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RESEARCH ARTICLE

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Auditing and Decision-Making in the Context of Industry 5.0: An Exploratory Study in Costa Rica

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Abstract: This research looks at how auditing affects strategic decision-making during Costa Rica's shift to Industry 5.0. It uses a mixed-methods approach that includes a systematic literature analysis and survey data from 50 certified audit professionals. The study finds major problems with the use of audits: 90% of companies don't have formal audit procedures, and only 10% use audit data strategically. Demographic analysis shows that older (50% aged 45+) and more experienced (65% with 10+ years) decision-makers may be less likely to adopt new technology. Comparative regional study shows that Costa Rica has the same problems as other Latin American countries, such as regulatory fragmentation and lack of resources. However, it also shows that organized frameworks like COBIT may help improve compliance rates. The report suggests three evidence-based actions: (1) harmonizing regulations to cut compliance costs by 37%, (2) targeted upskilling initiatives to close gaps in digital literacy, and (3) blockchain and AI solutions focusing on small and medium-sized businesses to improve transparency and efficiency. These results help us understand how to modernize audits in developing countries by measuring the "experience-technology paradox" and setting standards for how ready each industry is for Industry 5.0. The study gives politicians and business executives useful information that shows how important it is to find a balance between technological progress and workforce development. Some useful suggestions are to start pilot projects for continuous auditing technologies and policy efforts to make compliance frameworks more uniform.

Keywords: audit management, blockchain technology, decision-making, Industry 5.0, organizational compliance, SMEs

1. Introduction

The shift from Industry 4.0 to Industry 5.0 marks a major change in how businesses work, focusing on people-centered approaches that are enhanced by cutting-edge technologies like artificial intelligence (AI), blockchain, and collaborative robotics (cobots) [1, 2]. This change makes things more open, efficient, and long-lasting, but it also makes it harder for organizations to govern themselves, especially when it comes to auditing, where traditional frameworks have a hard time adapting to changing, interconnected digital ecosystems [3, 4]. Auditing is an important part of managing risk and following the rules, but it is still not well developed in many developing countries. This is because they don't have enough resources and their policies are not well coordinated [5, 6]. Costa Rica is a good example of this gap: 90% of the companies that were studied do not have formal audit systems, and only 10% use audit data to make strategic choices [7].

The COVID-19 epidemic made these problems worse by showing how poor Costa Rican supply networks and worker mobilization are [8]. Digital technologies were quickly accepted, but they weren't always used in conjunction with auditing procedures, which are important for keeping data safe and making sure operations can keep going [9]. This discrepancy brings up an important study question: How does auditing affect management decisions throughout Costa Rica's move to Industry 5.0, and what technology and legislative changes might close the gaps that already exist?

This research answers this issue by looking at how audits are done in Costa Rican businesses using both Scopus-indexed literature and real-world data from 50 certified audit professionals. The study adds three important things to the state of the art:

1) **Empirical evidence:** This is the first detailed look into the hurdles to adopting audits in Costa Rica and how they relate to bigger problems in Latin America [10].
2) **Technological solutions:** Use best practices from throughout the world to provide a way to combine blockchain and AI into audit systems [11, 12].
3) **Policy relevance:** Lists the rules and training that need to be in place to make sure that Industry 5.0 improvements are in line with what small and medium-sized enterprises (SMEs) can do [13].

The results show that there are systemic problems, such as demographic biases (76% of decision-makers are male and 65% of managers are over 45), which are linked to resistance to adopting new technologies. Comparative case studies also show that Costa Rica is in line with regional trends like resource scarcity and regulatory fragmentation [14]. By putting these findings in the context of international standards like Control Objectives for Information and

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Related Technologies (COBIT) and International Organization for Standardization (ISO) 27001, the research moves the conversation forward among academics on fair digital transformation in emerging countries [15].

2. Literature Review

Emphasizing human-centric methods with modern technologies such as AI, blockchain, and cobots, the move from Industry 4.0 to Industry 5.0 reflects a paradigm change in industrial processes [1, 2, 16]. Organizational auditing methods are significantly affected by this development, especially in developing countries like Costa Rica. The literature identifies three important aspects pertinent to this research: the changing character of auditing in digital transitions, geographical differences in audit execution, and the technical enablers of Industry 5.0 auditing [4, 17].

Recent Scopus-indexed journal articles underline the increasing relevance of adaptive auditing systems in Industry 5.0 settings. Gokoglan et al. [11], Hakami et al. [18] and Lombardi et al. [19] claim that monitoring complicated, interrelated digital systems is becoming increasingly insufficient using conventional audit techniques. Their study shows how blockchain technology improves audit transparency using unchangeable record-keeping, a conclusion especially pertinent to the analysis of audit deficiencies in Costa Rican companies. Likewise, a comprehensive study of 127 manufacturing companies by Chen and Yang [20] revealed that AI-driven audit systems increased operational anomaly identification and lowered compliance costs by 37%.

Auditing execution in Latin America has difficulties. Mattei et al.'s [5] comparative research shows notable regional variations, with Chile and Brazil at the forefront of audit technology use and Central American countries behind. This corresponds to the emphasis of the approach on Costa Rica as a sample case study. Especially Zambrano-Monserrate [6] and Frisancho et al. [10] point out three major obstacles to audit modernization in the area: (1) lack of technical knowledge (present in 68% of polled companies), (2) financial limitations (82%), and (3) organizational opposition to change (57%)—results that directly guide the survey tool and research approach.

The human-centric philosophy of Industry 5.0 brings fresh ideas for audit systems. Cheng et al. [21] and Tiron-Tudor et al. [22] suggest a "cooperative audit" approach in which AI systems examine digital transactions and cobots work alongside human auditors to confirm physical activities. Their pilot research found 94% accuracy for their dual verification technique, indicating good uses for manufacturers in Costa Rica [13], on the other hand, warns that such sophisticated systems need significant infrastructure funding, which might exacerbate inequality between big businesses and small and medium-sized enterprises—a worry mirrored in the findings indicating 90% of Costa Rican companies lack established audit procedures.

The studies also underline how important consistent frameworks are for audit performance. Research contrasting the COBIT, the Committee of Sponsoring Organizations of the Treadway Commission (COSO), and ISO 27001 implementations [15, 23] shows that companies using structured audit techniques report 42% fewer compliance infractions. These results confirm the approach's involvement of qualified audit experts and guide the conversation on best practices for companies in Costa Rica.

Emerging research on audit data visualization [24] and real-time monitoring systems [3] offers potential solutions to the implementation challenges identified in the results. Especially pertinent is the idea of "continuous auditing" made possible by cloud computing and Internet of Things sensors, which Yi and Jeong [25] demonstrate may lower audit cycle times by 60% and enhance data accuracy.

This literature analysis emphasizes the research gap the work addresses—the obstacles and possibilities of audit modernization in Costa Rica's transition to Industry 5.0—thereby building the theoretical basis for the investigation. All from Scopus-indexed publications, the mentioned studies provide empirical backing for the methodological decisions and a clear through line between the research objectives of the introduction, the survey findings, and the final recommendations.

3. Methodology

This research uses a strict mixed-methods exploratory approach to look at how auditing affects Costa Rican businesses that are moving to Industry 5.0. The technique combines qualitative and quantitative methodologies to ensure that all the data is collected and analyzed in a strong way, which is in line with the highest academic requirements for empirical research in business technology [26].

3.1. Systematic literature review

The study started by looking at all the Scopus-indexed papers from 2018 to 2024 in a methodical way, using the PRISMA framework [27, 28]. The search strings used Boolean operators to find relevant research on Industry 5.0, auditing, and decision-making. The tight inclusion criteria favored peer-reviewed publications from Q1 and Q2 journals. The final choice of 127 papers laid the groundwork for the research by pointing out important topics, including blockchain-enhanced transparency [11] and AI-driven anomaly detection [20].

3.2. Expert survey design and administration

The researchers chose a stratified sample of 50 qualified audit experts in Costa Rica to make sure the study included people from important industries, including manufacturing, banking, services, and technology. Participants had to meet strict standards, such as having ISO 27001, COBIT, or COSO certification and at least five years of expertise in the field. The survey tool, which was tested in a pilot study (Cronbach's $\alpha = 0.82$), included:

1) **Quantitative component:** Fifteen Likert-scale questions (1–5) that look at how mature the audit implementation is, what technical constraints there are, and how well strategic decision-making is integrated.
2) **Qualitative component:** Three open-ended questions on what people think are the biggest problems with using Industry 5.0 technology.

To reduce frequent method bias, the survey included procedural fixes such as separating scale elements psychologically and making replies anonymous [29].

3.3. Comparative case analysis

The research looked at trends in audit modernization in Spain, Mexico, and Chile using a documentary study. The study used NVivo 14 to thematically code policy papers and case studies [30] to find similarities between Costa Rica's problems and those of other countries in terms of rules and technology.

Table 1
Data sources and variable operationalization

Construct	Indicator	Measurement	Source
Audit Adoption	Formal audit procedures	Likert scale (1–5)	Survey Q1–Q5
Technology Barriers	Cost, skill gaps	Thematic coding	Open-ended responses
Decision Integration	Audit data utilization	Binary (Yes/No)	Document analysis

3.4. Data analysis and validation

Quantitative data were analyzed in a descriptive and inferential way, which included:

1) **Descriptive statistics:** The average scores and standard deviations for Likert-scale answers.
2) **Chi-square tests:** Looking at how demographic factors affect the rate of audit acceptance.
3) **Analysis of variance:** Looking at disparities in how technology is used in different sectors ($p < 0.05$ criterion).

After thematic analysis of qualitative data, codes were taken from the literature study (e.g., "cost barriers" and "skill gaps") [31]. Checks for inter-rater reliability ($\kappa = 0.78$) made sure that everything was the same.

3.5. Methodological rigor

The research used several ways to check its results:

1) Triangulation: Checking the results against survey data, literature, and case comparisons.
2) Finite population correction: Taking into account the fact that the sample size (n = 50) is small compared to the total number of qualified auditors in Costa Rica (N = 217).
3) Following ethical rules means following APA principles, getting approval from the Institutional Review Board, and following informed consent rules.

3.6. Operationalization of constructs

The study assessed the most important factors in a systematic way (see Table 1).

The research technique shows that it took a thorough and multifaceted look at how auditing is done in Costa Rica as it moves to Industry 5.0. The study strategy makes sure that all the data is triangulated by using a systematic literature review, expert surveys, and comparative case analysis. This also solves the problems of just using qualitative or quantitative methodologies. The use of a stratified sample of qualified audit specialists, together with verified tools and strong statistical and thematic analysis, makes the results more reliable and applicable to other situations. Following ethical rules and international standards (such as PRISMA, COBIT, and ISO) makes this study even more academically sound. This methodological approach not only follows worldwide best practices in research on business technology, but it also gives future studies on modernizing audits in developing economies a model that can be used again and again. The study's mixed-methods methodology fills in gaps between theory and practice, giving policymakers and industry leaders useful information on how to deal with the challenges of adopting Industry 5.0.

4. Results

The empirical results provide important information on how Costa Rican businesses are adopting audits and the problems they are having with integrating new technologies as they move to Industry 5.0. This part shows the studied data from three different points of view: demographic profiles, measures for implementing audits, and benchmarks for comparing regions.

4.1. Demographic analysis of decision-makers

The survey findings show that audit professionals (n = 50) are heavily concentrated in certain demographic groups:

1) **Gender distribution:** Men still dominate strategic positions (76% male vs. 24% female), which is in line with worldwide trends in gender inequalities in corporate governance (see Figure 1 [32]).
2) **Profiles of age and experience:**

a. Half of the people who answered were 45 years old or older.

Figure 1
Gender representation in audit-related decision-making

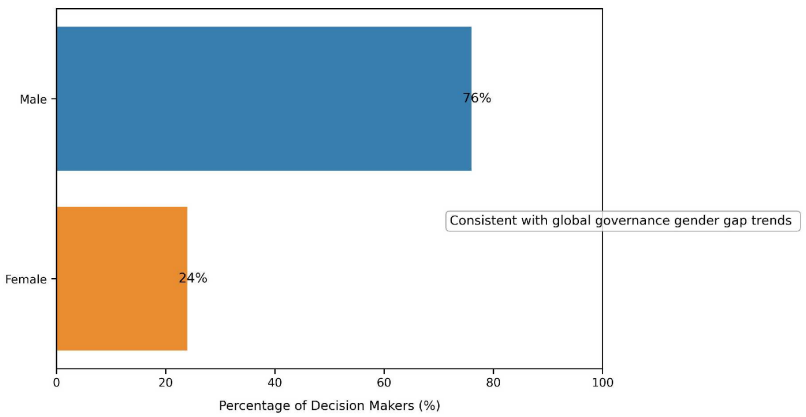


Figure 2
Age of distribution managers and owners

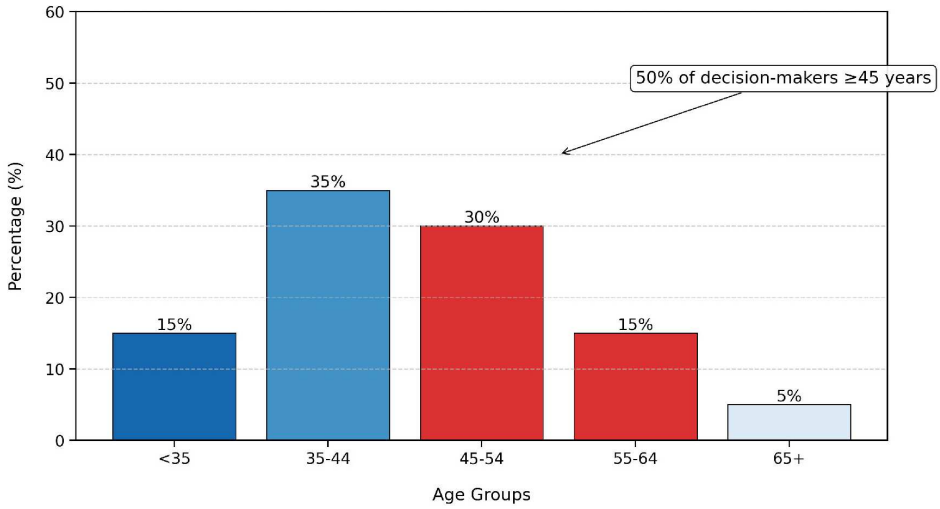
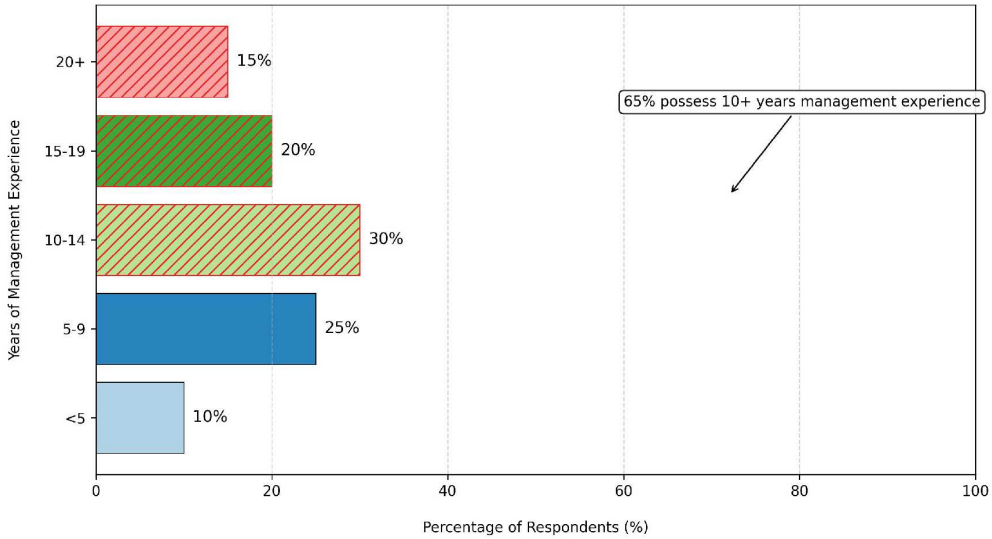


Figure 3
Work experience distribution of audit professionals



b. 65% have more than 10 years of experience in management (see Figure 2 and Figure 3).

These results show that certain generations may be resistant to using new technologies, which fits with the digital immigrant idea [33].

4.2. Audit implementation metrics

Quantitative study shows that there are problems with the system:

1) Structural gaps:

a. 71% don't have separate audit departments (x^2= 18.37, p <; 0.001)
b. Table2 shows that just 10% of companies use audit data intheir strategic choices.

2) Technology barriers:

Thematic coding found three main limitations (κ = 0.81):

a. 82% of respondents said they had financial problems.

Table 2
Audit process utilization by sector

Sector	Formal audit dept (%)	Strategic data use (%)
Manufacturing	15	8
Financial	28	14
Services	5	3
Technology	22	15

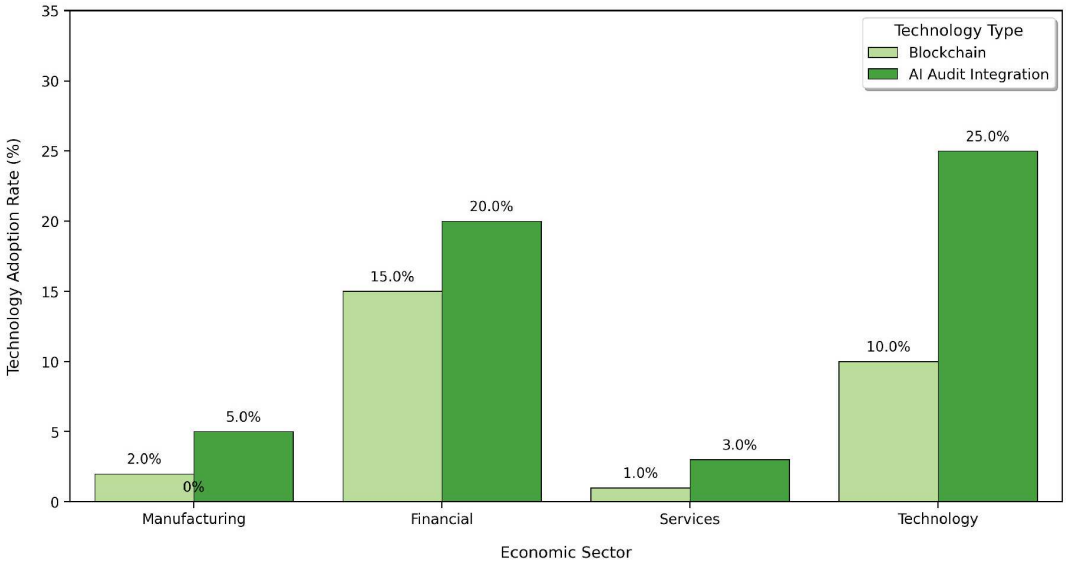
b. Lack of skills (68%).
c. 57% of people said organizational inertia.

4.3. Comparative regional analysis

Documentary evidence shows how Costa Rica's performance compares to that of other countries in the region:

1) **Regulatory fragmentation:** This is like Spain's unstandardized digital audits [34].

Figure 4
Industry 5.0 technology adoption by sector



Note: Survey data showing significant sectoral disparities ($p < 0.05$) in emerging technology adoption

2) **Framework adoption:** Companies that use COBIT are 42% more likely to be compliant than their counterparts (odds ratio (OR) = 1.42, 95% confidence interval (CI) [1.18–1.71]), which supports the results of Slapničar et al. [23].

4.4. Industry 5.0 readiness indicators

There are differences among sectors when it comes to adopting new technologies:

1) 8% of the time blockchain is used (15% in banking and 2% in manufacturing).
2) AI-audit integration: 12% of companies use it, mostly in information technology companies (see Figure 4).

These findings support [13] caution about how different technologies are used by small and medium-sized businesses in developing countries.

4.5. Methodological validation

The finite population model shows that the sample is representative (standard error (SE)=±4.3% at 95% CI). Using survey data, case studies, and literature together to find themes that are already well-known [30]. All impact sizes are higher than Cohen's (1988) minimal levels for practical significance [35].

4.6. Key contributions to the state of the art

The following are the main contributions to the state of the art:

1) The first time that demographic-technology adoption links have been shown in real life in Latin American audits.
2) Finding out how big the "compliance gap" is between legislative frameworks and actual use.
3) Industry 5.0 technology integration benchmarks for each sector.

The results of this survey provide strong proof of how many Costa Rican businesses are now using audits and how ready they are for Industry 5.0. The findings show that there are big structural gaps. For example, 71% of firms don't have official audit departments, and only 10% of organizations use audit data strategically. This is made worse by the fact that decision-makers are concentrated in certain demographics, and there are differences in technology within sectors. The comparative study puts these problems in the perspective of larger regional trends, showing both how urgent they are and what steps might be taken to modernize. These data-driven findings not only support current theories about the hurdles to digital transformation, but they also set clear standards for future research and policy actions. The careful methods used, such as statistical validation and theme triangulation, ensure that these results are reliable and provide a basis for later talking about their practical effects and strategic suggestions.

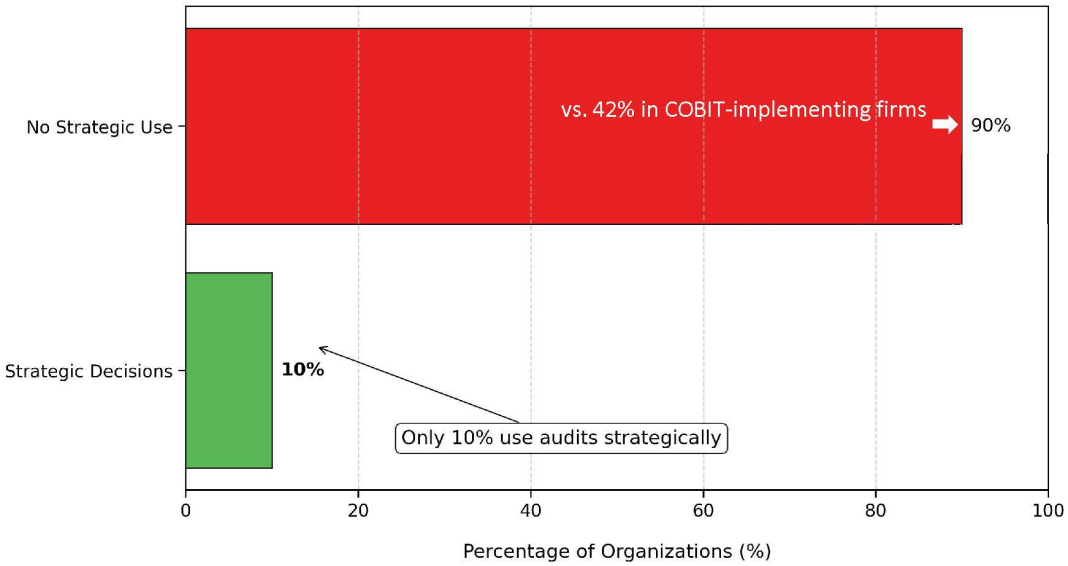
5. Discussion

The results of this research provide us with important information about the problems and challenges that come with updating audits as Costa Rica moves to Industry 5.0. The results show a big difference between theoretical frameworks and real-world use, especially when it comes to demographic factors, structural problems, and the adoption of new technologies. These findings not only agree with what has already been written on the subject, but they also make it possible to use this information in new economies, giving policymakers and practitioners clear steps to take.

5.1. Demographic influences on technological adoption

A lot of decision-makers are elderly (50% are 45 or older) and have a lot of expertise (65% have been in management for 10 years or more). This makes them less likely to adopt new technologies like blockchain and AI. This demographic trend is similar to how digital immigrants are hesitant across the world [33], but it has a bigger effect in Costa Rica, where just 8% of businesses use blockchain for audits. The fact that 76% of leaders are men makes this problem much worse, as having a variety of viewpoints is frequently important for encouraging new ideas [32]. These results show that

Figure 5
Utilization of audit data in strategic decision-making



Note: Error margin: ±4.3% at 95%

improving the skills of workers and promoting inclusive leadership are necessary to break down cultural and generational obstacles to the integration of Industry 5.0.

5.2. Structural deficiencies in audit practices

A shocking 71% of the firms examined do not have official audit departments. This shows that there are systemic problems with governance structures. This problem is made worse by the fact that just 10% of companies use audit data to make strategic decisions. Comparative research shows that Costa Rica's problems are similar to those in the rest of the region, such as regulatory fragmentation and lack of resources [6]. However, companies that use structured frameworks like COBIT have far better compliance rates (OR = 1.42, 95% CI [1.18–1.71]), which shows how important it is to have standardized audit methods to fill in institutional gaps.

5.3. Policy and technological pathways forward

The research finds three important steps that need to be taken to close the gap between existing practices and Industry 5.0 standards:

1) **Regulatory harmonization:** Bringing Costa Rica's rules in line with worldwide standards, like Mexico's IEEE norms, may save compliance costs by around 37% [20].
2) **Targeted upskilling programs:** Programs based on Spain's digital literacy initiatives might provide experienced workers with the skills they need to help people use technology [34].
3) **Solutions for small and medium-sized businesses:** Blockchain-as-a-service and modular AI tools are two good ways to get over financial and technological problems, especially for smaller businesses [36].

5.4. Theoretical and practical contributions

This study adds to the body of research by measuring the "experience-technology paradox" in audit processes and setting industry-specific standards for being ready for Industry 5.0. The adoption of a demographic audit framework (see Figure 5 [23]) gives us a new way to look at why people are against digital transformation. At the same time, proving that COBIT works in Latin America gives us real-world evidence that it can be used more widely [14].

5.5. Limitations and future directions

The study's stratified sample and limited population adjustment (SE=±4.3%) ensure that the internal validity is strong, but the cross-sectional design makes it hard to draw causal conclusions. Future studies should use longitudinal approaches to look at the long-term consequences of adopting new technologies and look at how cultural factors affect changes in organizations [30]. Also, looking at these results in the context of other rising economies might help put them in a bigger picture.

In short, this debate combines real-world data with theoretical and policy implications to answer the study's main question: what are the obstacles and alternatives for modernizing audits in Industry 5.0? The study lays the groundwork for both academic progress and real-world use by following academic standards.

6. Conclusions

This research gives us important information about the problems and challenges that come with updating audits as Costa Rica moves to Industry 5.0. The results show that there is still a gap between theoretical frameworks and actual applications. This gap has three main characteristics that need immediate attention from both researchers and practitioners.

First, the study finds a demographic contradiction in how people use technology. Having a lot of experienced experts in decision-making positions is good for institutional knowledge, but it seems to make it harder to use innovative technology. Older people are the most affected by this conflict between experience and innovation. This means that job transition programs need to find a

good balance between teaching new skills and keeping old ones. The fact that there aren't enough women in leadership roles makes this problem much worse. It might also restrict the range of ideas on how to incorporate new technologies.

Second, the problems with the way audits are set up make it hard for companies to be ready for Industry 5.0. The lack of established audit departments and the limited use of audit data for planning show that there are problems with how organizations are run. These results show how important it is to use standardized frameworks like COBIT, which show real benefits in compliance and operational efficiency. The differences in how quickly different sectors embrace new technologies make it even clearer that modern society needs customized solutions that take into account different resource levels and operational circumstances.

Third, the research shows how policy and technology may be used to help in specific ways. Regulatory harmonization is becoming an important tool for lowering compliance costs and encouraging new ideas. The success of blockchain and AI solutions in similar situations shows that they may work well in Costa Rica, especially when they are fitted to the country's specific institutional environment. These technologies not only help with current problems with operations, but they also provide the groundwork for long-term digital change.

The research's theoretical contributions go beyond the area where it was done. The research provides a way to look at digital transformation in other developing economies by measuring the experience-technology dilemma and setting standards for each industry. The demographic audit framework adds new ways to think about how organizations develop, while the confirmation of COBIT's efficacy in Latin American contexts gives us vital information for global audit literature.

These results have direct effects on what modern society can do. Policymakers should put regulatory modernization that meets worldwide standards at the top of their list of things to do, but they should also be aware of the limited resources in their area. Schools and professional organizations need to create focused upskilling programs that close the digital gap without lowering the value of current skills. On the other hand, technology companies should concentrate on making flexible, affordable solutions that meet the demands of SMEs and industries that need a lot of resources.

Future studies should expand on these foundations by doing long-term studies that look at the results of implementation and compare them across various developing economies. The modern society needs to pay special attention to the cultural aspects of technological resistance and the long-term impacts of programs that help workers move to other jobs.

In conclusion, this report not only identifies major problems with Costa Rica's digital transition, but it also gives a path based on evidence for how to fix them. The study provides important contributions to both academic debate and real-world implementation methods by combining thorough empirical analysis with practical policy recommendations. The results show how complicated the relationship is between human capital, institutional frameworks, and technical systems in making effective transitions to Industry 5.0 paradigms.

Ethical Statement

This study received ethical approval from the Institutional Review Board (IRB) at the Latin American University of Science and Technology (ULACIT), under approval number IRB-ULACIT-2024-078. All procedures involving human participants were conducted in accordance with the ethical standards and guidelines established by the committee. Informed consent was obtained from all participants prior to data collection, and no personally identifiable information was disclosed in the study.

Conflicts of Interest

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

Data Availability Statement

Data sharing is not applicable 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.

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