

Research Instrument for Assessing the Integration Level of IoT Technologies for the Green and Digital Transition in Organizations

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ABSTRACT: This paper aims to develop a research instrument—a questionnaire—designed to assess the integration level of Internet of Things (IoT) technologies in organizations. The goal is to identify the current state of digitalization and its contribution to sustainability, providing a basis for future studies and comparative analyses. The questionnaire can be used by researchers, managers, and decision-makers to identify challenges and opportunities in the green and digital transition. Depending on available time and resources, a pilot application is also considered to collect relevant data from public and private sector organizations. This study proposes a well-structured and applicable instrument suitable for various organizational contexts. It contributes to evaluating the integration level of IoT devices and supports strategic decision-making aimed at increasing operational efficiency and advancing sustainability through technology.

KEYWORDS: IoT, organizational digitalization, sustainability, evaluation questionnaire, green transition

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Introduction

The integration of Internet of Things (IoT)-based technologies into organizations has become a key element in achieving sustainability and digitalization goals, in line with the priorities of the European agenda [1], [2]. As digitalization continues to transform organizational processes across sectors, a systematic approach is required to understand the degree of penetration and integration of IoT technologies within both public and private institutions.

Assessing this level of integration is crucial for identifying barriers, opportunities, and the real impact on operational performance and sustainability [3].

The Internet of Things refers to a network of interconnected devices capable of collecting, transmitting, and analyzing real-time data. These technologies are used across a wide range of domains, including logistics, healthcare, education, industry, agriculture, and public administration [4], [5]. Successful integration of IoT requires not only a digital infrastructure, but also a coherent strategy, digital competencies, and an organizational openness to innovation [6]. For this reason, the development of standardized assessment tools—such as questionnaires applicable in various contexts—is essential to guide the process of digital transformation and green transition [7], [8].

Specialized literature emphasizes that the success of IoT implementation depends on the digital maturity of the organization and the level of internal competencies [9], [10]. Moreover, both qualitative and quantitative evaluations contribute to understanding how digital solutions can be scaled, adapted, and integrated into sustainable organizational development strategies [11]. Although multiple digital diagnostic tools have been proposed at the European level [5], [6], they are not always adapted to national or sector-specific contexts.

In this context, the article proposes the development of a research instrument—a questionnaire—designed to evaluate the level of IoT technology integration in organizations. The instrument is applicable in diverse contexts and aims to provide a useful analytical framework for researchers, managers, and decision-makers. Through this research, the authors aim to answer the following question: What is the current level of IoT technology integration in Romanian organizations, and how does this integration contribute to the green and digital transition?

Literature review

The specialized literature on IoT integration emphasizes that successful implementation requires not only technological readiness but also strategic and organizational preparedness. For example, Kranz [9] notes that realizing IoT's benefits often entails adapting business models and processes, while Sharma et al. [10] highlight the proliferation of IoT applications across industries and the importance of robust sensor networks. Furthermore, IoT is increasingly seen as a driver for sustainability through efficiency and resource optimization, although empirical evidence of its environmental impact is still emerging [7], [11]. These considerations underscore the need for targeted evaluation tools to measure IoT integration and outcomes, which justifies the development of the questionnaire proposed in this study [8].

At the European level, multiple initiatives have been developed to support digital transformation and evaluate organizational maturity in the adoption of new technologies. The European Commission [1] and OECD [5] have introduced diagnostic tools for small and medium-sized enterprises, aiming to assess digital readiness and promote technology-based competitiveness. However, as emphasized by Interreg Europe [6], such tools are often generic and may not adequately capture the specific characteristics of IoT implementation, which involves both infrastructure readiness and human capital development.

Several authors argue that IoT integration is most effective when accompanied by coherent digitalization strategies, strong leadership commitment, and continuous capacity building [4], [9]. The digital transformation process requires not only technological adoption but also organizational learning and restructuring, as companies must align their internal processes, data flows, and decision-making systems with digital objectives. This organizational adaptation is also associated with the green transition, since digital solutions can optimize energy consumption, reduce waste, and support sustainability goals [7].

Unhelkar [7] highlights that “green IT” and IoT technologies can work synergistically to reduce environmental impact by enhancing monitoring systems and enabling energy-efficient automation. Similarly, Perera et al. [11] emphasize that context-aware IoT systems, when properly designed, can support sustainable development by improving the way organizations manage data and resources.

Within this context, the present study builds on the findings of previous research to propose a structured research instrument capable of assessing the integration level of IoT technologies in organizations. By linking IoT adoption with digital maturity and sustainability objectives, the proposed questionnaire contributes to filling a methodological gap in current literature—providing both a conceptual and practical tool for evaluating the role of IoT in advancing the green and digital transition.

Methodology

This study employs a quantitative research methodology, using a standardized questionnaire as the main research instrument, developed to assess the level of integration of Internet of Things (IoT) technologies in organizations, in

correlation with digitalization and sustainability objectives. The choice of method is justified by the need to collect comparable and aggregable data that would allow for the analysis of organizational perceptions and practices from a systematic perspective. The instrument was developed based on the relevant literature and administered online through the Google Forms platform in 2025. The questionnaire was addressed to a single individual from each organization, provided they held a managerial position. This requirement was ensured through a logical filter implemented in the form, which allowed continuation only for respondents with decision-making roles. In total, 38 valid responses were collected from Romanian organizations, both from the public and private sectors.

The questionnaire was structured into six thematic sections: (1) Introduction and informed consent; (2) Data on the organization and respondent; (3) Level of digitalization; (4) Degree of IoT integration; (5) Contribution to sustainability; (6) Challenges and future perspectives. Most of the questions were closed-ended, using either multiple-choice or Likert-scale formats (1 to 5), along with a single open-ended question at the end. This structure enabled the collection of both descriptive data (about company) and evaluative data (perceptions, strategies, benefits, obstacles).

Participation in the study was voluntary and anonymous. Respondents were informed about the purpose of the study, the estimated completion time, and the exclusive scientific use of the collected data. Informed consent was explicitly requested at the beginning of the questionnaire. The collected responses are currently undergoing descriptive and inferential statistical analysis, with results to be presented in the subsequent sections of the paper. Participation in the study was voluntary and anonymous. Respondents were informed about the purpose of the study, the estimated completion time, and the exclusive scientific use of the collected data. Informed consent was explicitly requested at the beginning of the questionnaire. Additionally, this research study was approved by the Research Ethics Subcommittee of the University Ethics Committee at the National University of Science and Technology POLITEHNICA Bucharest (Approval No. 9/12.05.2025). All procedures respected principles of confidentiality and anonymity, and the data were used solely for academic purposes. The 38 valid responses collected—each from a single managerial-level representative—represent the initial phase of a broader research effort. Data collection is still in progress and aims to expand the sample to ensure greater representativeness and robustness of statistical results.

Results and further discussions

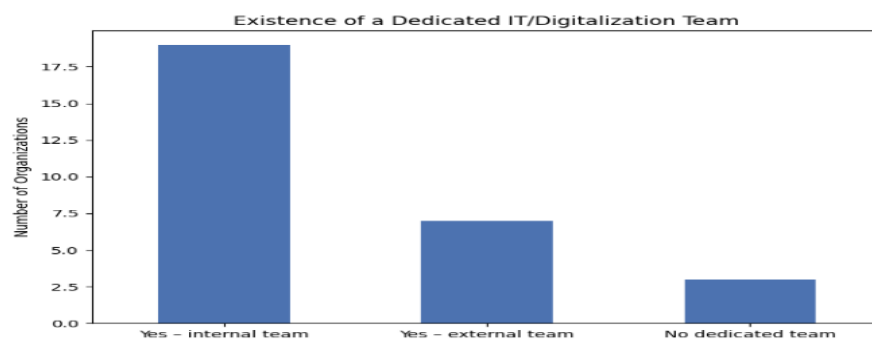
Sample Characteristics

The questionnaire on IoT technology integration was completed by 38 respondents. Among them, 29 held managerial positions and completed the entire survey, while 9 were in non-managerial roles (and were filtered out at the screening question due to a lack of decision-making authority). The majority of responding organizations were private enterprises (approximately 90%), with a predominantly SME profile — about one-third had fewer than 10 employees, and the rest were medium or large organizations in smaller proportions. The managerial roles of respondents ranged from Administrator (most frequently), Project Coordinator, to various director-level positions (General Director, IT Director, Digitalization Director) and other management roles, indicating that the sample includes individuals with diverse responsibilities in organizational management.

Organizations' Digitalization Level

A clear majority (66%) of the organizations reported having a formal or informal digitalization strategy, while 17% were in the process of developing one. A small percentage (7%) expressed intentions to formulate a strategy, and only 10% stated they currently have no digital strategy in place. These results highlight that most organizations are aware of the importance of planning for digital transformation (as illustrated in Figure 1).

Figure 1. Existence of an Internal or External IT/Digitalization Team



Source: authors' own elaboration.

Furthermore, most organizations reported having dedicated IT or digitalization teams: approximately 66% of respondents indicated having an internal specialized team, 10% rely on an external team, and the remaining ~24% lack a dedicated team altogether. The self-assessed digitalization level of the organizations averaged 3.69 on a 1–5 Likert scale, indicating a moderate to high degree of digital process integration (e.g., partially automated processes, significant use of digital solutions).

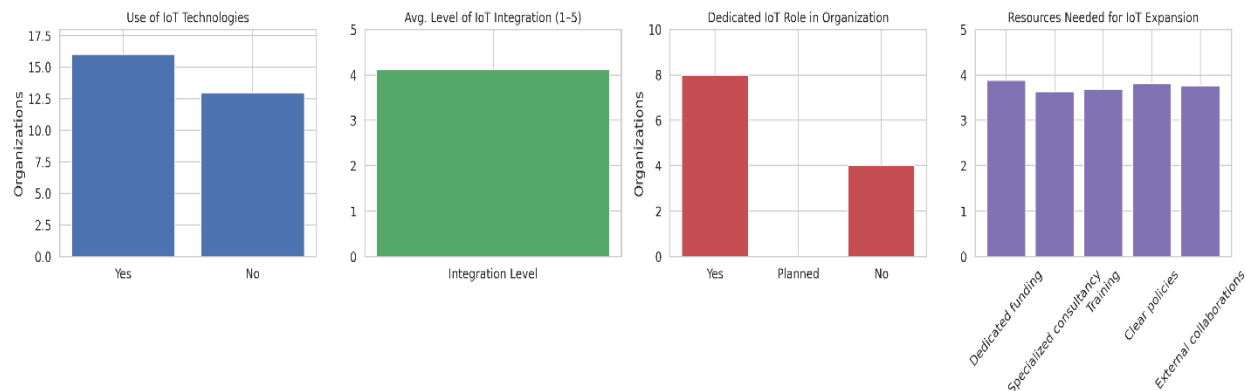
This relatively high level suggests that many companies have already taken important steps toward digital transformation. Moreover, openness to innovation was rated very positively—respondents reported an average of 4.38 out of 5, corresponding to organizations that are typically highly receptive to innovation. Most respondents (59%) described their organizational culture as “proactive” in terms of innovation (actively seeking new technologies and solutions), while approximately 34% described it as “balanced” (selectively open to innovation), and only around 7% considered their culture “conservative.” This cultural profile indicates a favorable environment for the adoption of new technologies in most of the surveyed organizations.

IoT Technology Adoption in Organizations

Regarding the Internet of Things, just over half of the surveyed organizations reported already using IoT technologies. Specifically, 55% of respondents indicated the use of IoT solutions, while the remaining 45% have not yet adopted such technologies (Figure 2).

Among the organizations that have implemented IoT, the level of integration is perceived as relatively high—the average reported level of IoT integration was 4.12 out of 5 (where 5 indicates a very high integration of IoT devices into the company’s processes). This suggests that, where IoT has been adopted, connected devices are well embedded within operational workflows and the existing digital infrastructure. IoT applications cover various organizational areas, with the most common being real-time monitoring (e.g., monitoring of processes, equipment, or operational parameters) and security, followed by process optimization in marketing and energy management. Less frequent are IoT applications in areas such as human resources or agriculture (limited to organizations with relevant profiles).

Figure 2. IoT Adoption, Integration Level, Governance, and Expansion Needs in Organizations



Source: authors' own elaboration.

IoT adoption is further supported by dedicated human resources—half of the organizations currently using IoT reported having appointed a person responsible for managing IoT initiatives, while approximately 25% plan to designate such a role in the near future. Only one quarter have not yet assigned a dedicated person for IoT, highlighting the attention given to these technologies in organizations where they are already in use. Moreover, around 50% of IoT-adopting organizations plan to expand the use of these technologies over the next two years, while the remaining organizations either lack concrete plans or are still undecided in this regard. This demonstrates a continuing upward trend in the strategic role of IoT in organizations that have already begun implementation (Figure 2).

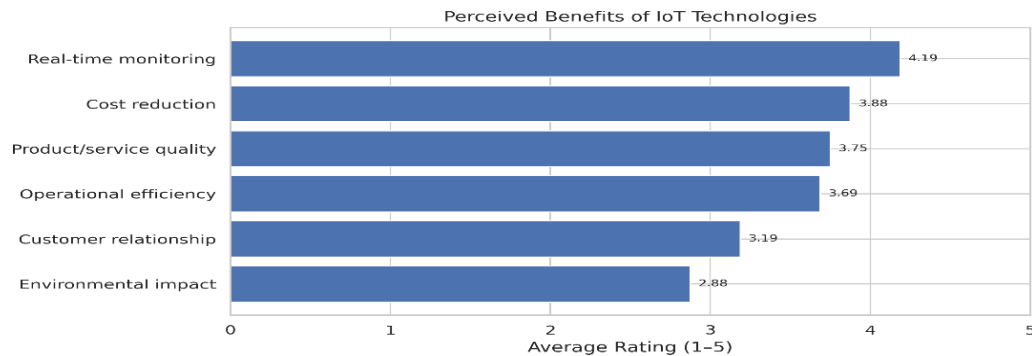
Perceived Benefits of IoT and Impact on Sustainability

The implementation of IoT brings multiple operational benefits, according to respondents' perceptions. The most significant advantages reported include real-time monitoring of operations and data—considered the main benefit of IoT—and the reduction of operational costs. On average, respondents rated IoT's contribution to improving process monitoring at 4.19 out of 5 (the highest score among all benefits), and its impact on cost reduction at 3.88 out of 5.

Additionally, the increase in overall operational efficiency and the improvement in product/service quality were among the notable benefits, with average scores around 3.7–3.8. On the other hand, the perceived effects of IoT on customer relations were moderate (3.19/5), while its contribution to reducing environmental impact received the

lowest score (2.88/5 on average). Figure 3 provides a comparative overview of the average evaluation of the main benefits obtained.

Figure 3. Perceived Benefits of IoT Technologies



Source: authors' own elaboration.

Considering these results, it becomes evident that IoT is primarily valued for process optimization and automation—particularly in areas such as monitoring, operational efficiency, and cost reduction—while environmental benefits or improvements in customer relations are not yet strongly perceived by most organizations. However, approximately 44% of organizations that use IoT have already implemented or are in the process of implementing a “green” strategy (focused on ecological sustainability), indicating an increasing awareness of the importance of sustainability.

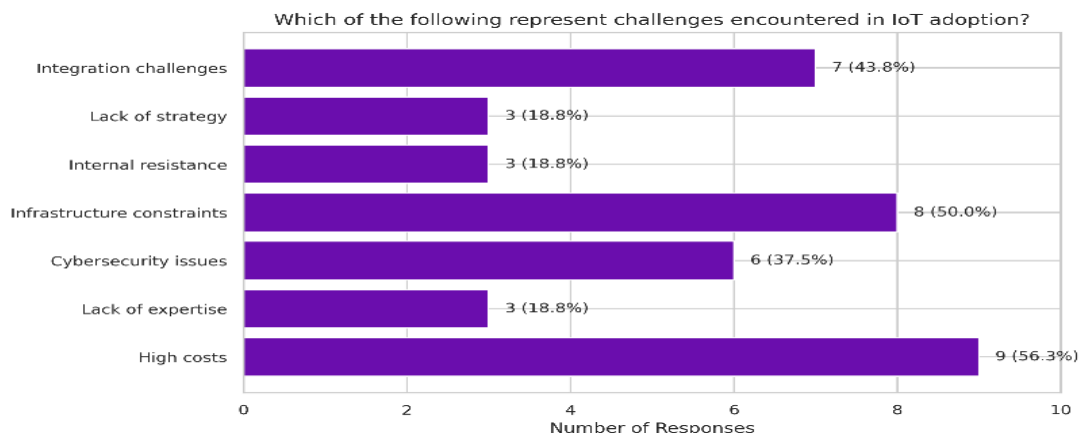
Moreover, the importance attributed to sustainability in strategic decision-making was rated, on average, at 3.88 out of 5 by respondents whose organizations use IoT, suggesting a significant concern for environmental issues and energy efficiency. Respondents generally believe that IoT contributes moderately to their organization’s sustainability goals—especially in terms of resource savings and energy efficiency (average scores of approximately 3.1–3.3 out of 5)—more so than to waste reduction, where the perceived contribution is relatively low.

Challenges in IoT Adoption

Despite the recognized benefits, organizations also face several challenges in implementing IoT technologies. The most commonly reported obstacles are economic and technical in nature. High implementation costs rank as the number one challenge, mentioned by 9 out of the 16 organizations that currently use IoT. The second most cited challenge involves IT or communication infrastructure constraints (e.g., the need for a robust network), reported by 8 respondents.

These are followed by issues related to the technological integration of IoT solutions with existing systems (7 mentions), as well as perceived cybersecurity concerns (6 mentions)—factors that may hinder the large-scale adoption of connected devices. In contrast, fewer organizations identified a lack of expertise (insufficient specialized personnel), internal resistance to change from employees, or the absence of a clear IoT strategy as major impediments—each of these was mentioned by only 3 respondents. The distribution of the main reported challenges is illustrated in Figure 4.

Figure 4. Which of the following represents challenges encountered in IoT adoption?).



Source: authors' own elaboration.

Notably, cost and infrastructure issues dominate organizational concerns, highlighting the need for adequate financial and technological resources to support IoT initiatives. While security concerns are not the top barrier, they nonetheless represent a significant challenge, emphasizing the importance of addressing cybersecurity risks in IoT projects. Overall, these obstacles help explain why some organizations are still hesitant to fully implement or scale up IoT solutions, despite their potential benefits.

Comparison of Perceived Contribution of IoT to Sustainability between Public and Private Sectors

For the 16 organizations that completed the sustainability section (all from the private sector), an overall IoT sustainability contribution score was calculated as the average of the ratings given to various sustainability aspects (e.g., energy efficiency, waste reduction, resource savings, environmental protection, automation of sustainable processes). The legal form of the organization was used to classify respondents into the private sector (LLC/Joint Stock Companies) and public sector (public institutions). It is worth noting that the public sector respondents ($N = 3$) did not report any IoT implementation in their organizations, thus indicating a practically nonexistent contribution of IoT to sustainability (minimum score). In contrast, private sector respondents ($N = 16$) reported using IoT and positively assessed its contributions.

Statistical Analysis Results: The average score for the contribution of IoT to organizational sustainability is considerably higher in the private sector compared to the public sector. Private organizations recorded an average score of 2.94 (standard deviation ± 1.14 , on a 1–5 scale), while public organizations had an average score of approximately 1.00 (± 0.00). However, given the extremely small number of public sector respondents ($N = 3$), this observed difference cannot be considered statistically meaningful. Although the t-test returned a very low p-value ($\approx 6.16 \times 10^{-6}$) due to the stark contrast in scores, the result lacks robustness; any comparative inference between sectors should thus be made with caution. Essentially, the analysis of IoT's contribution to sustainability is representative only of the private sector respondents in our sample.

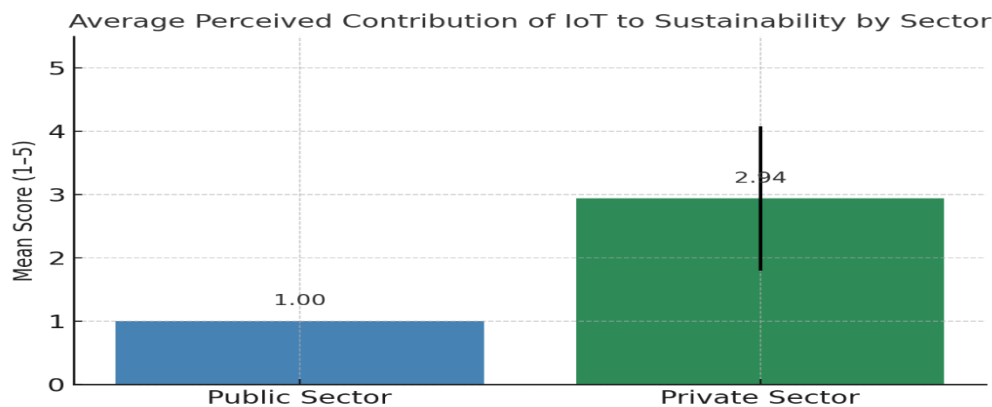
Table 1. Descriptive statistics of the IoT contribution score to sustainability, by organizational sector (public vs. private). The mean and standard deviation are calculated on a scale from 1 ("not at all") to 5 ("very much").

Sector	N	Mean IoT–Sustainability Score	Standard Deviation
Public	3	1.00	0.00
Private	16	2.94	1.14

Source: authors' own elaboration.

Figure 5 illustrates the mean IoT contribution score to organizational sustainability, by sector (public vs. private). A clear difference can be observed between the two categories of organizations, with the private sector reporting a much higher score than the public sector. The error bar for the private sector column indicates the standard deviation of individual values (while the standard deviation for the public sector is zero, since all scores were at the minimum level).

Figure 5: Average score of IoT contribution to organizational sustainability, by sector (public vs. private).



Source: authors' own elaboration.

Comparison of IoT Contribution to Sustainability between Organizations with and without Green Strategies

To assess whether there are significant differences between organizations with a green strategy and those without, independent samples t-tests were conducted on three variables indicating the contribution of IoT to sustainability: energy efficiency, waste reduction, and resource saving.

Table 2 below presents the mean scores reported by the two groups (with green strategy vs. without green strategy), along with the t-test results (t value, degrees of freedom, and p value). All ratings were based on a 5-point Likert scale, where 1 = “not at all” and 5 = “very much.”

Table 2. Results of independent t-tests on the perceived contribution of IoT to various sustainability aspects, by presence of a green strategy.

Aspect	Green Strategy (Mean ± SD)	No Green Strategy (Mean ± SD)	t	df	p
Energy efficiency	3.14 ± 1.46	2.80 ± 1.48	0.40	8.70	0.70
Waste reduction	3.14 ± 1.21	1.80 ± 1.79	1.46	6.59	0.19
Resource saving	3.43 ± 1.13	2.80 ± 1.48	0.80	7.20	0.45

Source: Source: authors' own elaboration.

All statistical analyses were performed using IBM SPSS Statistics, version 28.

Energy Efficiency. Organizations with a green strategy reported a mean contribution of IoT to energy efficiency of $M = 3.14$ ($SD = 1.46$), compared to $M = 2.80$ ($SD = 1.48$) for those without a strategy (see Table 1). An independent t-test revealed no statistically significant difference between the two means, $t(8.70) = 0.40$, $p = 0.70$. Statistically speaking, this result suggests that the perceived contribution of IoT to energy efficiency is similar in both types of organizations.

Waste Reduction. For IoT's contribution to waste reduction, organizations with a green strategy reported a higher mean of $M = 3.14$ ($SD = 1.21$), while those without had a lower mean of $M = 1.80$ ($SD = 1.79$). Although the mean difference is notable (approximately 1.34 points on a 1–5 scale), the t-test did not reveal statistical significance at the conventional confidence level, $t(6.59) = 1.46$, $p = 0.19$. In practical terms, this suggests a trend: organizations with green strategies seem to perceive greater benefits of IoT in reducing waste, though the result is not conclusive due to sample size and variation.

Resource Saving. Regarding resource saving, organizations with a green strategy reported a mean IoT contribution score of $M = 3.43$ ($SD = 1.13$), compared to $M = 2.80$ ($SD = 1.48$) for organizations without such strategies. The difference of about 0.63 favors the green strategy group (see Table 1). However, this difference was not statistically significant, $t(7.20) = 0.80$, $p = 0.45$. Thus, no sufficient evidence exists to confirm a statistically significant difference between the two groups. From a practical perspective, the moderate mean difference points to a slightly more favorable perception of IoT among organizations with green strategies, but without a substantial advantage. Overall, none of the observed differences reached statistical significance at the $p < 0.05$ level. Although organizations with a green strategy tend to assign higher average scores to the contribution of IoT technologies to sustainability—particularly in waste reduction and, to a lesser extent, in resource saving—these differences cannot be statistically confirmed with the available data. In practical terms, the results suggest that the perceived effects of IoT on sustainability are comparable between “green” organizations and those without green strategies, at least within the studied sample. However, the substantial mean difference in waste reduction (greater in organizations with green strategies) may indicate a potentially important practical impact, which would merit further investigation with a larger sample to determine whether it becomes statistically significant.

Conclusions

This study provided an overview of the level of digitalization and the integration of Internet of Things (IoT) technologies in organizations, highlighting both the benefits achieved and the challenges encountered. The survey results indicate that respondents perceive IoT integration as a positive factor in organizational activity, reporting advantages such as improved operational efficiency, increased data accuracy, and economic benefits. These aspects enable organizations to optimize business processes, explore new markets, and maintain competitive advantages. Additionally, most respondents believe that IoT contributes to achieving sustainability goals by enabling more efficient resource monitoring and waste reduction, thus confirming the relevance of IoT in the green transition.

A comparative analysis between the public and private sectors reveals qualitatively similar trends in IoT usage and integration. Nevertheless, due to the very limited public-sector sample ($N = 3$), no statistically reliable difference can be confirmed between the two sectors. In effect, the comparative findings primarily reflect the situation in private organizations ($N = 16$), where IoT's contribution to sustainability is clearly recognized. Similarly, the comparison between organizations with and without a formal green strategy showed no significant differences in perceived IoT sustainability benefits, likely owing to the limited sample size for each subgroup. Within our sample,

both “green” and non-green organizations reported comparable perceptions of IoT’s environmental value. Likewise, the comparison between organizations with and without a formal green strategy **revealed no statistically significant differences** in the perceived contributions of IoT to sustainability. This suggests that, given the limited sample in each group, IoT’s sustainability benefits are perceived **similarly regardless of the presence of a green strategy**, though a larger sample would be needed to confirm this observation.

Overall, the proposed research instrument proved applicable and valuable for assessing the degree of IoT integration in the context of the twin transition (green and digital). It provides a systematic approach for quantifying IoT adoption and its contributions, addressing the gap in the literature for empirical assessments of IoT’s impact on sustainability. The importance and usefulness of such an instrument are also emphasized by other authors, who argue that a well-designed evaluation tool can guide managerial practices, allowing decision-makers to assess their current position and plan future informed actions in the field of digital and green transformation. Thus, this research contributes both practically—by offering organizations a tool for IoT self-assessment—and scientifically, by validating the application of an original questionnaire in a real-world context and supplying empirical data on the relationship between IoT, digitalization, and sustainability.

Study Limitations

Despite the relevance of the findings, this study has several inherent limitations. The first limitation is the small sample size—only 38 respondents participated, and only 16 (in leadership roles) completed the section regarding green strategies. This restricts the robustness of inferences and the generalizability of conclusions. Second, there may be underrepresentation of certain industries or organizational types in the sample. Given the small number of respondents, some sectors may not be sufficiently covered, which can influence the distribution of responses. Moreover, since only individuals in leadership positions completed the full questionnaire, there may be a slight managerial bias, with the perspectives of other employees not being captured.

Lastly, the subjective nature of self-assessments represents a limitation: the responses reflect the respondents’ perceptions of the degree of IoT integration and the associated benefits or challenges. There may be a tendency to overestimate or underestimate the actual situation. These limitations, common in questionnaire-based research, highlight the need for caution in interpreting the results and suggest directions for future investigation—for instance, expanding the research with a larger and more diverse sample (as recommended in the literature), and complementing self-reported data with objective indicators of digital technology integration. Nevertheless, despite these constraints, the study provides valuable insights into organizations’ readiness for the green and digital transition and demonstrates the effectiveness of the proposed instrument in capturing current realities of IoT adoption.

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