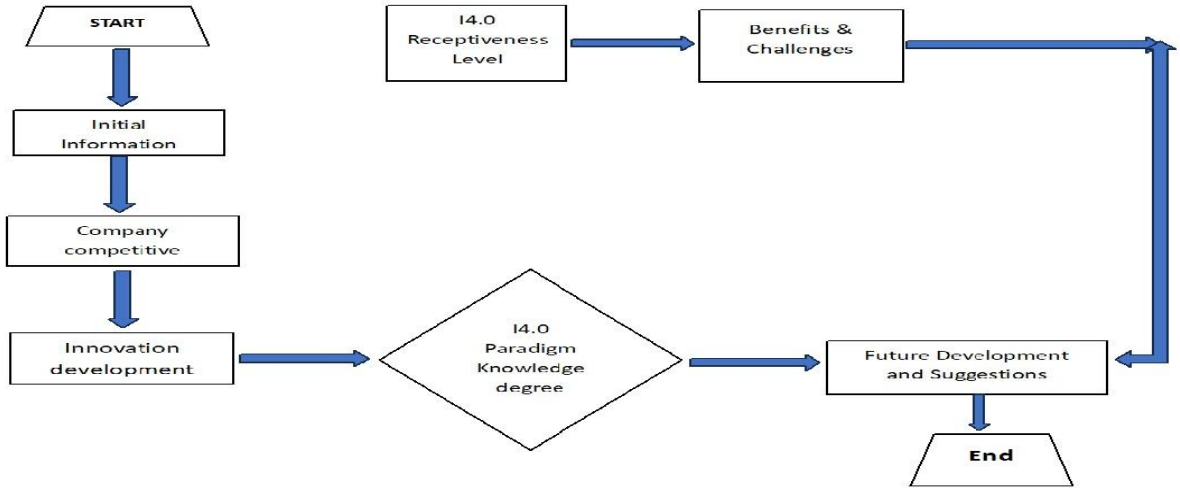
This research paper explores the existing knowledge, adoption rates, and practical application of Industry 4.0 within organizations. Through a structured questionnaire, data was gathered from multiple sectors to evaluate awareness levels, technology integration, workforce preparedness, and obstacles to implementation. The results shed light on current trends, identify gaps, and highlight opportunities for advancing the adoption of Industry 4.0 technologies. The emergence of the Fourth Industrial Revolution, commonly referred to as Industry 4.0, has transformed global manufacturing and industrial methodologies through the incorporation of cutting-edge technologies such as the Internet of Things (IoT), artificial intelligence (AI), cyber-physical systems, big data analytics, and cloud computing (Kagermann et al., 2013). This shift is not solely technological but also strategic, affecting how organizations function, provide value, and compete on a global scale. Industry 4.0 prioritizes real-time data processing, automation, digital connectivity, and decentralized decision-making—ultimately promoting a more agile, efficient, and innovative industrial ecosystem. As India progresses towards becoming a digitally empowered economy, the significance of Industry 4.0 has grown. The city of Pune, frequently acknowledged as a key industrial and IT center in Western India, is strategically positioned to spearhead this transformation. With a strong presence in the automotive, manufacturing, electronics, and information technology sectors, Pune presents a conducive environment for the adoption and advancement of Industry 4.0 principles. However, uncertainties persist regarding the readiness and maturity of industries in the region to undertake such digital transformation. The industry 4.0 framework acts as a mechanism to systematically evaluate an organization's capabilities across essential domains, including smart manufacturing, connectivity infrastructure, workforce digital skills, and data-driven operations (Lichtblau et al., 2015). Various maturity models, such as the Acatech Industry 4.0 Maturity Index and the Smart Industry Readiness Index (SIRI), have been established globally to measure and direct this transformation. These frameworks provide multidimensional insights into the extent to which an organization is advancing from digitization to the complete integration of intelligent systems. Recent scholarly work has emphasized the difficulties in

implementing Industry 4.0 in emerging economies, including India. Moeuf et al. (2018) and Sony & Naik (2020) underscore ongoing issues that hinder progress.

II. METHODOLOGY

A questionnaire was designed to examine multiple aspects of Industry 4.0 readiness and adoption. The survey covered areas such as organizational profile, level of awareness, familiarity with relevant technologies, current implementation status, infrastructural capabilities, workforce preparedness, and key challenges. It was distributed online, gathering responses from 100 participants representing a range of industries.

The purpose of the questionnaire was to find out how much people knew about I4.0, what aspects were relevant to their company, what innovative activities companies were doing, what potential advantages and challenges came with implementing enabling technologies, and, lastly, what the main concerns and future plans for I4.0 implementation were.



Structure of Survey

III. RESULTS

This section presents a concise overview of the questionnaire results. Considering the objective of the analysis regarding the current status of MSMEs.

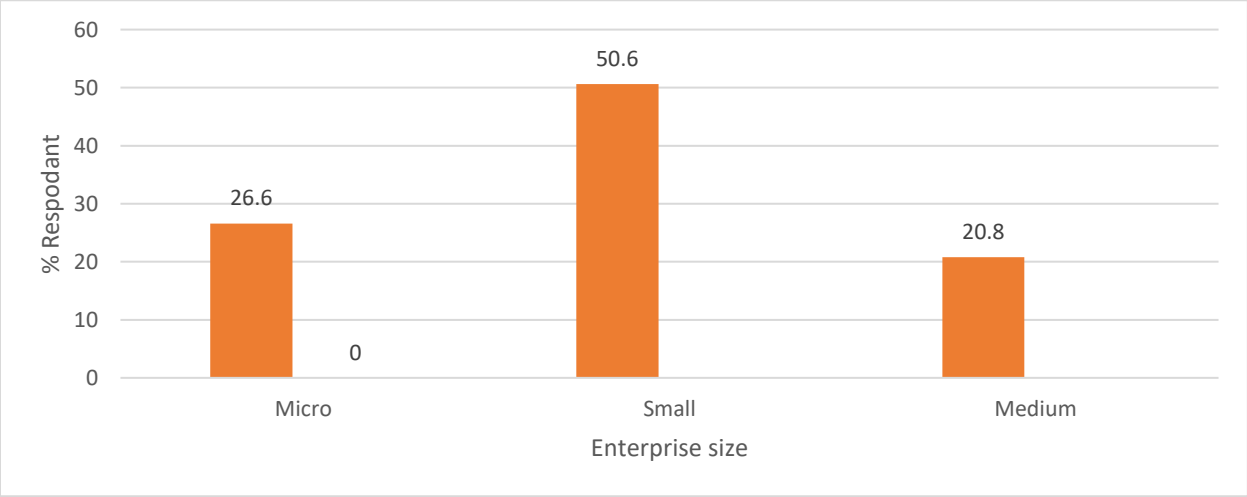


Fig. 1. Distribution of companies' size.

Figure 1 illustrates the distribution of respondents per company size. In particular, the sample is composed of 21 of medium-sized companies, 27% of micro-size, and 50% of small-size.

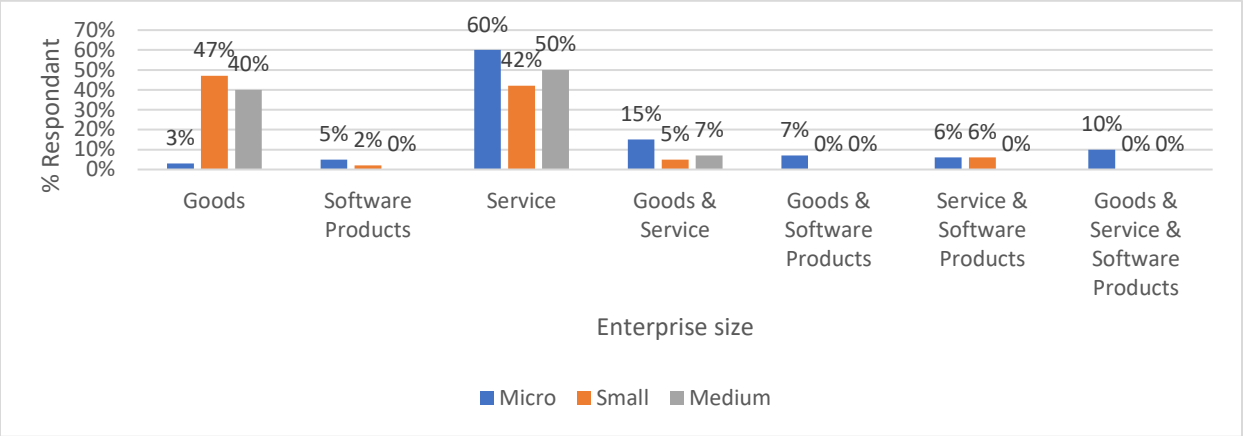


Fig. 2 Companies competitive context

Figure 2 Service-oriented dominance is apparent across all categories, particularly among micro (60%) and medium enterprises (50%), which indicates a preference for service-based models attributed to potentially lower capital investment and greater flexibility. A notable transition towards goods-based offerings is observed in small enterprises (47%), which sharply contrasts with micro enterprises (3%). This may imply an enhancement in production capacity and infrastructure as businesses evolve from micro to small size. The presence of software products as a standalone offering remains minimal across all business sizes, peaking slightly in micro enterprises (5%) and then completely vanishing in medium-sized ones. This indicates that pure software businesses are uncommon in this sample, possibly due to market size or resource limitations. Conversely, small and medium enterprises exhibit limited or no participation in these hybrid models, likely due to a focus on specialization or efficiency-driven scaling. No medium enterprises engage in any combination that includes software, highlighting a potential gap in digital-product integration at mid-level business scale activities but the remaining part (32%) occasionally carries out R&D activities using resources from other areas for participation in innovative projects; the small- size companies' picture is no clear: the 32% occasionally carry out R&D activities using dedicated resources, the 25% occasionally carry it out by exploiting resources dedicated to other areas while 43% do not carry out research and development.

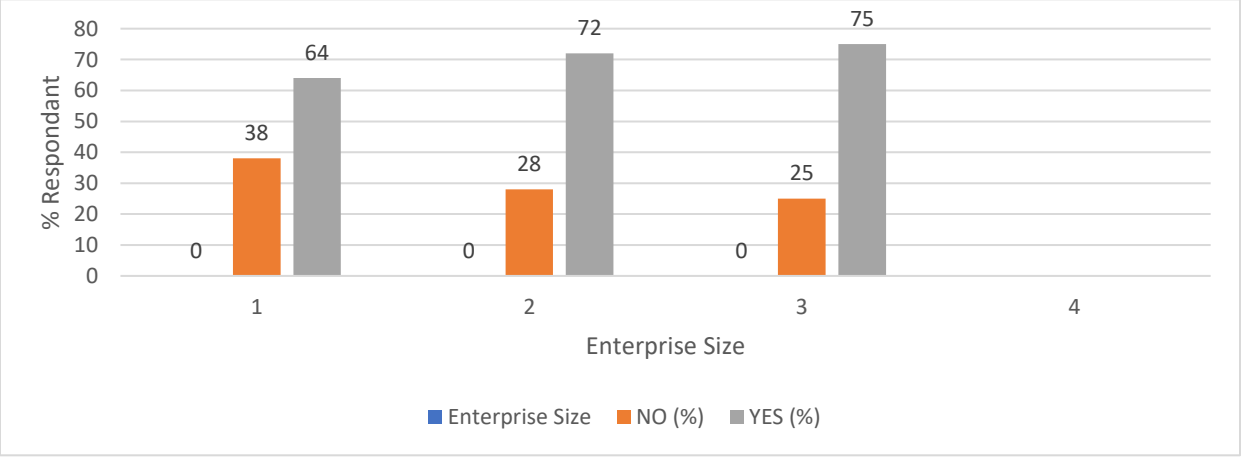


Fig. 3 Companies competitive context

Figure 3 Overall Positive Trend with Enterprise Size. As enterprise size increases, the YES response rate increases: Micro: 64% Small: 72% Medium: 75%. This suggests that larger enterprises are more likely to adopt or be prepared for the assessed factor (e.g., digital readiness, technology adoption, etc.). Micro Enterprises Lag Slightly Although a majority (64%) of micro enterprises responded YES, they still show the highest rate of NO (38%) compared to others. This could point to resource constraints, lack of expertise, or limited awareness in smaller setups. The YES response rises slightly from 72% (Small) to 75% (Medium), suggesting that once basic readiness is achieved, the marginal gains may taper off with scale.

To successfully advance with Industry 4.0 (I4.0), it is essential to deploy digital capabilities across the entire organization. This transition requires both time and substantial investment. Therefore, evaluating the current level of digital maturity and establishing clear targets for the next five years is critical. As part of this study, participants were asked about their future business plans regarding I4.0 implementation.

Unfortunately, the outlook is not very encouraging. Around 35% of respondents indicated no short-term investment plans. When analyzing future investment by company size, the data shows that almost all micro-enterprises do not plan to invest in any technology. Even those conducting preliminary studies on key technologies reported no intention to invest within the next five years.

In contrast, small enterprises show a relatively more proactive approach, with some planning to implement a limited set of technologies in the near term, particularly those they are currently studying.

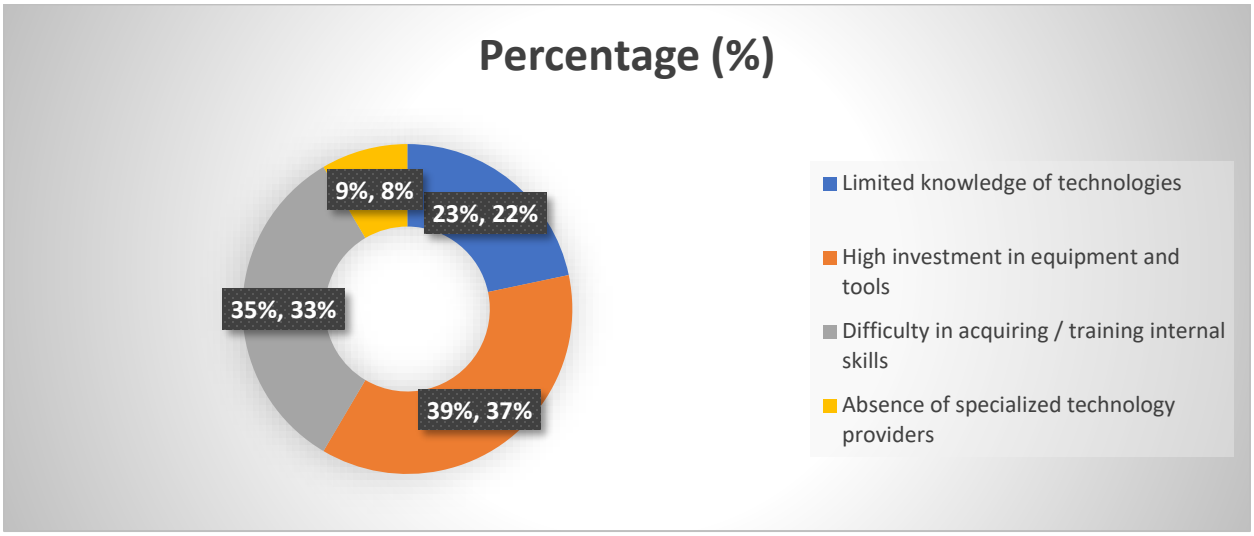


Fig 4. Obstacles in the way of I4.0 implementation

The above Figure 4 illustrates the primary obstacles to investing in Industry 4.0 technologies as identified by the surveyed companies: The most commonly cited obstacle is the substantial investment needed for equipment and tools (39%), highlighting that financial limitations are a major concern. The difficulty in acquiring or developing internal skills (35%) indicates a significant talent gap within organizations. A limited understanding of technologies (23%) suggests a lack of awareness or knowledge regarding I4.0 capabilities.

The shortage of specialized technology providers (9%) is a relatively minor concern, indicating that the supply side may be more prepared than the demand side. Conclusion: These results underscore the need for support in financial planning, workforce development, and awareness-raising initiatives to facilitate the adoption of Industry 4.0, especially among smaller enterprises.

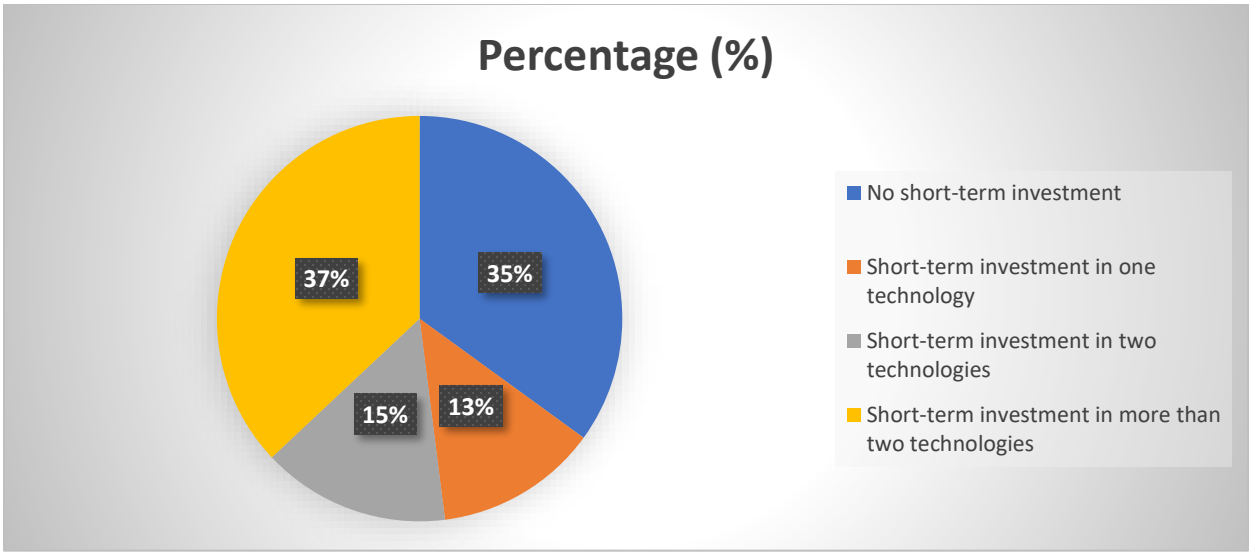


Fig 5 The possible time span for implementation of I4.0.

The data reflects the diversity in short-term investment planning for Industry 4.0 technologies:37% of companies are actively investing in more than two technologies, indicating a strong commitment among a notable portion of firms toward comprehensive digital transformation.35% of respondents reported no short-term investment plans, highlighting a substantial hesitation or constraint in initiating Industry 4.0-related initiatives .Only 13% plan to invest in a single technology, suggesting limited adoption or pilot-level efforts.15% intend to invest in two technologies, potentially reflecting companies in a transitional phase toward broader implementation. The findings suggest a polarized landscape: while a sizable portion of firms is taking aggressive steps toward Industry 4.0, a nearly equal portion remains disengaged. This gap underscores the need for targeted support and incentives, especially for firms at the early stages of adoption.

IV. DISCUSSIONS & CONCLUSIONS

Industry 4.0 (I4.0) presents both a significant opportunity and a critical necessity for companies aiming to stay competitive in global markets. It offers the potential to revolutionize how businesses operate and unlock new value. However, realizing this transformation requires companies—especially manufacturers—to deeply understand I4.0 concepts and identify how these technologies can be effectively applied in their specific context.

This study reveals a considerable gap in knowledge and readiness, particularly among MSMEs in the Campania region. Over half of the surveyed companies reported only a basic or low level of understanding of I4.0 technologies. This lack of awareness becomes more evident with smaller company sizes, where adoption of enabling technologies remains minimal or non-existent.

Short-term investment in I4.0 is often limited due to uncertainty and a poor understanding of its benefits. Many companies hesitate to act because they lack the necessary knowledge, skills, and financial resources. Furthermore, the shortage of skilled personnel is a major barrier. Simply investing in advanced technologies is not enough—companies must also ensure that their workforce is adequately trained to use them effectively.

MSMEs also face practical challenges, such as limited access to equipment and software, and the constant need to reduce costs while improving efficiency. Many are unsure about the financial and technical demands of I4.0 and its broader impact on their business models. While there is awareness of the need for digital transformation, many firms lack the internal capability and confidence to move forward.

Successful I4.0 implementation depends not only on technology, but also on leadership, digital culture, and continuous workforce development. In this regard, collaboration with universities, research institutions,

consultants, and innovation managers can play a crucial role. Such partnerships are essential for spreading knowledge, fostering innovation, and supporting transformation, especially for resource-constrained MSMEs.

To guide companies through this transition, a well-structured I4.0 roadmap is needed—particularly for MSMEs. This roadmap should help them understand key technologies, assess their readiness, set priorities, and implement change at a manageable pace.

In summary, many companies are still unaware of the full potential of I4.0. To move forward, they need support in building knowledge, skills, and confidence. This study provides a snapshot of the current situation and lays the groundwork for developing a strategic framework that will enable companies to embrace digital transformation with reduced risk.

The recommendations derived from this study are based on the synthesis of findings and suggestions made in the individual studies, while considering the strengths and weaknesses of each. The recommendations that surfaced from the various studies revolve around similar themes and can be summarized as follows:

(i) Manufacturers must deepen their understanding of how to leverage Industry 4.0 for value creation and to establish additional revenue streams by gaining insights from operational digital factories or engaging in digital "treks."

(ii) Organizations need to articulate a bold vision for the application of digital technologies and to outline a plan for digital transformation to expedite the pace of adoption. Without such a vision, support from individuals within the organization may wane, and fragmented experimentation in the long term is unlikely to produce the desired outcomes. A significant barrier to entry is the absence of a clear digital operations vision or support for it within businesses. When companies initiate digitization, they often engage in experimentation without a definitive plan regarding their objectives.

(iii) Innovation and the development of new business models should occur at the periphery of the current business rather than solely within the core business or externally, and these models must be scalable so that they can be integrated from the edge into the core, ultimately transforming the edge into the new core.

(iv) It is essential that innovations in scalable business models extend beyond traditional product innovation, which typically emphasizes product offerings, to encompass areas such as company structure, processes, networks, profit models, and customer-facing functions, including services and distribution channels.

(v) There is a pressing need for a thorough and proactive strategy to establish clear guidelines for data integrity and security, as well as the necessity for cybersecurity governance to implement and oversee appropriate controls.

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