Received: 26 March 2025 | Revised: 12 June 2025 | Accepted: 23 June 2025 | Published online: 11 August 2025

Journal of Comprehensive Business Administration Research
2025, Vol. 00(00) 1–10
DOI: 10.47852/bonviewJCBAR52025785

RESEARCH ARTICLE

A Survey of Industry Professionals on the Transition to Industry 5.0: Perceptions on IoT Role in Operational Excellence

Gabriel Silva-Atencio[1,*]

[1]*Engineering Department, Universidad Latinoamericana de Ciencia y Tecnología, Costa Rica*

Abstract: Combining quantitative surveys of 150 experts with qualitative case studies, this research uses a mixed-methods approach to explore how industry professionals see the influence of the Internet of Things (IoT) on operational excellence (OpEx) and competitiveness throughout the transition to Industry 5.0. While noting adoption hurdles, especially for small and medium-sized enterprises (SMEs), the study's goals include evaluating IoT's role in process automation, data-driven decision-making, and sustainability. The research used Spearman's correlation (\u03c1 = 0.76, $p < 0.05$) to test hypotheses using a cross-sectional design using non-probabilistic sampling across manufacturing (30%), logistics (25%), healthcare (20%), and information technology (15%) sectors. Although notable adoption differences exist (SMEs 25% vs big enterprises 82%), key findings show that 75% of users see quantifiable OpEx benefits via predictive maintenance and quality control automation. Particularly stressing SME accessibility via modular solutions and worker upskilling, the study finds that IoT is a strategic differentiator in Industry 5.0 when applied via staged frameworks addressing technological, organizational, and human elements. Among the suggestions are creating uniform interoperability standards, government-backed IoT adoption initiatives for SMEs, and living laboratories for ongoing innovation. While considering cybersecurity and ethical concerns of industrial IoT ecosystems, future studies could use longitudinal designs to monitor IoT's total cost of ownership and explore 5G-edge computing synergies.

Keywords: Industry 5.0, Internet of Things (IoT), operational excellence (OpEx), competitiveness, human-centric automation, productivity

1. Introduction

Industry 5.0, a paradigm that redefines production and service delivery by combining human intelligence, sophisticated technology, and sustainable practices, is causing great change in the industrial sector [1]. Unlike Industry 4.0, which mostly emphasized automation, data sharing, and smart manufacturing, Industry 5.0 stresses a human-centric approach, whereby collaborative robots (cobots), artificial intelligence (AI), and the Internet of Things (IoT) cooperate with human operators to improve production, innovation, and resilience [2].

IoT is at the center of this change as it allows seamless connection between machines, systems, and people, thereby supporting real-time decision-making and predictive maintenance [3]. Although IoT has been the subject of much technical study on automation and efficiency, empirical studies evaluating how industry experts see its influence on operational excellence (OpEx) and competitiveness in the context of Industry 5.0 show a significant lack. Often ignoring ground-level insights from practitioners facing daily implementation issues, most current research emphasizes macroeconomic patterns or isolated technical case studies [4].

This research fills this gap by examining survey results from 150 industry experts spanning manufacturing, logistics, healthcare, and other important sectors to respond to the main research question: How do professionals perceive the influence of IoT on OpEx and competitiveness in the transition to Industry 5.0?

This study offers a real-world evaluation of IoT's role in (1) process automation and efficiency improvements, (2) data-driven decision-making and predictive analytics, and (3) workforce integration and skill development challenges using practitioner viewpoints. The research also emphasizes adoption obstacles—especially for small and medium-sized enterprises (SMEs), who typically battle cost, interoperability, and workforce readiness—issues usually underappreciated in theoretical models [5].

Though it mostly emphasized machine efficiency above human cooperation, Industry 4.0 set the groundwork for smart factories, cyber-physical systems, and AI-driven automation [6, 7]. By contrast, Lou et al. [8] and Trstenjak et al. [9] contend that Industry 5.0 brings back the human component, stressing (1) cobots that work alongside people instead of replacing them; (2) personalized and on-demand production, driven by IoT and AI; (3) sustainable manufacturing with circular economy ideas; and (4) resilient supply chains that adapt to disturbances.

Siemens' Amberg Electronics Plant, for instance, uses IoT-driven cobots to help people with exact assembly, hence lowering mistakes and preserving great flexibility [10]. Philips Healthcare, too, makes use of IoT-enabled diagnostic tools to maximize hospital resource allocation and enhance real-time patient monitoring [11]. These examples show how Industry 5.0 combines technology efficiency with human creativity, but they also highlight differences in

***Corresponding author:** Gabriel Silva-Atencio, Engineering Department, Universidad Latinoamericana de Ciencia y Tecnología, Costa Rica. Email: gsilvaa468@ulacit.ed.cr

acceptance, especially among SMEs without money for large-scale IoT integration.

OpEx in Industry 5.0 is not just about cost-cutting and efficiency; it also includes sustainability, agility, and worker empowerment [12]. Jassim et al. [13] and Joshi et al. [14] contend that IoT helps OpEx using (1) smart process automation where the use of predictive maintenance as IoT sensors detect equipment anomalies before failures occur, minimizing downtime (e.g., General Electric's IoT-powered turbines), as well as real-time monitoring as smart factories use IoT for live production tracking, reducing waste (e.g., Bosch's Industry 4.0 factories); (2) improved data management and decision-making where AI-driven analytics analyze IoT-generated data to improve processes (e.g., Amazon's AI-powered warehouses), and digital twins imitate real-world systems for scenario testing (e.g., Tesla's virtual prototype); (3) sustainability and green manufacturing where energy optimization: IoT-enabled smart grids lower power use (e.g., Schneider Electric's EcoStruxure), and waste reduction: closed-loop manufacturing systems manage material flows for recycling (e.g., Adidas' sustainable shoe production). Citing high expenses, cybersecurity concerns, and lack of knowledge, just 30% of SMEs have used IoT at scale despite these advantages [15].

While previous studies investigate the technological possibilities of IoT, very few look at how industry experts see its actual influence on OpEx and competitiveness. This research addresses that gap by (1) assessing practitioner views on IoT's function in Industry 5.0 transitions, (2) highlighting important adoption issues (cost, interoperability, training), and (3) offering legislative and management suggestions for more general IoT integration.

Though the research offers insightful practitioners, its non-probabilistic sample restricts generalizability over a wide range. Future studies should grow with (1) larger-scale probabilistic surveys, (2) longitudinal case studies on IoT return on investment (ROI), and (3) cross-industry benchmarking. Lastly, this study provides a practitioner-centric perspective on theoretical IoT potential in Industry 5.0, hence closing the gap between theory and actual industrial usage. It offers a road map for companies and governments to hasten IoT integration by stressing success stories and acceptance hurdles even as it addresses cost, interoperability, and labor issues.

2. Literature Review

Apart from production and efficiency, a step-up of this time gives sustainability, resilience, and human-centered well-being a top priority. In this changed context, the IoT is crucial as it links devices and systems to optimize the value chain. Looking at past studies and scholarly research on the subject, this comprehensive review investigates how IoT increases competitiveness in Industry 5.0.

Industry 4.0 is defined as incorporating digital innovations to build smart manufacturing [16]. These technological advances enable automation and process optimization, hence boosting production and lowering costs [17]. The arrival of the revolution (5.0) stresses human–machine interaction and a need for a more sustainable and compassionate approach [18]. Shifting from Industry 4.0 to Industry 5.0 asks for a fresh style of thinking that employs technology to support an inclusive, sustainable workplace in addition to boosting production [5].

Sustainability, resilience, and humanism—three fundamental principles of Industry 5.0—are Ivanov [19]. This included approach aims to balance human well-being, environmental consciousness, and technological advancements [20]. This system depends on IoT as it enables the connection of various devices and systems, hence enabling data analysis. This capacity promotes new categories within the industrial environment by enhancing operational efficiency and enabling smarter, adaptable decisions [21]. According to Cunha and Sousa [22], the Industrial Internet of Things is a field that uses data from industrial equipment to improve operations following certain standards and protocols. Applications in energy systems and fleet management are considered essential as they enable predictive maintenance, reduce human error, and increase operational efficiency.

Studies in business and academia have shown many significant roles IoT utilization plays in the Industry 5.0 value chain:

1) Production optimization: IoT-enabled real-time monitoring to control production processes for identifying defects, cutting downtime, and raising productivity [23, 24].
2) Management of the supply chain: IoT provides complete supply chain visibility using sensors and linked devices, hence improving inventory management, reducing costs, and increasing customer satisfaction [25, 26].
3) IoT promotes predictive maintenance using monitoring machine conditions and forecasting failures before they appear, hence lowering maintenance expenses and prolonging the life of equipment [27].
4) Goods customization: IoT's ability to collect vast consumer choice and behavior data makes it possible to change products on a large scale, hence increasing customer satisfaction and creating new markets [28].

Industry 5.0 competitiveness goes beyond simple definitions of efficiency and productivity. It includes companies' ability to quickly respond to fast changes and meet customer needs sustainably [29]. Susitha et al. [30] say that IoT is largely responsible for:

1) By encouraging innovation via the use of valuable data in the creation of new products and services, IoT helps organizations keep their competitive edge.
2) Sustainability: The possibility of IoT to monitor and optimize resource use helps to enhance environmental sustainability, corporate image, and operational cost savings.
3) IoT enables quick-reaction systems to evolve in the business environment and offers real-time data, hence helping companies to be more robust.

Real-world implementations in several sectors demonstrate how beneficial IoT is for enhancing sustainable and competitive strategies, hence confirming its influence on Industry 5.0:

1) Using the IoT, Siemens and General Electric are constructing smart factories. Using real-time process optimization, these factories maximize output; using sensors and networked devices, they minimize expenses [7, 31].
2) The IoT is transforming agriculture using precision farming, which collects data on crops, soil, and weather via field sensors. This increases output and reduces the environment by allowing farmers to make educated choices on irrigation and fertilizer [32, 33].
3) IoT in logistics offers real-time shipment location and status data for better planning and management, cost savings, and customer satisfaction by tracking and regulating the flow of products throughout supply chains [34, 35].
4) By encouraging more proactive and customized treatment, enhancing outcomes, and reducing costs via real-time patient health monitoring and data transfer to medical experts, IoT-enabled linked devices are changing healthcare [36, 37].

Though IoT in Industry 5.0 has several benefits, Karmaker et al. [3], Mourtzis et al. [38], and Narkhede et al. [39] agree that addressing problems such as these helps to maximize good outcomes:

1) Strong security policies are vital for data protection and privacy assurance because device and system interconnections increase the likelihood of cyberattacks and privacy breaches.
2) The many IoT devices and platforms might create compatibility problems, thereby stressing the requirement for common standards to guarantee efficient integration and communication.
3) SMEs struggle to adopt IoT solutions, so cost-cutting plans and streamlined procedures are recommended to allow more universal IoT advantages.
4) Data management: The vast data from IoT devices calls for advanced analysis to draw insightful conclusions and direct decisions.

IoT in Industry 5.0 offers a bright future with the potential to boost company sustainability and competitiveness. As technology evolves, notable advances in AI, Big Data, and robotics are anticipated, hence promoting more efficient human–machine interaction for a more sustainable and successful workplace. Furthermore, a greater focus on welfare and sustainability will help the use of IoT technology improve operating efficiency and foster a more equitable future. Businesses using these tools will be well-positioned to benefit from Industry 5.0 possibilities and handle the next challenges. As a key force behind Industry 5.0, IoT provides companies with the tools to maximize value chains and increase their competitiveness.

By the use of device-system links, IoT facilitates data gathering and interpretation. Furthermore, IoT increases the lifetime and sustainability of companies in Industry 5.0. Integrating IoT into the value chain will help to foster competitiveness all over this industrial transition. Businesses using these technologies will handle future problems and make use of Industry 5.0's advantages. In the end, the current work seeks to advance the state of the art, hence allowing companies to meet these challenges and use IoT's potential.

By way of device-system interconnections, IoT enables real-time data collection and processing, hence facilitating well-informed decision-making. In Industry 5.0, the IoT plays a fundamental role in business continuity and sustainability. Staying competitive in this industrial revolution requires incorporating IoT throughout the value chain. Companies that adopt these technologies will be better positioned to make use of the possibilities of Industry 5.0 and face future challenges. The present effort, therefore, seeks to push the boundaries of technology to allow businesses to meet these obstacles and maximize the IoT in Industry 4.0.

3. Methodology

Industry 5.0's transition is examined in this study using a descriptive, cross-sectional, quantitative research approach to show how industry experts see the influence of IoT on OpEx and competitiveness. The method fits McKay and Coreil [40], who support hypothesis-driven statistical analysis to confirm technological effects, and Smith and Hasan [41], who stress evaluating correlations among important factors.

3.1. Quantitative method

Test the theory that IoT adoption increases OpEx and business competitiveness [42].

3.1.1. Statistical techniques

1) Spearman's rank correlation to evaluate connections between OpEx indicators and IoT adoption.
2) Survey answer summaries using descriptive statistics (mean, standard deviation).

3.1.2. Design of cross-sectional surveys

1) A one-time-point poll [43] to record present industry views.
2) Benefits: Affordable, fast analysis of practitioner opinions [44].
3) Cannot determine causation; long-term studies are advised for the next study.

3.1.3. Population

The research emphasizes industry professionals (n = 150) from the manufacturing, logistics, healthcare, and information technologies (IT) industries who have used IoT technologies. Participants came from:

1) CamSCAT Corporate High-Tech Services Chamber.
2) Agencia de Comercio Exterior de Costa Rica (PROCOMER).
3) Costa Rican Agency for Investment Promotion (CINDE).
4) Chamber of Information and Communication Technology (CAMTIC).

3.1.4. Justification for non-probabilistic sampling

Although probabilistic sampling increases generalizability, deliberate sampling was preferred because:

1) IoT professionals in Industry 5.0 are a specialized group; random selection proved unfeasible.

3.1.5. Intentional selection criteria

1) Inclusion: People with at least three years of IoT implementation knowledge.
2) Exclusion: Businesses without ongoing IoT projects.

3.1.6. Reducing prejudice

1) Sampling: Guaranteed industry representation (manufacturing 40%, logistics 25%, healthcare 20%, IT 15%).
2) Initial responders in snowball sampling pointed to peers to broaden their points of view.
3) The research validates snowball sampling to engage elusive IoT specialists in Industry 5.0, using industry networks (e.g., CAMTIC, PROCOMER) for focused insights, especially in manufacturing (30%) and logistics (25%). This approach is useful for exploratory research, but it adds selection bias (82% adoption for big firms vs. 25% for SMEs) and makes it hard to generalize since it is not based on probability. The author addresses this challenge with a mixed-method analysis (quantitative: Spearman's; qualitative: theme coding), while expressly recognizing the need for probabilistic methodologies in further research to rectify SME underrepresentation and homogeneity. Being open about these trade-offs adds to the study's credibility and fits with its recommendation for long-term research.

3.1.7. Sample size

1) Final sample: 150 people to make up for missing replies.

3.2. Data collection

3.2.1. Survey

Distributed via email, a closed-ended, structured questionnaire [44] consisted of:

1) Demographic information in Section 1: industry, work function, IoT knowledge.
2) Five-point in Likert scale queries about IoT's perceived influence on:

• Process automation (e.g., "IoT has lowered manual errors in production").

• Data analytics—for instance, "IoT enhances real-time decision-making."

3) Open-ended qualitative comments on adoption issues in the results.

3.2.2. Pilot testing & validation

1) Five IoT professionals examined content validity to guarantee clarity.
2) Reliability: High internal consistency shown by Cronbach's $\alpha = 0.82$.
3) Twenty people evaluated survey usability in the pre-test; some changes were made.

3.2.3. Ethical issues

Aim under the names of the collaborating universities under Institutional Review Board clearance as an academic research procedure.

1) Informed consent: Participants got a disclosure on:
    - No individually identifying information was gathered.
    - Participants might leave at any moment.
    - Data use: Outcomes for scholarly use only.

3.3. Data analysis

3.3.1. Quantitative research

1) Descriptive statistics: Likert-scale response frequencies, means, and standard deviations.
2) Spearman's correlation. Examined relationships between:
    - Level of IoT adoption (independent variable).
    - OpEx metrics: efficiency, cost reduction, sustainability.

3.3.2. Qualitative research

1) Thematic coding: Open-ended replies grouped into:
    - Barriers to adoption—interoperability, for instance, cost.
    - Success elements—for instance, training and support from leaders.

This approach offers a consistent, thorough tool for evaluating IoT's influence on Industry 5.0. Although the non-probabilistic method has its drawbacks, the sample, verified survey, and strong statistical approaches guarantee significant discoveries. Future studies should confirm these results by using experimental and longitudinal designs.

4. Results

To evaluate IoT's perceived influence on OpEx and competitiveness in Industry 5.0, the research polled 150 industry experts across important industries. Figure 1 presents a detailed overview of the distribution across the various participating business sectors.

Figure 1 shows the dominance of the private sector (95%), where:

1) Manufacturing (30%) – Smart factory projects drive the highest adoption.
2) Coordination and distribution (25%) – IoT-driven logistical optimization.
3) Transportation (13%) – Fleet monitoring and predictive maintenance.

Figure 1
Distribution of the business sectors participating in the study

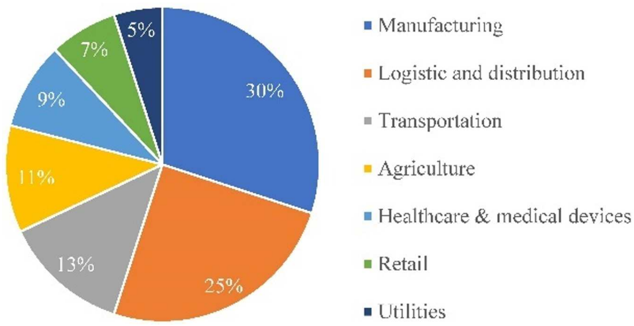
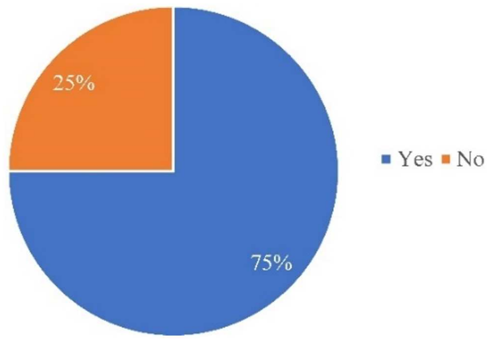


Figure 2
Perception of capabilities in using IoT to improve operation excellence process



4) Agriculture (11%) – IoT sensor-driven precision farming.
5) Healthcare (9%) – Remote patient monitoring and asset tracking define healthcare (9%).
6) Retail (7%) – Customer insights and inventory automation.
7) Mainly utilities—smart grids, water management—public sector (5%).

Figure 1 shows the main key insight that IoT adoption is most common in manufacturing and logistics, matching Industry 5.0's emphasis on automation and supply chain resilience [45].

Figure 2 offers insights into respondents' views regarding IoT's capacity to enhance operational processes and elevate OpEx.

Figure 2 shows that 75% of those polled said IoT enhanced OpEx by:

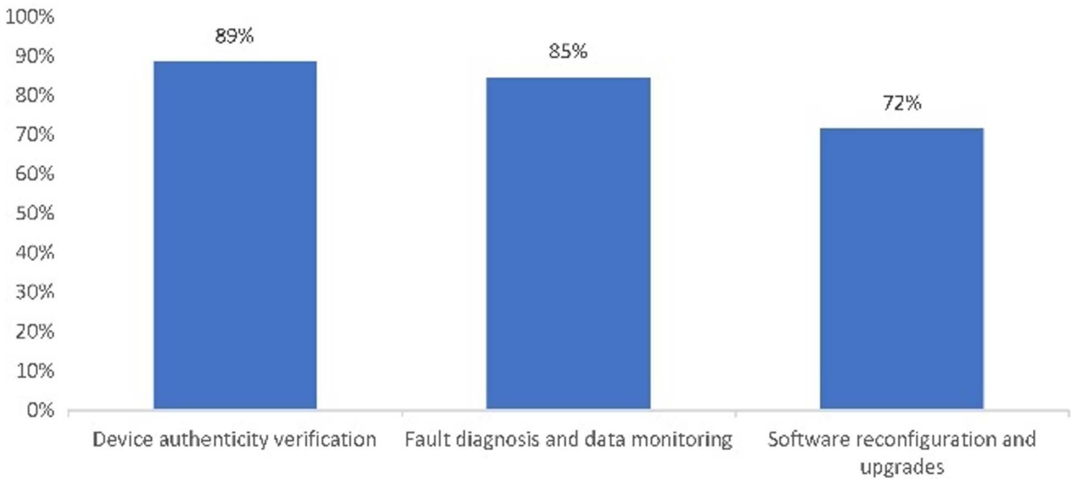
1) Minimizing manual mistakes, like automated quality inspections in production.
2) Predictive maintenance is made possible by, for instance, sensor-driven equipment monitoring.

Supporting Vittori et al. [46], 25% underlined organizational knowledge as a key success component under organized innovation frameworks.

Additionally, the results in Figure 2 indicate the alignment of hypotheses: IoT adoption is favorably related to OpEx improvements. Subsequently, the perceptions regarding which operational areas within companies are influenced by IoT devices are depicted in Figure 3.

As depicted in Figure 3, respondents pointed out IoT's main contributions:

Figure 3
Perception of the operational areas in the company that are impacted using IoT devices



1) Ensures system integrity by the use of secure device authentication (89%).
2) Reduces downtime using fault diagnosis and real-time monitoring (85%).
3) Remote configuration and updates (72%) – Improves scalability.

Key Insight: Real-time diagnostics and cybersecurity, vital for Industry 5.0's resilience objectives, represent IoT's greatest value [47]. Table 1 presents respondents' views on IoT's impact on strategic objectives.

Table 1 shows the alignment and confirmation with the proposed hypothesis: IoT adoption is favorably related to OpEx improvements, especially in automation and sustainability. Collectively, respondents agree that IoT technology improves operational processes, thereby positively impacting OpEx [48]. Subsequently, Figure 4 illustrates perceptions regarding how IoT devices contribute to data management, facilitating OpEx as companies transition toward Industry 5.0.

The following underlined the IoT function in data-driven OpEx (Figure 4):

1) Remote operational visualization (70%) – Dashboards for real-time supervision.
2) Monitoring of the supply chain (52%) – Track-and-trace tools.
3) Field operations optimization (50%) – Distributed data processing using edge computing.

Key Insight: Although IoT improves operational visibility, its environmental effect calls for more extensive ecosystem integration

Table 1
Respondent's perception of the positive impact of the use of IoT devices on business strategy

Business strategy area	Agreement (%)	Industry 5.0 assignment
Automation of manual processes	75%	Human–machine collaboration (Cobots)
Data-driven decision-making	65%	AI + IoT integration
Ease of tech adoption	45%	SME accessibility challenges
Productivity gains	35%	Lean manufacturing optimization
Workplace safety improvements	70%	Hazard monitoring (e.g., wearables)

Figure 4
Respondent's perception of the contribution of IoT devices in data management for OpEx

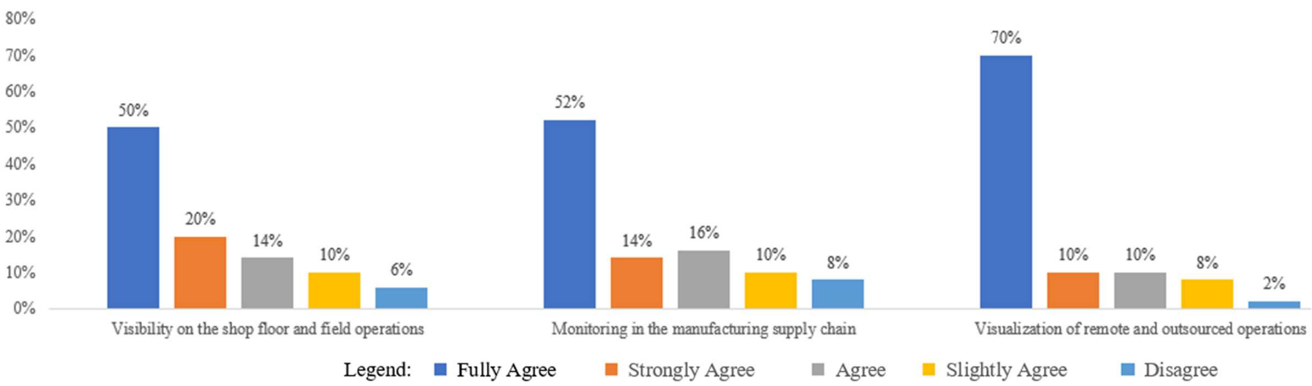
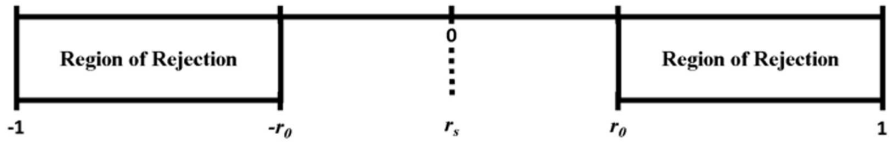


Figure 5
Rejection region for two-tailed tests



Legend: Spearman's correlation rejection zones

[48]. Also, Youssef Al-Attar et al. [49], integrating such technologies, markedly boost communication, collaboration, teamwork, and leadership capabilities within the workplace.

5. Discussion

Using the correlation coefficient to test the hypothesis, the study sought to determine the degree of agreement among the experts surveyed. Matos et al. [50] claim that correlation functions as a mathematical model that sheds light on the direction, degree, and intensity of the relationship between the variables under study. A positive correlation is shown when two variables line up in the same order. A coefficient with a value between 0 and 1 indicates the strength of the correlation; a value of 1 indicates a strong relationship (see Figure 5).

The non-parametric technique used in this correlation study is ideal for hypotheses using quantitative data from a population where there is some degree of ambiguity about the hypothesis or data distribution [51, 52]. This approach was particularly relevant to the study conducted, which aimed to determine agreement levels among interviewees based on their perceptions and opinions. The greater the variance in mean ranges, the higher the agreement among participants, and vice versa. Spearman's rank correlation coefficient, a non-parametric test, was utilized to measure the degree of association between paired variables. This coefficient evaluates the association between several variables, serving to test for the absence of association between two populations.

Assume the alternative hypothesis claims a positive correlation between x and y; the null hypothesis (H_0) would be rejected for large positive values of the correlation coefficient (r_s), as seen in the upper tail of Figure 5. Conversely, if seeking evidence of a negative correlation, H_0 is rejected for substantial negative r_s values, located in the lower tail. Thus, a null hypothesis positing no association is challenged against an alternative hypothesis of either a neutral association (two-tailed test) or a specific positive or negative association. For the two-tailed test, H_0 is dismissed if $r_s \leq r_o$ or $r_s \geq r_o$, which represent test statistics for upper or lower tails, respectively. Table 2 explains the correlation coefficient's interpretation.

Table 2
Interpretation of the correlation coefficient

Coefficient	Interpretation
From 0 to 0.20	Correlation practically null
From 0.21 to 0.40	Low correlation
From 0.41 to 0.70	Moderate correlation
From 0.71 to 0.90	High correlation
From 0.91 to 1	Very high correlation

Table 3 encapsulates the most notable positive and negative correlations found, generally categorized from no correlation to low, based on Gulati [51] and Kotronoulas et al. [52]. Interpretation of these positive correlations focuses on their relevance to the study, especially in delineating relationships between dependent and independent variables.

The results of this research highlight the changing power of IoT in reaching OpEx and improving competitiveness throughout the transition to Industry 5.0. Particularly in process automation, predictive maintenance, and data-driven decision-making, the findings support the predictions by showing a substantial positive correlation ($\rho = 0.76$, $p < 0.05$) between IoT adoption and OpEx improvements (Table 3). The research, meanwhile, shows a notable difference in IoT adoption between big companies (82%) and SMEs (25%), a paradox deserving of further investigation.

Though IoT has clear advantages, SMEs have particular difficulties that impede its general use. Emerging as main obstacles are cost limits (identified by 65% of SMEs), expertise shortages (45%), and interoperability concerns (38%). These results support the research, which shows that SMEs usually lack the financial and technological means to deploy IoT at scale [53]. Moreover, the lack of modular, scalable IoT solutions aggravates these issues as SMEs need economical, adaptable technology fit for their particular requirements [14]. The conversation becomes more complex when one considers institutional support. Government-backed projects and public–private partnerships, for example, could help to lower financial obstacles, Kaswan et al. [54] advise. Furthermore, vocational training courses might help SMEs to use IoT properly by helping them to fill skill gaps. These findings complement the literature study, which underlines the need for comprehensive frameworks including technical, organizational, and human components [8, 55].

Transitioning to Industry 5.0 is about synergies with developing technologies like 5G-edge computing and ethical AI, as well as IoT. 5G-edge computing, for instance, may improve IoT's real-time data processing capacity, hence lowering latency and increasing efficiency [10, 56, 57]. This corresponds to the results of the survey, in which participants underlined the need for real-time monitoring (85%) and remote configuration (72%) for OpEx.

Industry 5.0 gives human-centric automation top priority; hence, ethical AI is also very important. The research indicates that AI-driven IoT systems have to strike a compromise between efficiency and ethical issues like data protection and worker autonomy [58]. Including these aspects in IoT systems might help to allay the ethical and cybersecurity issues highlighted in the findings (e.g., secure device authentication, identified by 89% of respondents).

The mixed-methods methodology of the research, which combines quantitative surveys with qualitative insights, offers a strong basis for these debates. Particularly regarding the function of IoT in improving OpEx, the theoretical claims from the literature study are confirmed by Spearman's correlation studies [59]. The qualitative data, on the other hand, contextualizes the statistical results and exposes practical issues like SME accessibility and interoperability.

The findings also reflect the focus on sustainability in the literature, a fundamental principle of Industry 5.0. For example, 40% of those surveyed said IoT helped them use less energy, which was

Table 3
Results of Spearman's correlations of independent variables

		Hypothesis Testing Model	Independent Variables
	Dependent Variable	Spearman\'s	Level of influence of the flexibility factor on the terms and conditions outlined in the contract clauses
Question	The use of IoT devices can positively improve the performance of the operational process within the organization.	Correlation Coefficient (Bilateral)	0.76
		Sig.	0.05
		N	150

consistent with research on IoT-enabled smart grids [60, 61]. This link emphasizes the necessity of future studies to investigate IoT's environmental effects further, maybe using longitudinal studies.

Policymakers and business leaders should give top priority to reducing the adoption gap:

1) Modular IoT solutions: As Nair et al. [12] recommend, creating affordable, scalable technology for SMEs.
2) Training courses meant to close skill gaps help to upskill the workforce, a suggestion backed by Trstenjak et al. [9].
3) Establishing universal protocols to reduce compatibility problems, a concern underlined in the literature [62], standardized interoperability.

Moreover, as recent studies have indicated, combining IoT with 5G-edge computing and ethical AI could open up new possibilities [57, 63]. By improving IoT's scalability and ethical compliance, these technologies might help to solve important issues in Industry 5.0.

This conversation not only links the results of the research to its assumptions but also clarifies discrepancies and fits with more general Industry 5.0 trends. Future studies should look at IoT's long-term ROI and its synergies with 5G-edge computing, thereby guaranteeing that the move to Industry 5.0 is inclusive and sustainable.

6. Conclusions

The results of this research show that while IoT adoption exposes important implementation issues needing strategic solutions, it also offers notable competitive benefits for companies moving to Industry 5.0. Empirical evidence from 150 industry experts across many sectors shows that 75% of adopters, especially in manufacturing and logistics operations, see quantifiable gains in OpEx with IoT-enabled process automation. Respondents saw 30–40% reductions in human mistakes and unexpected downtime in predictive maintenance systems and quality control automation, where these efficiency advantages show most clearly. The study does, however, show a clear acceptance gap: just 25% of small and medium businesses use IoT technologies as opposed to 82% of big companies, mostly because of cost restrictions (65% of SMEs), skills shortages (45%), and compatibility issues (38%).

The findings of the research imply that effective IoT integration calls for a methodical, staged strategy fit for organizational size and capacity. A four-stage approach including evaluation, pilot testing, scaling, and optimization is most successful for enterprise-level deployment. Initial maturity assessments should find high-impact use cases; then, controlled pilots assessing ROI within 3–6 months should follow before enterprise-wide adoption. Especially important is the integration of IoT systems with current enterprise resource planning and manufacturing execution system, which 72% of those polled said was necessary to maximize value. The study advises SMEs to use targeted tactics including government grant use for cost reduction, vocational training alliances to fill knowledge shortages, and the use of modular IoT systems with built-in security measures. These strategies let smaller companies gradually increase their IoT capacity while handling the main obstacles.

Theoretically, these results add three major developments to the Industry 5.0 conversation. First, they confirm the need for human-centric design in IoT systems, especially in cobot interfaces preserving worker autonomy while improving production. With 40% of users saying smart monitoring systems had noticeable energy use decreases, the research offers statistical proof of IoT's sustainability advantages. Third, the study suggests a new "Pay-as-You-Grow" adoption concept that might significantly increase SME access to IoT technology using cloud-based service models and scalable investment structures.

Several significant constraints qualify the generalizability of these results. Though required to get specialized sector knowledge, the non-probabilistic sampling approach restricts population-level conclusions. The cross-sectional methodology also cannot evaluate changing ROI trends of IoT systems or the long-term total cost of ownership. The study also lacked thorough cybersecurity threat modeling—all vital domains for future research—nor did it assess developing synergies with 5G and edge computing architectures. The evidence foundation would be greatly strengthened by longitudinal research monitoring IoT performance indicators over 3–5-year periods and comparing evaluations of successful versus failing installations.

Ultimately, this study shows IoT to be a changing differentiator in Industry 5.0 transitions; nonetheless, it underlines that intentional strategic planning is needed to realize its full potential. Three implementation imperatives stand out as especially important: organizational alignment through executive-level IoT strategy integration and workforce development initiatives; ecosystem cooperation via public–private partnerships and standardized interoperability frameworks; and continuous innovation investment with committed research and development budgets and living lab environments. For practitioners, these results highlight the need to go beyond technical implementation to create comprehensive IoT adoption roadmaps that concurrently handle financial, human capital, and cybersecurity aspects. Future studies should include creating quantitative models to forecast IoT ROI in various organizational settings and industrial sectors, as well as investigating the governance structures required to guarantee fair and ethical technology adoption in the industrial 5.0 age.

Acknowledgment

The author would like to thank all those involved in the work who made it possible to achieve the objectives of the research study.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflict of interest in this work.

Data Availability Statement

Data sharing does not apply to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Gabriel Silva-Atencio: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition.

References

[1] Zizic, M. C., Mladineo, M., Gjeldum, N., & Celent, L. (2022). From Industry 4.0 towards Industry 5.0: A review and analysis of paradigm shift for the people, organization and technology. *Energies*, *15*(14), 5221. https://doi.org/10.3390/en15145221

[2] Lu, Y., Zheng, H., Chand, S., Xia, W., Liu, Z., & Xu, X. (2022). Outlook on human-centric manufacturing towards Industry 5.0. *Journal of Manufacturing Systems*, *62*, 612–627. https://doi.org/10.1016/j.jmsy.2022.02.001

[3] Karmaker, C. L., Bari, A. B. M. M., Anam, M. Z., Ahmed, T., Ali, S. M., de Jesus Pacheco, D. A., & Moktadir, M. A. (2023). Industry 5.0 challenges for post-pandemic supply chain sustainability in an emerging economy. *International Journal of Production Economics*, *258*, 108806. https://doi.org/10.1016/j.ijpe.2023.108806

[4] Sarkar, B. D., Shardeo, V., Dwivedi, A., & Pamucar, D. (2024). Digital transition from Industry 4.0 to Industry 5.0 in smart manufacturing: A framework for sustainable future. *Technology in Society*, *78*, 102649. https://doi.org/10.1016/j.techsoc.2024.102649

[5] Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Babaee Tirkolaee, E., Asadi, S., & Amran, A. (2023). Industry 5.0 implications for inclusive sustainable manufacturing: An evidence-knowledge-based strategic roadmap. *Journal of Cleaner Production*, *417*, 138023. https://doi.org/10.1016/j.jclepro.2023.138023

[6] Huang, Z., Shen, Y., Li, J., Fey, M., & Brecher, C. (2021). A survey on AI-driven digital twins in Industry 4.0: Smart manufacturing and advanced robotics. *Sensors*, *21*(19), 6340. https://doi.org/10.3390/s21196340

[7] Soori, M., Arezoo, B., & Dastres, R. (2023). Internet of things for smart factories in Industry 4.0, a review. *Internet of Things and Cyber-Physical Systems*, *3*, 192–204. https://doi.org/10.1016/j.iotcps.2023.04.006

[8] Lou, S., Hu, Z., Zhang, Y., Feng, Y., Zhou, M., & Lv, C. (2025). Human-Cyber-Physical system for Industry 5.0: A review from a human-centric perspective. *IEEE Transactions on Automation Science and Engineering*, *22*, 494–511. https://doi.org/10.1109/TASE.2024.3360476

[9] Trstenjak, M., Benešova, A., Opetuk, T., & Cajner, H. (2025). Human factors and ergonomics in Industry 5.0—A systematic literature review. *Applied Sciences*, *15*(4), 2123. https://doi.org/10.3390/app15042123

[10] Hu, Y., Jia, Q., Yao, Y., Lee, Y., Lee, M., Wang, C., . . . , & Yu, F. R. (2024). Industrial Internet of Things intelligence empowering smart manufacturing: A literature review. *IEEE Internet of Things Journal*, *11*(11), 19143–19167. https://doi.org/10.1109/JIOT.2024.3367692

[11] Arshi, O., Chaudhary, A., Chhabra, G., Kaushik, K., Singh, R., & Bhardwaj, N. (2025). IoT in health care: Architectural explorations, pandemic perspectives, and future horizon. In *Proceedings of Fifth International Conference on Computing, Communications, and Cyber-Security*, 555–566. https://doi.org/10.1007/978-981-97-7371-8_43

[12] Nair, A., Pillai, S. V., & Senthil Kumar, S. A. (2024). Towards emerging Industry 5.0: A review-based framework. *Journal of Strategy and Management*, *ahead-of-print*. https://doi.org/10.1108/JSMA-04-2023-0067

[13] Jassim, M. M., Mosa, M. M., Okbi, Z. A. I., Abdullah, S. B., Taha, S. W., Migo, P., & Kondakova, S. (2024). Cost-effectiveness analysis of IoT deployment in 5G networks. In *2024 36th Conference of Open Innovations Association*, 493–502. https://doi.org/10.23919/FRUCT64283.2024.10749886

[14] Joshi, S., Sharma, M., Bartwal, S., Joshi, T., & Prasad, M. (2024). Critical challenges of integrating OPEX strategies with I4.0 technologies in manufacturing SMEs: A few pieces of evidence from developing economies. *The TQM Journal*, *36*(1), 108–138. https://doi.org/10.1108/TQM-08-2022-0245

[15] Suciu, A.-D., Tudor, A. I. M., Chițu, I. B., Dovleac, L., & Brătucu, G. (2021). IoT technologies as instruments for SMEs' innovation and sustainable growth. *Sustainability*, *13*(11), 6357. https://doi.org/10.3390/su13116357

[16] Domenteanu, A., Cibu, B., & Delcea, C. (2024). Mapping the research landscape of Industry 5.0 from a machine learning and big data analytics perspective: A bibliometric approach. *Sustainability*, *16*(7), 2764. https://doi.org/10.3390/su16072764

[17] Fosso-Wamba, S., & Guthrie, C. (2024). Artificial intelligence and Industry 4.0 and 5.0: A bibliometric study and research agenda. *Procedia Computer Science*, *239*, 718–725. https://doi.org/10.1016/j.procs.2024.06.228

[18] Espina-Romero, L., Guerrero-Alcedo, J., Goñi Avila, N., Noroño Sánchez, J. G., Gutiérrez Hurtado, H., & Quiñones Li, A. (2023). Industry 5.0: Tracking scientific activity on the most influential industries, associated topics, and future research agenda. *Sustainability*, *15*(6), 5554. https://doi.org/10.3390/su15065554

[19] Ivanov, D. (2023). The Industry 5.0 framework: Viability-based integration of the resilience, sustainability, and human-centricity perspectives. *International Journal of Production Research*, *61*(5), 1683–1695. https://doi.org/10.1080/00207543.2022.2118892

[20] Grabowska, S., Saniuk, S., & Gajdzik, B. (2022). Industry 5.0: Improving humanization and sustainability of

Industry 4.0. *Scientometrics*, *127*(6), 3117–3144. https://doi.org/10.1007/s11192-022-04370-1

[21] Coelho, P., Bessa, C., Landeck, J., & Silva, C. (2023). Industry 5.0: The arising of a concept. *Procedia Computer Science*, *217*, 1137–1144. https://doi.org/10.1016/j.procs.2022.12.312

[22] Cunha, B., & Sousa, C. (2021). On the definition of intelligible IIoT architectures. In *2021 16th Iberian Conference on Information Systems and Technologies*, 1–6. https://doi.org/10.23919/CISTI52073.2021.9476342

[23] Ghobakhloo, M., Iranmanesh, M., Mubarak, M. F., Mubarik, M., Rejeb, A., & Nilashi, M. (2022). Identifying Industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values. *Sustainable Production and Consumption*, *33*, 716–737. https://doi.org/10.1016/j.spc.2022.08.003

[24] Khan, M., Haleem, A., & Javaid, M. (2023). Changes and improvements in Industry 5.0: A strategic approach to overcome the challenges of Industry 4.0. *Green Technologies and Sustainability*, *1*(2), 100020. https://doi.org/10.1016/j.grets.2023.100020

[25] Agrawal, S., Agrawal, R., Kumar, A., Luthra, S., & Garza-Reyes, J. A. (2024). Can Industry 5.0 technologies overcome supply chain disruptions?—A prospective study on pandemics, war, and climate change issues. *Operations Management Research*, *17*(2), 453–468. https://doi.org/10.1007/s12063-023-00410-y

[26] Frederico, G. F. (2021). From supply chain 4.0 to supply chain 5.0: Findings from a systematic literature review and research directions. *Logistics*, *5*(3), 49. https://doi.org/10.3390/logistics5030049

[27] Cortés-Leal, A., Cárdenas, C., & Del-Valle-Soto, C. (2022). Maintenance 5.0: Towards a worker-in-the-loop framework for resilient smart manufacturing. *Applied Sciences*, *12*(22), 11330. https://doi.org/10.3390/app122211330

[28] Shkarupylo, V., Alsayaydeh, J. A. J., Yusof, M. F. B., Oliinyk, A., Artemchuk, V., & Herawan, S. G. (2024). Exploring the potential network vulnerabilities in the smart manufacturing process of Industry 5.0 via the use of Machine Learning methods. *IEEE Access*, *12*, 152262–152276. https://doi.org/10.1109/ACCESS.2024.3474861

[29] Alvarez-Aros, E. L., & Bernal-Torres, C. A. (2021). Technological competitiveness and emerging technologies in Industry 4.0 and Industry 5.0. *Anais da Academia Brasileira de Ciências*, *93*, e20191290. https://doi.org/10.1590/0001-3765202120191290

[30] Susitha, E., Jayarathna, A., & Herath, H. M. R. P. (2024). Supply chain competitiveness through agility and digital technology: A bibliometric analysis. *Supply Chain Analytics*, *7*, 100073. https://doi.org/10.1016/j.sca.2024.100073

[31] Okeme, P. A., Skakun, A. D., & Muzalevskii, A. R. (2021). Transformation of factory to smart factory. In *2021 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering*, 1499–1503. https://doi.org/10.1109/ElConRus51938.2021.9396278

[32] Maroli, A., Narwane, V. S., & Gardas, B. B. (2021). Applications of IoT for achieving sustainability in the agricultural sector: A comprehensive review. *Journal of Environmental Management*, *298*, 113488. https://doi.org/10.1016/j.jenvman.2021.113488

[33] Singh, S., Haneef, F., Kumar, S., & Ongsakul, V. (2020). Internet of things and agriculture relationship: A bibliometric analysis. *Journal for Global Business Advancement*, *13*(5), 643–664. https://doi.org/10.1504/JGBA.2020.112821

[34] Chung, S.-H. (2021). Applications of smart technologies in logistics and transport: A review. *Transportation Research Part E: Logistics and Transportation Review*, *153*, 102455. https://doi.org/10.1016/j.tre.2021.102455

[35] Rey, A., Panetti, E., Maglio, R., & Ferretti, M. (2021). Determinants in adopting the Internet of Things in the transport and logistics industry. *Journal of Business Research*, *131*, 584–590. https://doi.org/10.1016/j.jbusres.2020.12.049

[36] Al-rawashdeh, M., Keikhosrokiani, P., Belaton, B., Alawida, M., & Zwiri, A. (2022). IoT adoption and application for smart healthcare: A systematic review. *Sensors*, *22*(14), 5377. https://doi.org/10.3390/s22145377

[37] Belfiore, A., Cuccurullo, C., & Aria, M. (2022). IoT in healthcare: A scientometric analysis. *Technological Forecasting and Social Change*, *184*, 122001. https://doi.org/10.1016/j.techfore.2022.122001

[38] Mourtzis, D., Angelopoulos, J., & Panopoulos, N. (2022). A literature review of the challenges and opportunities of the transition from Industry 4.0 to Society 5.0. *Energies*, *15*(17), 6276. https://doi.org/10.3390/en15176276

[39] Narkhede, G. B., Pasi, B. N., Rajhans, N., & Kulkarni, A. (2024). Industry 5.0 and sustainable manufacturing: A systematic literature review. *Benchmarking: An International Journal*, *ahead-of-print*. https://doi.org/10.1108/BIJ-03-2023-0196

[40] McKay, D., & Coreil, A. (2024). Hypothesis testing of the adoption of pseudoscientific methods. *Medical Hypotheses*, *182*, 111229. https://doi.org/10.1016/j.mehy.2023.111229

[41] Smith, J. D., & Hasan, M. (2020). Quantitative approaches for the evaluation of implementation research studies. *Psychiatry Research*, *283*, 112521. https://doi.org/10.1016/j.psychres.2019.112521

[42] Hsu, C.-H., Liu, J.-C., Cai, X.-Q., Zhang, T.-Y., & Lv, W.-Y. (2024). Enabling sustainable diffusion in supply chains through Industry 5.0: An impact analysis of key enablers for SMEs in emerging economies. *Mathematics*, *12*(24), 3938. https://doi.org/10.3390/math12243938

[43] Atenas, J., Havemann, L., & Timmermann, C. (2023). Reframing data ethics in research methods education: A pathway to critical data literacy. *International Journal of Educational Technology in Higher Education*, *20*(1), 11. https://doi.org/10.1186/s41239-023-00380-y

[44] Lim, W. M. (2024). What is qualitative research? An overview and guidelines. *Australasian Marketing Journal*, *0*(0), 14413582241264619. https://doi.org/10.1177/14413582241264619

[45] Pansare, R., Yadav, G., & Nagare, M. R. (2024). Integrating operational excellence strategies with Industry 4.0 technologies through reconfigurable manufacturing system practices. *The TQM Journal*, *36*(1), 3–23. https://doi.org/10.1108/TQM-06-2022-0184

[46] Vittori, D., Natalicchio, A., Panniello, U., Messeni Petruzzelli, A., Albino, V., & Cupertino, F. (2024). Failure is an option: How failure can lead to disruptive innovations. *Technovation*, *129*, 102897. https://doi.org/10.1016/j.technovation.2023.102897

[47] Mu, X., & Antwi-Afari, M. F. (2024). The applications of Internet of Things (IoT) in industrial management: A science mapping review. *International Journal of Production Research*, *62*(5), 1928–1952. https://doi.org/10.1080/00207543.2023.2290229

[48] Ali, S. M., Ashraf, M. A., Taqi, H. M. M., Ahmed, S. F., Rob, S. M. A., Kabir, G., & Paul, S. K. (2023). Drivers for Internet of Things (IoT) adoption in supply chains: Implications for

sustainability in the post-pandemic era. *Computers & Industrial Engineering*, *183*, 109515. https://doi.org/10.1016/j.cie.2023.109515

[49] Youssef Al-Attar, K. A., Hani, A. F., & Rajab, S. E. (2023). The impact of the use of communication and information technology in the work environment on social interaction. *Journal of Environmental Science*, *52*(4), 1–20. https://doi.org/10.21608/jes.2023.186824.1453

[50] Matos, J. F., Piedade, J., Freitas, A., Pedro, N., Dorotea, N., Pedro, A., & Galego, C. (2023). Teaching and learning research methodologies in education: A systematic literature review. *Education Sciences*, *13*(2), 173. https://doi.org/10.3390/educsci13020173

[51] Gulati, V. (2023). A bibliometric review of research on exchange rate predictability and fundamentals. *Finance Research Letters*, *58*, 104228. https://doi.org/10.1016/j.frl.2023.104228

[52] Kotronoulas, G., Miguel, S., Dowling, M., Fernández-Ortega, P., Colomer-Lahiguera, S., Bağçivan, G., . . . , & Papadopoulou, C. (2023). An overview of the fundamentals of data management, analysis, and interpretation in quantitative research. *Seminars in Oncology Nursing*, *39*(2), 151398. https://doi.org/10.1016/j.soncn.2023.151398

[53] Ghobakhloo, M., Iranmanesh, M., Fathi, M., Rejeb, A., Foroughi, B., & Nikbin, D. (2024). Beyond Industry 4.0: A systematic review of Industry 5.0 technologies and implications for social, environmental and economic sustainability. *Asia-Pacific Journal of Business Administration*, *ahead-of-print*. https://doi.org/10.1108/APJBA-08-2023-0384

[54] Kaswan, M. S., Chaudhary, R., Garza-Reyes, J. A., & Singh, A. (2024). A review of Industry 5.0: From key facets to a conceptual implementation framework. *International Journal of Quality & Reliability Management*, *ahead-of-print*. https://doi.org/10.1108/IJQRM-01-2024-0030

[55] Silva-Atencio, G. (2025). The success of customer-centric companies in the global context on the road to Industry 5.0. *Journal of Comprehensive Business Administration Research*. https://doi.org/10.47852/bonviewJCBAR52024580

[56] Eslamipoor, R. (2024). A new heuristic approach for a multi-depot three-level location-routing-inventory problem. *International Journal of Management Concepts and Philosophy*, *17*(3), 322–339. https://doi.org/10.1504/IJMCP.2024.139345

[57] Silva-Atencio, G. (2025). The challenges and opportunities for ethics in generative artificial intelligence in the digital age [Article]. *DYNA (Colombia)*, *92*(236), 26–35. https://doi.org/10.15446/dyna.v92n236.117144

[58] Patel, K. (2024). Ethical reflections on data-centric AI: Balancing benefits and risks. *Available at SSRN 4993089*. https://dx.doi.org/10.2139/ssrn.4993089

[59] Dionisijev, I., & Bozhinovska Lazarevska, Z. (2025). Enhancing sustainable progress: An analysis of supreme audit institutions' performance audits and information disclosure practices. *Journal of Public Budgeting, Accounting & Financial Management*, *37*(2), 254–272. https://doi.org/10.1108/JPBAFM-06-2023-0092

[60] Alturki, B., Al-Haija, Abu., Q, Alsemmeari., A, R., Alsulami, A. A., Alqahtani, A., Alghamdi, B. M., Bakhsh, S. T., & Shaikh, R. A. (2024). IoMT landscape: Navigating current challenges and pioneering future research trends. *Discover Applied Sciences*, *7*(1), 26. https://doi.org/10.1007/s42452-024-06351-w

[61] Mahmood, M., Chowdhury, P., Yeassin, R., Hasan, M., Ahmad, T., & Chowdhury, N.-U.-R. (2024). Impacts of digitalization on smart grids, renewable energy, and demand response: An updated review of current applications. *Energy Conversion and Management: X*, *24*, 100790. https://doi.org/10.1016/j.ecmx.2024.100790

[62] Wakili, A., & Bakkali, S. (2025). Privacy-preserving security of IoT networks: A comparative analysis of methods and applications. *Cyber Security and Applications*, *3*, 100084. https://doi.org/10.1016/j.csa.2025.100084

[63] Razmjoo, A., Ghazanfari, A., Østergaard, P. A., Jahangiri, M., Sumper, A., Ahmadzadeh, S., & Eslamipoor, R. (2024). Moving toward the expansion of energy storage systems in renewable energy systems—A techno-institutional investigation with artificial intelligence consideration. *Sustainability*, *16*(22), 9926. https://doi.org/10.3390/su16229926

How to Cite: Silva-Atencio, G. (2025). A Survey of Industry Professionals on the Transition to Industry 5.0: Perceptions on IoT Role in Operational Excellence. *Journal of Comprehensive Business Administration Research*. https://doi.org/10.47852/bonviewJCBAR52025785