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RESEARCH ARTICLE

The Importance of Teleworking and Its Implications for Industry 5.0: A Case Study

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ABSTRACT Teleworking became popular in the 1970s as a response to the energy crisis resulting from the rise in oil prices, and its adoption increased exponentially during the COVID-19 pandemic as an isolation measure to avoid contagion and ensure business continuity. Industry 5.0 companies, among others, had to rapidly embrace teleworking during the pandemic, which involved taking risks such as allowing remote access to data and services without complete control over technical infrastructure and trusting employees to remain productive without direct supervision. This paper aims to explore the perceptions and expectations of Industry 5.0 employees about the adoption of teleworking under regular conditions after the pandemic, addressing concerns about productivity, supervision, cyberattacks, and potential additional investments. The objective is to provide comprehensive data that allow companies to make informed decisions about whether to continue teleworking in the future. It also presents a causal model that explains the intention to adopt teleworking and provides insights for managers of Industry 5.0 companies to make decisions related to this issue.

INDEX TERMS Teleworking, Industry 5.0, productivity, causal model, sustainability.

I. INTRODUCTION

The introduction of new technologies is driving human progress and creating a more secure, sustainable and intelligent society, resulting in the emergence of a new paradigm known as Industry 5.0. This industrial paradigm, which is an evolution of Industry 4.0, involves the integration of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain to enable collaboration between humans and machines, resulting in the development of human-centric solutions [1].

Fig. 1 illustrates the transition from Industry 4.0 to Industry 5.0, representing a pivotal shift in industrial evolution. Industry 4.0, known for its incorporation of IoT, AI, and

robotics, establishes intelligent factories that streamline operations and promote collaboration between humans and robots. In contrast, Industry 5.0 represents the subsequent stage, highlighting the integration of human intelligence with AI-driven industrial robotics. This shift marks a crucial moment in innovation management, focusing on interconnected systems where human creativity and decision-making improve flexibility. Industry 5.0 redefines robots as collaborative robots (cobots), turning them into valuable partners, and redirects the industrial emphasis from technology-driven to human-centered. The figure visually summarizes this progression, outlining the fundamental principles of both Industry 4.0 and the transformative principles of Industry 5.0.

Teleworking, a pivotal component within the Industry 5.0 framework, involves the execution of work tasks remotely, aligning seamlessly with this paradigm's principles. It stands

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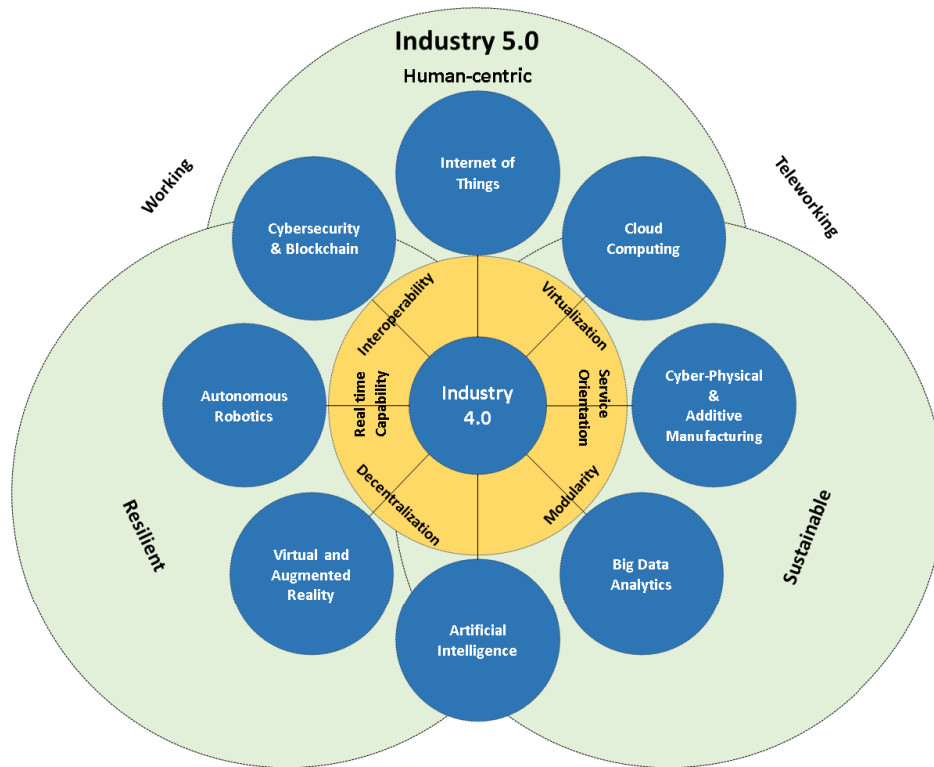


FIGURE 1. Teleworking framework for Industry 5.0.

out from other flexible work arrangements by emphasizing the use of teleworking technologies, including AI and IoT, to establish a distributed and adaptive work environment. In teleworking, employees use their creativity, decision-making, and problem-solving skills to enhance productivity, fostering a connection with smart factories. This shift aligns with EU policy principles outlined by researchers, emphasizing a people-centric perspective. This type of flexible work differs from conventional models, as it allows employees to operate from various locations while actively engaging in human-machine collaboration through advanced communication technologies [2]. Teleworking, within the context of Industry 5.0, is positioned as an advantageous element, offering various benefits consistent with the paradigm's core values and contributing to the harmonious integration of human intelligence and technological advancements [3].

As mentioned earlier, Industry 5.0 marks a transformative progression from Industry 4.0, prioritizing the symbiotic relationship between humans and machines in smart manufacturing. Unlike its predecessor, Industry 5.0 views robots as collaborative partners, or cobots, integrating human intelligence and encouraging adaptability within smart factories. Industry 5.0 accommodates both telework and non-telework scenarios, showcasing its flexibility in diverse work structures. The paradigm not only advances technological capabilities but also underscores values of sustainability and improved quality of life, reflecting a holistic approach to smart manufacturing evolution [4].

In this new scenario established by Industry 5.0, the concept of hybrid work takes on a transformative role, revolutionizing traditional approaches to work and redefining the workplace environment. Hybrid work, enabled by advanced digital technologies and human-centered manufacturing practices, seamlessly integrates remote work capabilities with on-site collaboration in manufacturing and industry settings. The adoption of a hybrid model of teleworking by companies is influenced by several factors. First, employee preferences play a crucial role, with flexibility in time and localization flexibility valued [5]. Second, the existence of a specific legislative framework on teleworking adopted by the authorities is important, as it positively relates to the level of adoption of teleworking [6]. Additionally, the availability of job resources, such as autonomy and emotional intelligence, can moderate the relationship between teleworking and performance, thereby influencing its adoption. Furthermore, the COVID-19 pandemic has significantly affected the concept of teleworking, making it a desired employee benefit and an essential part of the working environment even after the pandemic [7]. Finally, the practice and popularity of teleworking have expanded due to the pandemic, leading to the need for innovative ways to address organizational and employee needs in a hybrid work model context, such as resource availability, professional relationships, and technology [8].

In the context of contemporary work arrangements, Industry 5.0 represents a significant evolution in how

organizations structure their workforce and approach labor practices. Various work arrangements, such as platform-based labor, crowdsourcing, self-employment, voluntary work, participation in open-source projects, outsourcing, and consulting, challenge traditional working contracts by offering alternative employment models characterized by flexibility, autonomy, and collaboration. These arrangements often blur the lines between employees and independent contractors, prioritizing project-based work and skill-based contributions over fixed-term employment relationships. Teleworking, as a common feature across many of these arrangements, further enables individuals to work remotely, contributing to the flexibility and autonomy they seek. With teleworking, individuals can participate in platform-based labor, participate in crowd-sourcing initiatives, conduct self-employment ventures, contribute to open-source projects, and provide consulting or outsourcing services from anywhere, challenging the traditional notion of work confined to physical office spaces and fixed schedules [9], [10]. Teleworking improves efficiency and productivity by removing geographical limitations and allowing virtual collaboration without interruption. It also provides access to a wider talent pool, reduces the need for physical infrastructure, and encourages a healthier work-life balance. Additionally, teleworking is in line with Industry 5.0's sustainability objectives, as it reduces the environmental impact of commuting.

The SARS-CoV-2 pandemic required companies to embrace teleworking rapidly. This meant that they had to take risks that they would not have otherwise, such as allowing remote access to their data and services without having complete control over the technical infrastructure and the way of access and trusting their employees to remain productive despite the lack of direct supervision. For employees, teleworking posed a risk to their job security, as it could lead to fewer career advancement opportunities and less visibility to their supervisors.

After the lifting of restrictions and the return to normal operations, there has been a certain decrease in the application of teleworking. This implies that valuable information and experience gained during the confinement period, when teleworking was more prevalent than ever, is gradually being forgotten. As a consequence, it is important to explore the perceptions and expectations of employees about their intention to adopt teleworking under regular conditions after the pandemic. This work aims to address the concerns that Industry 5.0 companies may have about productivity, supervision, the risks of cyberattacks, and potential additional investments. In addition, it seeks to understand the expectations of Industry 5.0 workers regarding a possible reduction in the commuting to their usual places of work.

Previous studies have explored various aspects of teleworking-related issues. However, this research aims to integrate these findings through a model that explains the motivations behind adopting teleworking and its subsequent results. The objective is to provide comprehensive data that allow Industry 5.0 companies to make informed decisions

about whether to keep teleworking in the future and to use a specific methodology to investigate the effects of teleworking on Industry 5.0. This methodology involved detailed data collection through an online survey and analysis techniques that focused on examining trends and technologies related to teleworking on Industry 5.0. The approach used was structural equation modeling, and the results are assessed using Partial Least Squares (PLS) analysis.

The main contributions of this work are:

- Identifying the most significant factors impacting the decision to continue teleworking from the perspective of employers and employees in Industry 5.0.
- Defining a causal model that evaluates the possibility of integrating teleworking in Industry 5.0 after the COVID-19 pandemic.
- Analyzing the benefits and limitations of teleworking in the mark of the Industry 5.0 paradigm.

To our knowledge, there are no previous works that define a causal model to evaluate the integration of Teleworking in the Industry 5.0 paradigm.

This paper is organized as follows: Section II presents the review of the literature on teleworking, including an analysis of the motivations, advantages, and disadvantages of teleworking, as well as a summary of previous research and its key findings. Section III outlines the hypotheses to be tested and the proposed explanatory model to test these hypotheses. Section IV shows the experimental setup that was performed to evaluate the hypotheses based on different metrics. Section V provides an evaluation of the results, which includes an analysis of the reliability of the measurement model and the validation of the structural model. Finally, Section VII presents the conclusions of the analysis.

II. RELATED WORKS

The concept of teleworking was introduced in the 1970s as a response to the energy crisis caused by high oil prices [11]. It was proposed as a solution to mitigate the crisis by reducing commuting and fuel consumption. Similarly, since March 2020, when the World Health Organization declared COVID-19 a pandemic, teleworking has been suggested as a means of isolation to prevent contagion. Consequently, companies had to adopt teleworking in an emerging and improvised way to ensure business continuity. During periods of confinement, teleworking reached unprecedented levels of implementation.

The recent global health emergency has transformed the world into a genuine laboratory [12], experimenting with teleworking, which has been implemented in almost all sectors of production. In many cases, companies had to adapt to remote operations without proper prior preparation or access to all necessary technological and communication resources. Any necessary adjustments and improvements were made continuously as the pandemic unfolded. According to the International Labor Organization (ILO), this teleworking laboratory covered 17.4% of workers around the world, 25-30% of workers in Latin America, and 37% of teleworkers in Europe,

as reported by the European Foundation for the Improvement of Living and Working Conditions (Eurofound) [13].

Research has shown that teleworking can provide access to experts not available in the local area, reduce operational costs, improve productivity, reduce traffic congestion, reduce noise and carbon emissions [14], and improve the health and well-being of employees [15]. Thus, in [11] it was concluded that teleworking, among other benefits, has positively contributed to increased productivity, quality of life, environmental protection, and improved mobility. Similarly, the authors of [16] found that teleworking has advantages such as improved quality of life, work-family balance, increased productivity, better workload assessment, cost reduction, stress reduction, and reduced commuting time. The International Labor Organization, in the thematic paper for the Global Dialogue Forum on the Challenges and Opportunities of Teleworking for Workers and Employers in the Information and Communications Technology Services Sectors (ICTS) held in October 2016, identified increased productivity, reduced energy consumption and carbon footprint, improved staff morale, and significantly reduced travel times, among other benefits of teleworking [17].

It should be noted that teleworking has its drawbacks, such as isolation, stress, and the uncertain advantages of reducing traffic and pollution. Furthermore, some research has indicated that teleworking does not necessarily lead to a decrease in the number of trips [15]. Other disadvantages of teleworking, identified in the literature, include excessive stress or depression [18], feelings of exploitation, job insecurity, difficulty in adapting to teleworking, lack of connection with the company, professional isolation, and lack of recognition [16].

The potential for cybersecurity breaches is a commonly cited disadvantage of teleworking, as it often involves accessing organizational systems outside the company network. This risk is further increased by the increasing popularity of teleworking, which presents a significant challenge to companies to protect their data [19]. To gain a better understanding of the adoption of teleworking, researchers have developed theoretically based statistical models to explore different aspects of this phenomenon.

In Table 1, a systematic approach was utilized to select and present research articles. The inclusion criteria were based on their relevance to the research objectives, specifically focusing on studies that offer insights into the integration of technologies in the context of Industry 5.0 and teleworking. The selection of articles was justified by considering their methodological rigor, empirical evidence, and alignment with the research focus. These chosen articles were evaluated for their contributions to the field, emphasizing the gaps they addressed and the insights they provided. This work contributes to the existing knowledge by summarizing key findings, identifying trends, and presenting a comprehensive overview of the current research landscape in teleworking.

Employees during the pandemic-induced teleworking period experienced positive effects on organizational performance, work productivity, and work-life balance [25]. Flexible working hours, family time, and autonomy were seen as advantageous factors in the decision to telework [26]. Furthermore, teleworking during the pandemic was found to have a positive effect on social well-being, work-family balance, and task-technology fit, which in turn had a positive influence on teleworking performance [27]. Nevertheless, it is important to note that teleworking was not successful in terms of supervisor support and organizational trust [28].

Some previous works [29], [30] indicate that teleworking does not uniformly improve efficiency and productivity. Self-reported performance was higher for teleworking employees compared to those working in the ordinary workplace, but the extent of the change in performance depended on individual characteristics and the extent of teleworking practice in the organization [31]. Moreover, firms that engaged in teleworking had higher total factor productivity than those that did not [32]. However, the relationship between the extent of teleworking use and productivity was non-linear. Heterogeneous findings were identified regarding the effects of teleworking on work-life balance and psychological health, with moderating factors such as gender, boundary management strategies and frequency of teleworking that influence the results [33]. Performance seemed to benefit from teleworking, but certain factors like having pets, young children, or dependents could negatively affect it [34]. To achieve optimal outcomes, organizations should establish teleworking policies, provide support and technologies, and develop people management practices. Despite this, employees anticipated more work becoming telework-eligible in the new normal and welcomed this shift [35]. In conclusion, teleworking during the pandemic was seen as advantageous in terms of work-related outcomes and personal flexibility, but there were difficulties related to social integration and support from supervisors and organizations.

Consequently, this article aims to investigate critical factors that must be taken into account when introducing teleworking, such as productivity, cybersecurity, investments, and supervision, among others. Previous research has looked into these factors separately and studied their individual effects on the implementation of teleworking. However, this work intends to create a causal model that links these factors and evaluates their implications when teleworking is adopted in the context of Industry 5.0.

III. RESEARCH MODEL

The COVID-19 pandemic has caused a shift in the way people work, with teleworking becoming increasingly popular. Surveys have been conducted to assess the opinions of employees on the feasibility of continuing to work remotely in the post-pandemic era. Results vary between regions, with companies, employees, and governments having different views on a full return to in-person work, the continuation

TABLE 1. Research on teleworking through statistical modeling.

Title	Study conducted	Findings
For whom did teleworking not work during the Pandemic? understanding the factors impacting teleworking satisfaction in the US using a multiple indicator multiple cause (MIMIC) model. [20]	It links teleworking satisfaction with experienced and perceived benefits; and, barriers related to teleworking.	People of all ages face difficulties when it comes to teleworking, with younger and older people perceiving fewer benefits and more obstacles than those in the middle-age range. This implies that specific strategies should be employed, such as making on-site workdays mandatory for younger employees, providing technological assistance to older staff, and addressing concerns about social exclusion for all age groups.
The relationship between teleworking from home and employee health: a systematic review [21]	Relates teleworkers to their health status.	Employers should take advantage of the stress relief advantages of teleworking; however, those who need more social contact may be adversely affected. Additionally, teleworking can make it difficult to differentiate between work and personal life, which can lead to a constant feeling of being on the job, reducing autonomy, and having a negative effect on health.
COVID-19 and Beyond: Employee Perceptions of the Efficiency of Teleworking and Its Cybersecurity Implications. [22]	Examines the impact of perceptions of teleworking risks, changes in cyber attacks during teleworking, the ability of organizations to respond to cyber attacks, and key challenges in achieving an adequate response to cyber attacks.	Research identified key factors that affect the relationship between teleworking and organizational effectiveness, with varying levels of impact. It has been noted that there is a reciprocal connection with increased cyberattacks, which requires the implementation of defense strategies, investment in infrastructure, and ongoing training for employees. Teleworking is also acknowledged to be not suitable for certain industries and job roles in the COVID-19 era.
The adoption of remote work platforms after COVID-19 lockdown: New approach, new evidence. [12]	Investigates on the drivers influencing behavioral intentions and expectations to use remote work after COVID-19 confinement.	The post-closure adoption of remote work is explained by three main variables: behavioral intention, behavioral expectation, and facilitating conditions, with demographic characteristics and factors related to specific remote work features that moderate these relationships. Gender, generational gap, and behavioral trends must be considered to improve employee acceptance rates.
Teleworking at times of a pandemic: The role of voluntariness in the perception of disadvantages of teleworking [23]	Examines whether the voluntary nature of teleworking moderates the association between the amount of teleworking and perceptions of disadvantage.	Individuals who can choose remote work voluntarily report fewer disadvantages with increased teleworking. Findings suggest that autonomy in work execution is crucial, and employees being free to choose the amount of teleworking hours is significant. However, other factors, such as family, financial, and home work situation, may influence the perception of telecommuting disadvantages.
Work from Home or Bring Home the Work? Burnout and Procrastination in Brazilian Workers During the COVID-19 Pandemic [24]	Investigates the relationship between burnout and procrastination.	No differences in fatigue symptoms were observed between remote and in-person employees. Those working remotely showed higher levels of task procrastination. Research emphasizes the need for caution when interpreting the advantages of working from home, implying that its advantages are highly dependent on the work-life balance situation for employees.

of remote work, or the adoption of a hybrid model [13], [36], [37], [38]. Therefore, it is important to understand the expectations and opinions of employees on the possibility of continuing to work remotely in the future.

Fig. 2 shows the factors that, after the literature review, have been identified as the most emerging when adopting teleworking: cyberattacks, productivity levels, investment demand, worker supervision, and transportation requirements.

This research has used a deductive approach to compare pre- and post-pandemic expectations and perceptions of teleworking, particularly in Industry 5.0. The following subsections will discuss and create the research hypotheses of our approach.

A. PERCEPTION OF RISK OF CYBERATTACKS

The COVID-19 pandemic resulted in a sudden adoption of teleworking by companies, which prevented them from fully assessing the implications of this decision, particularly with respect to two crucial aspects: the capacity of the technological infrastructure and the acquisition of the skills necessary for employees to adapt to this mode of work. In response, technology and industry experts issued warnings to organizations and workers about the growing threat of cyberattacks around the world. The Federal Bureau of Investigation (FBI) reported a 600% increase in successful cyberattacks in the US and a 300% increase worldwide since the beginning of the COVID-19 pandemic. The increase in successful cyberattacks is believed to be related

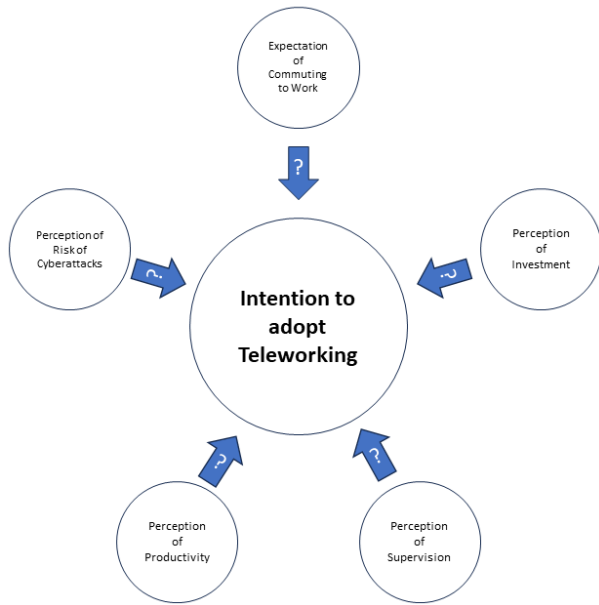


FIGURE 2. Expectations and Concerns of Adopting Teleworking.

to the increasing number of people working remotely [19], [39].

The lack of preparation of teleworkers for information security and cybersecurity issues, along with the abrupt adoption of teleworking due to the COVID-19 pandemic, has made them vulnerable to cyberattacks [39]. Cybercriminals have exploited the human factor, which accounts for 90% of unauthorized access incidents [19]. Based on this analysis, the following hypothesis is proposed:

- **H1:** The Perception of Risk of Cyberattacks (PRC) has a significant impact on the Intention to Adopt Teleworking (IAT).

B. PERCEPTION OF INVESTMENT

Industry 5.0 presents companies with a unique opportunity to invest in smart digital information and manufacturing technologies through the Internet. This highlights the critical importance of cybersecurity due to the growing threat of cybercrime. By investing in cybersecurity, companies can enhance their cyberdefenses, protect against potential cyberattacks, and differentiate themselves in the market.

On the other hand, it is important to remember that many home networks can be made up of outdated PCs and communication devices, which can be exploited by cybercriminals due to their vulnerabilities [40]. Therefore, those who opt to work remotely should consider investing in new equipment to complete their assignments.

As a result, our research aims to confirm the following hypothesis.

- **H2:** The Perception of Investment (PI) has a significant impact on the Perception of Risk of Cyberattacks (PRC).

Taking into account hypothesis H1, we also hypothesize that the Perception of Risk of Cyberattacks acts as a mediator variable, since it mediates the relationship between

the Perception of Investment in cybersecurity measures and the Intention to Adopt Teleworking. Thus, a greater investment in cybersecurity, which reduces the perceived risk of cyberattacks, enhances the intention to adopt teleworking. Employees may be more inclined to adopt teleworking if they perceive a lower risk of cyberattacks, which can be influenced by the company's investment in cybersecurity. As a consequence, our model will try to confirm that:

- **H2_a:** The Perception of Risk of Cyberattacks (PRC) acts as a mediator variable between the Perception of Investment (PI) and the Intention to Adopt Teleworking (IAT).

C. EXPECTATION OF COMMUTING TO WORK

Some previous works suggest that one of the benefits of teleworking is that employees do not have to commute from their homes to their offices, which can also reduce traffic congestion and environmental pollution [15], [41], [42]. Avoiding commuting can also lead to additional benefits, including savings in fuel, vehicle maintenance, insurance, parking, and reduced stress associated with driving during rush hour. These factors can be decisive when considering teleworking [11].

Therefore, Hypothesis H3 is proposed based on these considerations:

- **H3:** The Expectation of Commuting to Work (ECW) significantly influences the Intention to Adopt Teleworking (IAT).

D. INTENTION TO ADOPT TELEWORKING

It seems clear that the viability of teleworking depends on productivity, and companies depend on sustained production levels during remote work. At the same time, employees are tasked with providing goods and services in accordance with the quality and efficiency standards established by their respective companies.

Research indicates that teleworking provides advantages such as enhanced privacy, increased concentration, reduced interruptions, extended working hours, and flexible schedules, all of which can contribute to improvements in productivity [43]. However, some studies suggest that teleworkers may experience lower productivity levels compared to their office counterparts, where factors such as inadequate communication, infrastructure, or teleworking configuration may affect this decrease in productivity [44]. This requires a thorough analysis of the decisions for the adoption of teleworking from the perspective of productivity at work prior to implementation, as emphasized in [45] and [46]. Accordingly, the following hypothesis is proposed:

- **H4:** The Perception of Productivity (PP) significantly influences the Intention to Adopt Teleworking (IAT).

E. PERCEPTION OF PRODUCTIVITY

Examining employee productivity is a critical aspect in understanding organizational effectiveness and performance, particularly in Industry 5.0. In addition, this productivity

must be achieved in accordance with the information security and cybersecurity policies of companies. This situation occasionally becomes a dilemma since, on the one hand, security controls may restrict access to information and services required to perform their tasks. On the other hand, it is not possible to access information without meeting the established minimum security standards. This duality creates a conflict that has a direct impact on workers' productivity levels.

Posey and Canham [47] conducted a study to investigate the relationship between productivity and compliance with cybersecurity policies in organizations. They observed that organizations that prioritize productivity over security are more likely to have a higher rate of non-compliance with security policies, while those that prioritize security over productivity may experience delays in work. Similarly, in [19] was found that workers were willing to take cybersecurity risks, including those related to cybersecurity, to gain the advantages of teleworking. As a result, based on the analysis, the following hypothesis is proposed:

- **H5:** The Perception of Productivity (PP) significantly influences the Perception of Risk of Cyberattacks (PRC).

F. PERCEPTION OF SUPERVISION

Supervision is a key factor in achieving optimal results from teleworkers, as suggested in [48]. Employees must be supervised to ensure that their efforts contribute to the production of goods or services for which they were hired. Studies on productivity in teleworking have revealed that inadequate supervisor support and lack of clear instructions can make teleworkers feel isolated, exploited and unmotivated, thus reducing their productivity [44].

For this reason, companies should implement performance evaluation systems that focus on results rather than on the employee behavior during task execution, which has been the conventional approach for office workers [48]. Supervision is a crucial way to give telecommuters a sense of support, which can lead to increased motivation and the maintenance of productivity. Consequently, this analysis suggests the following hypothesis:

- **H6:** The Perception of Supervision (PS) significantly influences the Perception of Productivity (PP).

Taking into account hypothesis H4, we hypothesize that the Perception of Productivity acts as a mediator variable, since it mediates the relationship between the Perception of Supervision and the Intention to Adopt Teleworking. Thus, an increased perception of productivity due to higher supervision leads to a greater intention to adopt teleworking, as employees feel they can be effective even when working remotely. As a consequence, our model will try to confirm that:

- **H6_a:** The Perception of Productivity (PP) acts as a mediator variable between the Perception of Supervision (PS) and the Intention to Adopt Teleworking (IAT).

Fig. 3 shows the theoretical model of structural equations proposed for our research, where the latent variables (constructs) are represented with circles and the predictive relationships between variables are represented with arrows.

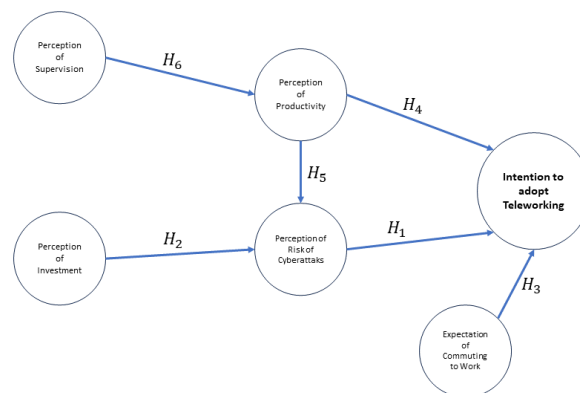


FIGURE 3. Proposed Research Model.

As can be seen, the proposed model is more complex than a regression model since certain variables act as both predictor and dependent variables.

IV. EXPERIMENTAL SETUP

A. DATA ANALYSIS METHOD

The present study utilizes PLS-SEM (partial least squares structural equation modeling) as the technique to validate the proposed model. PLS-SEM is a popular approach to causal-predictive analysis, especially in the early stages of research, when theoretical knowledge may be limited and the problems analyzed are complex [49]. In terms of sample size, PLS-SEM is designed for small sample sizes, but it is suggested that the sample size is at least equal to the number of connections between latent variables (constructs) in the model [50]. For a model consisting of six relationships, as in the present study (see Fig. 3), the minimum suggested sample size is 75.

1) METRICS FOR THE MEASUREMENT MODEL

The model evaluation is conducted through: (i) internal consistency (Cronbach's alpha and composite reliability); (ii) convergent validity (average variance extracted (AVE) and factor loadings); (iii) discriminant validity (Fornell-Larcker criterion, Heterotrait-Monotrait ratio (HTMT), and cross-loadings between indicators and latent variables).

α : CRONBACH'S ALPHA AND COMPOSITE RELIABILITY

These metrics are used to determine whether the sample is free of bias or whether the responses are dependable. Specifically, *Cronbach's alpha* α (1) and *Composite Reliability* ρ_c (2) measure the consistency of the items on the scale, and it is recommended to have values of at least 0.7 [49].

$$\alpha = \frac{k}{k-1} \left[1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right] \quad (1)$$

where:

- k : Number of items.
- σ_i^2 : Variance of each item.
- σ_i^2 : Variance of the sum of items.

$$\rho_c = \frac{[\sum \lambda_i]^2}{[\sum \lambda_i]^2 + \sum_i(1 - \lambda_i^2)} \quad (2)$$

where:

- λ_i : Factor loadings of each indicator on each latent variable.

b: CONVERGENT VALIDITY

Convergent validity assesses whether a set of indicators represents a single underlying construct. This is determined by the Average Variance Extracted (AVE) of each construct (3), with a recommended threshold of 0.5 [51].

$$AVE = \frac{\sum_i \lambda_i^2}{\sum_i \lambda_i^2 + \sum_i(1 - \lambda_i^2)} \quad (3)$$

c: DISCRIMINANT VALIDITY

Discriminant validity is used to measure the extent of divergence between model constructs. This is done through techniques such as Fornell-Larcker, Heterotrait-Monotrait, and cross-loadings between indicators and latent variables [52]. The Standardized Root Mean Square Residual (SRMR) is a measure for assessing observed and predicted correlations (4). An SRMR value of zero implies a perfect fit, while a value below 0.08 is considered a good fit.

$$SRMR = \sqrt{\frac{1}{n} \sum_i (\lambda_i - \hat{\lambda}_i)^2} \quad (4)$$

where:

- λ_i : Value of the dependent variable of observation i .
- $\hat{\lambda}_i$: Value approximated by the regression model for observation i .

2) METRICS FOR THE STRUCTURAL MODEL

To validate the structural model, the following hypothesis tests have been used: (i) Coefficient of Determination; (ii) Path Coefficients; (iii) Effect Size.

a: COEFFICIENT OF DETERMINATION

This test evaluates if the variance of the internal variables is explained by the prediction constructs, using the coefficient of determination (R^2) (5). The value of R^2 is expected to be greater than 0.1 [53].

$$R^2 = 1 - \frac{\sum_i (\lambda_i - \hat{\lambda})^2}{\sum_i (\lambda_i - \bar{\lambda})^2} \quad (5)$$

where:

- λ_i : Value of the dependent variable of observation i .
- $\hat{\lambda}_i$: Value approximated by the regression model for observation i .
- $\bar{\lambda}$: Mean of the dependent variable of all observations.

b: PATH COEFFICIENTS

The evaluation of the path coefficients (β) examines whether the predictor variables have a significant effect on the variance of the endogenous variables (R^2). Endogenous variables are dependent variables because they correlate with other factors. A β value of 0.2 or higher is generally considered significant. To determine the significance non-parametrically, bootstrapping and t -Student values are used.

c: EFFECT SIZE

The effect size (f^2) (6) is a measure of the impact of a predictor variable on the variance of endogenous variables (R^2) when removed from the model. According to Cohen’s guidelines, an f^2 value of more than 0.02 is considered small, one of 0.15 or higher is considered medium, and one of 0.35 or higher is considered large. The effect size is calculated as:

$$f^2 = \frac{R^2}{(1 - R^2)} \quad (6)$$

B. DATA SOURCE

Once the model was defined and the hypotheses were established, the next step was to identify the indicators that would help measure the defined constructs. A survey of 25 questions was prepared using a Likert scale of 1 to 5 points. The survey is presented in Table 2, where the mean value of the responses and their standard deviations are also provided.

The number of indicators used to validate both the measurement model and the structural model are presented in Table 3.

The information for this research was obtained by conducting a survey using a web-based questionnaire that the participants completed on their own. The survey was carried out in Ecuador within 3 months between January to March 2023 and distributed to employees of companies that have adopted the Industry 5.0 paradigm, equally divided between those who worked remotely and those who did not.

Participants were recruited through company email lists and social media platforms. Furthermore, the survey gathered data from a wide variety of participants, encompassing different demographics such as company size (classified as small, medium, and large), job roles (including engineers, data analysts, project managers, software developers, and supply chain managers), and nationality (encompassing Ecuadorian-owned companies, international organizations with branches in Ecuador, multinational corporations with local manufacturing facilities, and joint ventures in Industry 5.0 technologies).

From more than 1000 questionnaires distributed, a total of 505 responses could be obtained, consisting of 47% female and 53% male participants. Table 4 summarizes the characteristics of the respondents. The age distribution of the respondents and the corresponding proportions within the sample are as follows: 15-24 years old (4%), 25-34 years old (27%), 35-44 years old (37%), 45-55 years old (27%)

TABLE 2. Questions and statistics collected.

Code	Construct / Indicator	Mean	Standard deviation
Perception of Risk of Cyberattack			
PRC-1	Do you know what cyberattacks are?	3.403	0.930
PRC-2	Do you know of any way to avoid cyberattacks?	3.018	1.054
PRC-3	How frequent do you consider Internet theft or fraud to be?	3.885	0.794
PRC-4	Have you been a victim of electronic theft or fraud?	3.562	0.818
Intention to Adopt Teleworking			
IAT-1	Would you consider accepting a telecommuting job?	4.188	0.888
IAT-2	Do you believe that teleworking diminishes opportunities for promotion or career growth?	3.885	1.102
IAT-3	Which mode of teleworking do you find most convenient: None, Per Diem, Occasional, Part-time, or Full-time?	3.774	1.132
IAT-4	Do you think that teleworking helps improve your quality of life?	3.732	1.007
IAT-5	Do you think that local or national governments should encourage companies to adopt teleworking?	3.924	1.063
Expectation of Commuting to Work			
ECW-1	If the commute time to your workplace is long, would you opt for teleworking?	3.953	1.121
ECW-2	Does teleworking reduce your need to travel to other locations?	4.026	0.998
ECW-3	Do you consider that the adoption of teleworking changes travel patterns both at the individual and family level?	3.900	1.066
ECW-4	Do you think that teleworking reduces the stress of driving during rush hours?	3.959	1.100
Perception of Investment			
PI-1	Do you consider teleworking to mean investing in a planned environment that provides a reasonable place to work?	3.624	0.910
PI-2	Do you consider that teleworking involves investing in the necessary equipment for teleworking?	3.594	0.942
PI-3	Do you consider that teleworking means greater investment in technological infrastructure for companies?	3.491	1.078
PI-4	Do you believe that your company's investments in technology infrastructure make it more secure and reliable?	3.744	0.950
Perception of Productivity			
PP-1	In the teleworking modality, have you complied with the agreed times to achieve the established goals?	4.079	0.989
PP-2	Do you think you perform better when working remotely than in your office?	3.324	1.186
PP-3	How would you rate your work performance in the teleworking mode?	3.679	0.997
PP-4	Do you consider that in the teleworking modality you achieve a better concentration in the development of work activities?	3.432	1.168
Perception of Supervision			
PS-1	Do you consider that in your company there is supervision based on the achievement of objectives?	3.712	1.068
PS-2	Do you think that your company uses appropriate and objective measures or metrics to assess achievement and performance?	3.318	1.062
PS-3	In teleworking mode, are frequent updates on the status of the work received or delivered?	3.594	1.068
PS-4	Has your company developed profiles of employees who can telework?	2.929	1.322

TABLE 3. List of Constructs.

Constructs	Acronym	No. of Indicators
Perception of Risk of Cyberattacks	PRC	4
Intention to Adopt Teleworking	IAT	5
Expectation of Commuting to Work	ECW	4
Perception of Investment	PI	4
Perception of Productivity	PP	4
Perception of Supervision	PS	4
	Total	25

and older than 56 years (5%). The company size distribution shows a preference for larger companies, which may indicate a higher participation from well-established firms. The education level and computer skills suggest that many participants are highly educated, which is consistent with

the demands of Industry 5.0 workforce. The industry sector shows a varied distribution among sectors, acknowledging a slight advantage for technology due to the emphasis on advanced technologies in Industry 5.0.

Regarding the acceptance of teleworking as a modality for performing work activities, 5% of the respondents stated that they would not accept it, 21% were undecided, and 74% expressed acceptance without any additional consideration. These preliminary results demonstrate a high level of acceptance for teleworking, even though mobility and isolation restrictions were lifted in Ecuador in February 2022.

The demographic and professional characteristics of the respondents provide a rich dataset to explore the complexities of teleworking acceptance in the context of Industry 5.0. The diversity in company size, industry sector, age, gender, education level, and computer skills allows for a detailed

TABLE 4. Characteristics of Survey Participants (n=505).

Variable	Category	Count (Percentage)
Gender	Male	268 (53%)
	Female	237 (47%)
Age	15-24 years	20 (4%)
	25-34 years	136 (27%)
	35-44 years	187 (37%)
	45-55 years	137 (27%)
	Older than 56 years	25 (5%)
Company Size	Small (1-50 employees)	115 (23%)
	Medium (51-250 employees)	180 (36%)
	Large (251+ employees)	210 (42%)
Education Level	High School Diploma	55 (11%)
	Bachelor's Degree	220 (44%)
	Master's Degree	175 (35%)
	PhD or higher	55 (11%)
Computer Skills	Basic	130 (26%)
	Intermediate	210 (42%)
	Advanced	165 (33%)
Industry Sector	Manufacturing	130 (26%)
	Technology	140 (28%)
	Services	110 (22%)
	Research & Development	60 (12%)
	Other (Include logistics, etc.)	65 (13%)

analysis of how different factors influence teleworking practices. These insights are essential for tailoring strategies to enhance teleworking implementation and acceptance effectively across various segments of the workforce.

Finally, it should be noted that the survey, as said earlier, was answered by 505 employees, which is more than the suggested minimum sample size of 75 for a model with six connections, as stated in Section IV-A.

V. RESULTS

A. EVALUATION OF THE MEASUREMENT MODEL

The model was computed using the least square-based structural equation model in SmartPLS 3.0. The data were analyzed in two steps. First, the measurement model was evaluated to determine the reliability and validity of the operational measurements. The relationship between the underlying structures was then confirmed. Confirmation factors were considered to evaluate the effectiveness and reliability of external models.

The internal consistency of the constructs was validated using Cronbach's Alpha (α) and Composite Reliability (ρ_c) indexes. As mentioned above, it is recommended that both indexes have at least a value of 0.7 to be acceptable [54], [55]. The results presented in Table 5 indicate that all the constructs of the model exceed the suggested values. This indicates that the constructs show internal validity and can be considered reliable.

Furthermore, the convergent validity of the constructs was assessed in order to determine whether a set of indicators represents a single underlying construct. This evaluation involved calculating the average variance extracted (AVE) for each construct, following the recommendation of [51], who suggested a value greater than 0.5. The results, also presented in Table 5, indicate that the AVE for all constructs exceeds the recommended threshold, which implies that the constructs

account for at least 50% of the variance in their respective indicators.

TABLE 5. Reliability and Validity Indicators.

Constructs (Acronym)	Cronbach's Alpha (α)	Composite reliability (ρ_c)	Average variance extracted (AVE)
ECW	0.826	0.884	0.657
IAT	0.858	0.898	0.640
PI	0.775	0.855	0.597
PP	0.852	0.900	0.692
PRC	0.783	0.860	0.607
PS	0.833	0.885	0.659

The external loadings of the indicators were evaluated to assess the convergent validity. This parameter reflects the relationship between the indicator and its constructs and should be greater than 0.707 [56]. Table 6 presents the values obtained, which all exceed the suggested threshold, suggesting that the indicators of the constructs are related.

In the subsequent analysis, the discriminant validity will be assessed to determine the degree of differentiation between the model constructs. This evaluation will employ the Fornell-Larcker method, the Heterotrait-Monotrait (HTMT) method, and an examination of the cross-loadings between indicators and latent variables. First, the Fornell-Larcker method proposes that the square root of AVE should be greater than the correlation maintained with any other construct [57]. Table 7 shows that the square root of the mean variance extracted from a construct is greater than the value of the constructs with which it correlates, indicating that all constructs are different.

Following the Heterotrait-Monotrait (HTMT) method, the recommended threshold is not to exceed a value of 0.85 [58]. Table 8 shows that all constructs meet this criterion, thus indicating that the constructs have sufficient differentiation.

Then, as proposed by Virtaneva et al. [59], the cross-loadings method suggests that factor loadings should be higher with their respective variables than with others in the model. In Table 6, it is evident that the cross-factorial loadings of indicators within each construct exceed the loadings of indicators associated with other constructs.

Finally, the Standardized Root Mean Square Residual (SRMR) helps to evaluate the agreement between observed and predicted correlations. A value of zero indicates a perfect fit, and a value below 0.08 is considered a good fit [60]. The value obtained of 0.072 suggests that the proposed model is satisfactory.

B. EVALUATION OF THE STRUCTURAL MODEL

After verifying that the measurement model meets the reliability and validity criteria, the structural model will be evaluated. Fig. 4 shows the calculated values of the coefficients of determination (R^2), the path coefficients (β) and the t -student parameter, which will be used to assess the structural model proposed in this study.

The coefficient of determination R^2 provides information on the proportion of variance in endogenous variables that

TABLE 6. Cross Factorial Loadings.

Constructs/Indicators	ECW	IAT	PI	PP	PRC	PS
ECW-1	0.886	0.701	0.357	0.651	0.392	0.345
ECW-2	0.792	0.480	0.244	0.492	0.270	0.257
ECW-3	0.744	0.475	0.344	0.463	0.303	0.230
ECW-4	0.813	0.607	0.263	0.579	0.348	0.288
IAT-1	0.495	0.735	0.315	0.504	0.582	0.334
IAT-2	0.683	0.880	0.349	0.630	0.493	0.338
IAT-3	0.457	0.746	0.250	0.500	0.361	0.303
IAT-4	0.596	0.843	0.294	0.599	0.416	0.269
IAT-5	0.588	0.785	0.253	0.637	0.358	0.234
PI-1	0.315	0.315	0.831	0.195	0.271	0.131
PI-2	0.198	0.164	0.737	0.078	0.224	0.100
PI-3	0.289	0.301	0.750	0.210	0.246	0.173
PI-4	0.335	0.334	0.769	0.270	0.287	0.296
PP-1	0.527	0.577	0.201	0.810	0.266	0.348
PP-2	0.570	0.629	0.196	0.824	0.324	0.260
PP-3	0.551	0.602	0.246	0.858	0.336	0.312
PP-4	0.629	0.593	0.192	0.837	0.298	0.309
PS-1	0.348	0.308	0.198	0.317	0.174	0.826
PS-2	0.213	0.240	0.184	0.224	0.227	0.843
PS-3	0.319	0.373	0.217	0.389	0.304	0.844
PS-4	0.212	0.220	0.133	0.190	0.207	0.727
PRC-1	0.350	0.427	0.272	0.266	0.850	0.256
PRC-2	0.315	0.417	0.234	0.269	0.794	0.239
PRC-3	0.271	0.393	0.276	0.274	0.712	0.123
PRC-4	0.338	0.476	0.260	0.330	0.755	0.269

TABLE 7. Square Root of the Average Variance Extracted (AVE).

Constructs	ECW	IAT	PI	PP	PRC	PS
ECW	0.810					
IAT	0.712	0.800				
PI	0.374	0.367	0.773			
PP	0.684	0.722	0.251	0.832		
PRC	0.411	0.553	0.335	0.368	0.779	
PS	0.351	0.369	0.233	0.368	0.287	0.812

is explained by the constructs that predict the variable. The values obtained are presented in Table 9. All coefficients for endogenous variables exceed 0.1, as recommended [61]. This confirms that the constructs that predict the endogenous variables in our model effectively account for their variance.

Hypotheses were tested by analyzing the direct path coefficients β , and the results are presented in Table 10. It should be noted that all coefficients $\beta \geq 0.2$, as recommended [62]. Therefore, it can be inferred that the predictor variables contribute significantly to the variance of the endogenous variables.

TABLE 8. Heterotrait-monotrait ratio (HTMT).

Constructs	ECW	IAT	PI	PP	PRC	PS
ECW						
IAT	0.822					
PI	0.459	0.441				
PP	0.804	0.841	0.300			
PRC	0.502	0.673	0.427	0.448		
PS	0.395	0.415	0.271	0.408	0.342	

The hypotheses were also subjected to testing through bootstrapping analysis. This technique assesses the

TABLE 9. Coefficient of determination R^2 .

Constructs	R^2
Perception of Risk of Cyberattacks	0.135
Perception of Investment	0.112
Expectation of Commuting to Work	0.507
Intention to Adopt Teleworking	0.616
Perception of Productivity	0.136
Perception of Supervision	0.187

significance of the structural model regressions [63], using a two-tailed t -student test with a significance level of 5%. With 5000 degrees of freedom (the sampling value utilized), the critical value of t is 1.96, which is lower than the empirical t -student values shown in Table 10. Consequently, all hypotheses have a considerable effect on their related latent variables and are strongly supported.

TABLE 10. Contrast of Hypotheses.

Hypothesis	β	t -student	Results
H1	0.333	7.374	Supported
H2	0.635	7.710	Supported
H3	0.712	20.431	Supported
H4	0.599	15.206	Supported
H5	0.368	7.724	Supported
H6	0.368	7.461	Supported

Finally, as mentioned above, the effect size (f^2) is a measure that indicates whether a predictor variable has a small, medium, or large effect upon removal. This, in turn, influences the variance of the endogenous variables. Table 11 presents the effect size values for our model.

From these results, hypotheses H3 and H4 have a large effect on the endogenous variables if they were removed, hypotheses H1, H5, and H6 have a medium effect if removed, and H2 has a small effect.

Let us analyze now the mediating effects of the Perception of Productivity and the Perception of Risk of Cyberattacks on the Intention to Adopt Teleworking. Table 12 shows the results.

For hypothesis H2_a the indirect path coefficient is $0.368 \times 0.599 = 0.220$, while for hypothesis H6_a the indirect path coefficient is $0.635 \times 0.333 = 0.211$, having both $\beta \geq 0.2$, as recommended. The t -student values are calculated as Indirect effect/Standard deviation. After analyzing their values, both hypotheses involving mediating effects are empirically supported.

C. DISCUSSION OF THE RESULTS

The research model was formulated based on the expectations related to the adoption of teleworking in Industry 5.0, including factors such as productivity and commuting to work. Furthermore, the model includes aspects related to potential influencing factors in the adoption of teleworking, such as cybersecurity, investment considerations, and strategies used to supervise teleworkers.

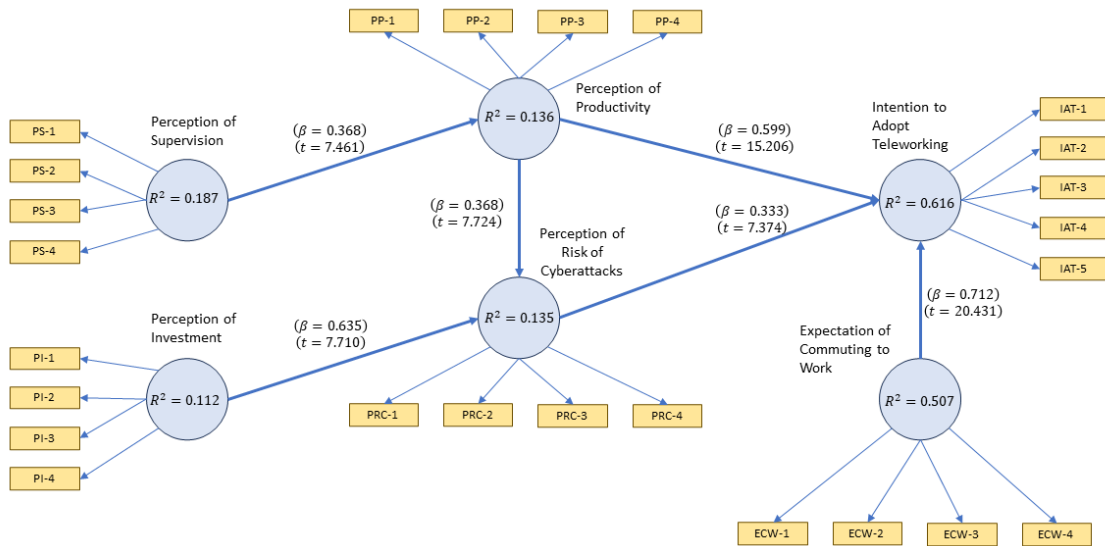


FIGURE 4. Structural Model Coefficients.

TABLE 11. Effect Size values.

Hypothesis	f ²	Effect
H1	0.249	Medium
H2	0.127	Small
H3	1.030	Large
H4	0.809	Large
H5	0.157	Medium
H6	0.157	Medium

TABLE 12. Contrast of Mediating Effects.

Hypothesis	Indirect effect β	Standard deviation	t-student	Results
H2 _a	0.220	0.057	3.859	Supported
H6 _a	0.211	0.034	6.205	Supported

Under this context, the validation of the measurement model and the assessment of the structural model revealed that all constructs are reliable, and all hypotheses are supported. This implies that the model is considered adequate.

Based on the values obtained for the coefficient of determination (R²), it can be inferred that:

- The model suggests that half of the employees willing to telework are motivated by the expectation of reducing the number of trips to work.
- The intention to adopt teleworking is explained by the model in 61%, suggesting that more than half of workers inclined to teleworking believe that an investment in cybersecurity by their companies will increase their productivity and protect them from cyberattacks.
- The perception of investment is explained by the model in 11%, which means that this percentage of employees anticipates investments in security-related matters.
- The model showed that around 13% of the employees perceive that supervision leads to an increase in their productivity.

- The model suggests that 13% of workers believe that security measures will not have a negative impact on productivity when it comes to the risk of a cyberattack.

With this background, the results of the study are discussed below.

1) HYPOTHESIS H1: THE PERCEPTION OF RISK OF CYBERATTACKS HAS A SIGNIFICANT IMPACT ON THE INTENTION TO ADOPT TELEWORKING

The statistical results show that the perception of risk of cyberattacks significantly influences the intention to adopt teleworking (β = 0.333) and that if this relationship is removed from the model, there would be a medium effect (f² = 0.249) on the intention to adopt teleworking.

This construct was designed to measure the level of knowledge and understanding that employees have regarding cybersecurity issues. With the increased risk of cyberattacks when working remotely, especially when workers access systems and information through unprotected devices and networks, it is essential to assess employees' awareness of the potential risks they may encounter.

In addition, flexible working hours allow employees to relocate and carry out their tasks in various settings, such as shared workspaces, cafeterias [64], or libraries [65]. In many cases, this practice involves connecting to the office through public networks, which often lack adequate security controls [19].

The analysis showed that the mean values of the indicators used to measure the perception of cyberattacks were between 3 and 4 on the Likert scale. This implies that the respondents had a limited to moderate understanding of cybersecurity and the risks associated with online activities and transactions. This could point to a lack of knowledge among respondents in terms of security issues. Therefore, companies should consider taking steps to address any identified security gaps.

2) HYPOTHESIS H2: THE PERCEPTION OF INVESTMENT HAS A SIGNIFICANT IMPACT ON THE PERCEPTION OF RISK OF CYBERATTACKS

In this case, the statistical findings indicate a significant influence of the perception of investment on the perception of risk of cyberattacks ($\beta = 0.335$). Furthermore, it should be noted that omitting this relationship from the model would have a small impact ($f^2 = 0.127$) on the perception of risk of cyberattacks.

Companies have experienced significant losses due to cybercrime during the pandemic, particularly in the context of teleworking. The estimated losses can be attributed to various types of cyberattacks such as phishing, malware, social engineering, and ransomware attacks. The increase in remote work and digital processes has made individuals and organizations more vulnerable to these attacks [66], [67]. The COVID-19 crisis has created opportunities for hackers to target individuals and companies, leading to economic losses and data breaches [68]. The use of new platforms and technologies, while facilitating remote work, has also loosened physical and technical safeguards, making it easier for cybercriminals to exploit vulnerabilities. Companies must implement well-defined software upgrade procedures, use secure networks, and conduct regular penetration tests to protect against cyberattacks. However, there is a need for increased action and investment in the implementation of cybersecurity solutions to mitigate risks.

Consequently, companies find it imperative to invest in security solutions to effectively combat cybercriminals. This aspect was one of the topics presented to the respondents in the survey (see Table 2). Based on the values of their responses, they expressed the opinion that companies should invest further to ensure the security of teleworking. From the results in Table 12, the Perception of Risk of Cyberattacks has a mediating effect on the relationship between the Perception of Investment and the Intention to Adopt Teleworking (Hypothesis H2_a). Employees may hesitate to embrace teleworking if they perceive significant cybersecurity risks, regardless of the investments made by the organization. Therefore, when implementing teleworking, it is essential to take into account investments in cybersecurity. These investments should be seen as part of the overall investments in technology that companies make to keep their technology up-to-date. This increased investment is often seen as necessary to mitigate risks and protect organizational assets [69].

3) HYPOTHESIS H3: THE EXPECTATION OF COMMUTING TO WORK SIGNIFICANTLY INFLUENCES THE INTENTION TO ADOPT TELEWORKING

The statistical results indicate a significant influence of the expectation of commuting to work on the intention to adopt teleworking ($\beta = 1.030$). Furthermore, removing this relationship from the model would have a substantial effect ($f^2 = 0.712$) on the intention to adopt teleworking.

The results of the survey align with the idea of adopting teleworking, with average responses between 4 and 5. This indicates a strong desire to embrace telecommuting, mainly due to the expectation of reducing trips to physical offices. These results confirm Hypothesis H3 and align with the findings obtained by some researchers on the possibility that teleworking has the potential to be a game-changer for sustainable mobility, especially in cooperation with local companies [70]. A research carried out in Japan found that a significant number of non-telecommuters expressed a desire to switch to teleworking, and the number of workers who wanted 100% teleworking increased. Socioeconomic and demographic characteristics were found to strongly influence the choice between commuting and ICT-based work [71].

A survey of small and medium businesses conducted by [72] showed that 83.33% of the participants saw a decrease in travel as a benefit of teleworking. This is in line with the results of our research, which sought to determine if employees viewed the reduction in travel as an advantage of teleworking.

In addition, studies have shown that avoiding commuting during peak hours can lead to lower stress levels, which can improve the overall well-being of employees [73]. This is beneficial for both employers and employees [43]. Additionally, the perception of commuting under the teleworking mode not only benefits the individual worker; it also helps address larger issues faced by cities, such as traffic congestion and air pollution [74].

4) HYPOTHESIS H4: THE PERCEPTION OF PRODUCTIVITY SIGNIFICANTLY INFLUENCES THE INTENTION TO ADOPT TELEWORKING

The implementation of teleworking has been found to have a positive impact on productivity. The statistical results show that the perception of productivity has a significant effect on the intention of adopting teleworking ($\beta = 0.599$). Moreover, if this relationship were removed from the model, it would have a considerable impact ($f^2 = 0.809$) on the intention to adopt teleworking.

The survey responses yielded mean values between 3 and 4, suggesting that employees who adopted teleworking perceived themselves as productive. This is consistent with the advantages that some researchers have come to determine, where studies have shown that companies that engage in teleworking have higher Total Factor Productivity than those that do not [32]. Additionally, teleworkers who use strategies such as task-oriented working, having a productive attitude, and using modern communication technology for social contact tend to have better job performance [75].

However, it is important to note that the implementation of teleworking strategies varies between individuals and that there may be differences in the association between the implementation of the strategy and the performance. Major Japanese IT companies have faced challenges in effectively using teleworking to improve productivity, highlighting the

need to redesign the working environment surrounding teleworking [76]. In addition, the availability of digital resources and remote leadership has been found to positively impact teleworking productivity.

5) HYPOTHESIS H5: THE PERCEPTION OF PRODUCTIVITY SIGNIFICANTLY INFLUENCES THE PERCEPTION OF RISK OF CYBERATTACKS

The statistical results indicate that the perception of productivity has a significant effect on the perception of risk of cyberattacks ($\beta = 0.368$). Moreover, removing this variable from the model would result in a medium effect ($f^2 = 0.157$) on the perception of cyberattack risk. These results support the hypothesis that when productivity is prioritized over security, employees may disregard established security protocols and regulations [47]. This behavior, which may be motivated by the need to achieve certain productivity goals in companies, can result in a greater risk of cyberattacks.

Recent studies have demonstrated that teleworking can have an effect on how employees perceive the efficiency and security of their organization [22]. Successful telecommuting projects have been found to be related to interactions between telecommuters and their supervisors, and their perception of productivity [77]. However, teleworking can also present challenges in terms of information security and cyber threats, which can affect productivity and job satisfaction [78]. Therefore, it is important for organizations to have effective risk control systems to reduce risks and ensure productivity in teleworking environments.

6) HYPOTHESIS H6: THE PERCEPTION OF SUPERVISION SIGNIFICANTLY INFLUENCES THE PERCEPTION OF PRODUCTIVITY

In this last hypothesis, the statistical results reveal that the perception of supervision significantly influences the perception of productivity ($\beta = 0.368$). If this variable were removed from the model, it would have a medium effect ($f^2 = 0.157$) on the perception of productivity. This hypothesis confirms that, in teleworking mode, supervision plays a crucial role in maintaining adequate levels of productivity. To achieve this, it is essential to define clear goals and objectives for workers to achieve.

The mean values of the supervision indicators, which range from 3 to 4, suggest that workers and activities are monitored between “sometimes” and “almost always.” This implies that companies have made moderate attempts to create performance evaluation systems for teleworking. Additionally, it is clear that it is necessary to find suitable ways to supervise work in order to avoid any negative effects on productivity. A positive perception of productivity from teleworking often leads to a perception that less direct supervision is necessary. This can influence organizational culture by promoting trust and autonomy among employees, which can further enhance their inclination towards teleworking. In [79] and [80] a

discussion on how teleworking affects the perceptions of job roles and supervision needs is found.

Similarly, from the results in Table 12, the Perception of Productivity mediates the relationship between the Perception of Investment and the Intention to Adopt Teleworking. When employees perceive that teleworking enhances their productivity and efficiency, they may be more receptive to the investments made by the organization to support teleworking initiatives. Moreover, if teleworking is perceived to boost productivity, organizations might be more inclined to invest in technologies and infrastructure that facilitate remote work, anticipating a return on investment through enhanced employee output and satisfaction [81], [82].

Studies [83], [84] have shown that trust on the part of supervisors positively affects job satisfaction and self-reported productivity. In addition, employers and employees' perceptions about teleworking are related in terms of promoting greater trust and improved performance [85]. Supervisors play a crucial role in managing the work environment and the issues of work relationships that are essential to address a pandemic or other crisis [86]. Therefore, effective supervision in teleworking situations can contribute to higher levels of productivity. However, increased concerns about the risk of cyberattacks with teleworking can lead to heightened supervision and monitoring of remote workers. This could involve more stringent control measures to secure data and manage work, which could affect employee morale and their perception of trust and autonomy, since security policies can impact employee behavior and perceptions of supervision [87], [88].

D. EVALUATION AND DISCUSSION OF THE STRUCTURAL MODEL WITH CONTROL VARIABLES

In order to analyze the acceptance of teleworking in Industry 5.0, it's crucial to articulate how the distribution of respondents across various demographics, such as company size, industry sector, education level, computer skills, gender, and age, impacts the study's findings. This section examines the outcomes of an enhanced PLS-SEM model after incorporating three control variables (Gender, Education Level, and Industry Sector) into the analytical framework. This exploration allows to distinguish the specific influences of primary constructs from those of demographic and contextual factors that could potentially confound or augment the relationships within the model.

The hypotheses were tested again after introducing the control variables. The results are presented in Table 13. The values of the coefficients β have slightly decreased, indicating that the additional variance explained by the control variables makes the direct effects of other predictors on the outcome appear slightly weaker. The t -student values are also adjusted downward, suggesting that the inclusion of control variables redistributes the statistical weight, potentially reducing the original paths' statistical significance. Table 13 now accurately represents the adjusted

findings of the hypothesis testing, taking into account the explanatory power of the new control variables that was previously assigned exclusively to the factors originally modeled.

TABLE 13. Contrast of Hypotheses after introducing Control Variables.

Hypothesis	β	<i>t</i> -student	Results
H1	0.318	6.952	Supported
H2	0.621	7.183	Supported
H3	0.705	19.437	Supported
H4	0.587	14.092	Supported
H5	0.352	6.889	Supported
H6	0.359	7.033	Supported

In the revised structural model, three new hypotheses were introduced to account for the influence of gender, education level, and industry sector on the intention to adopt teleworking. These control variables are essential for understanding the nuanced dynamics that affect teleworking behaviors within Industry 5.0, offering a detailed view on the elements that might promote or obstruct the use of teleworking technologies. Each hypothesis is analyzed based on its theoretical foundations and its significance to ongoing studies. The new hypotheses are:

- **H7:** Gender affects the Intention to Adopt Teleworking.
- **H8:** The education level of employees influences their Intention to Adopt Teleworking.
- **H9:** The industry sector of an employee's company impacts their Intention to Adopt Teleworking.

The results after testing the effect of the control variables are shown in Table 14. The updated structural model is shown in Fig. 5.

From these results, some conclusions can be extracted:

- From the data analysis, the values of β and *t*-student in hypothesis H7 reflect a statistically insignificant influence of gender on the intention to adopt teleworking, making this hypothesis not supported. It is suggested that there would be minimal variations in teleworking preferences between male and female respondents within the sample. As a consequence, this hypothesis is changed to be consistent with the obtained results:
 - **H7:** Gender does not significantly affect the Intention to Adopt Teleworking.
- Results support hypothesis H8, so that a higher education level positively influences the intention to adopt teleworking. This result is obtained on the premise that individuals with higher educational qualifications are likely more familiar with and capable of using advanced technologies, thus potentially more receptive to the flexibility and technical demands of teleworking. This relationship highlights the importance of the role of human capital in the diffusion of innovation, particularly in the context of advanced industrial practices such as those envisioned in Industry 5.0.
- From the new structural model, hypothesis H9 is supported. It suggests that employees in technology-focused

TABLE 14. Model analysis after introducing Control Variables.

Hypothesis	β	<i>t</i> -student	Results
H7	0.054	0.832	Not Supported
H8	0.256	3.158	Supported
H9	0.237	3.212	Supported

sectors are more likely to adopt teleworking compared to those in other sectors. This hypothesis is predicated on the notion that sectors with a strong technological orientation, such as software and biotechnology, inherently possess the infrastructure and cultural readiness for teleworking. The investigation of this hypothesis provides insights into sector-specific variations in teleworking adoption, which can inform targeted strategies for teleworking implementation across different industrial landscapes.

After analyzing the results of the enhanced structural model, it must be pointed out that including control variables delineates the complex effects that demographic and sectoral contexts had on teleworking adoption, offering detailed insights into workplace dynamics. The adjusted model, through revised path coefficients and hypothesis evaluations, underscored the interplay of various factors that influence teleworking. In particular, while variables such as educational level and industry sector significantly impacted teleworking intentions, gender did not demonstrate a significant effect. This finding emphasized the need for teleworking strategies that acknowledge and cater to the diverse backgrounds and industrial settings of employees to ensure that the benefits of teleworking are universally accessible and effective.

Empirical validation supported the original hypotheses, reinforcing the fundamental relationships within the model while providing richer insights into what drove the adoption of teleworking. These findings not only enrich academic discussions around teleworking and Industry 5.0 but also serve as valuable information for organizations that want to optimize teleworking to boost productivity, flexibility, and employee satisfaction in the context of technological advancements. This study highlights the necessity for organizations to design teleworking policies that consider a wide range of influencing factors. By addressing the varied needs and circumstances of their workforce, companies can fully harness the advantages of teleworking, promoting an environment conducive to innovation and sustained growth in the age of Industry 5.0.

VI. INTEGRATING TELEWORKING WITHIN INDUSTRY 5.0: IMPLICATIONS AND STRATEGIC CONSIDERATIONS

The findings of this study have significant implications for the evolving landscape of industrial production, particularly within the framework of Industry 5.0. Industry 5.0 represents a paradigm shift in manufacturing, emphasizing the integration of advanced technologies with human-centric approaches to drive innovation, customization, and flexibility in production processes.

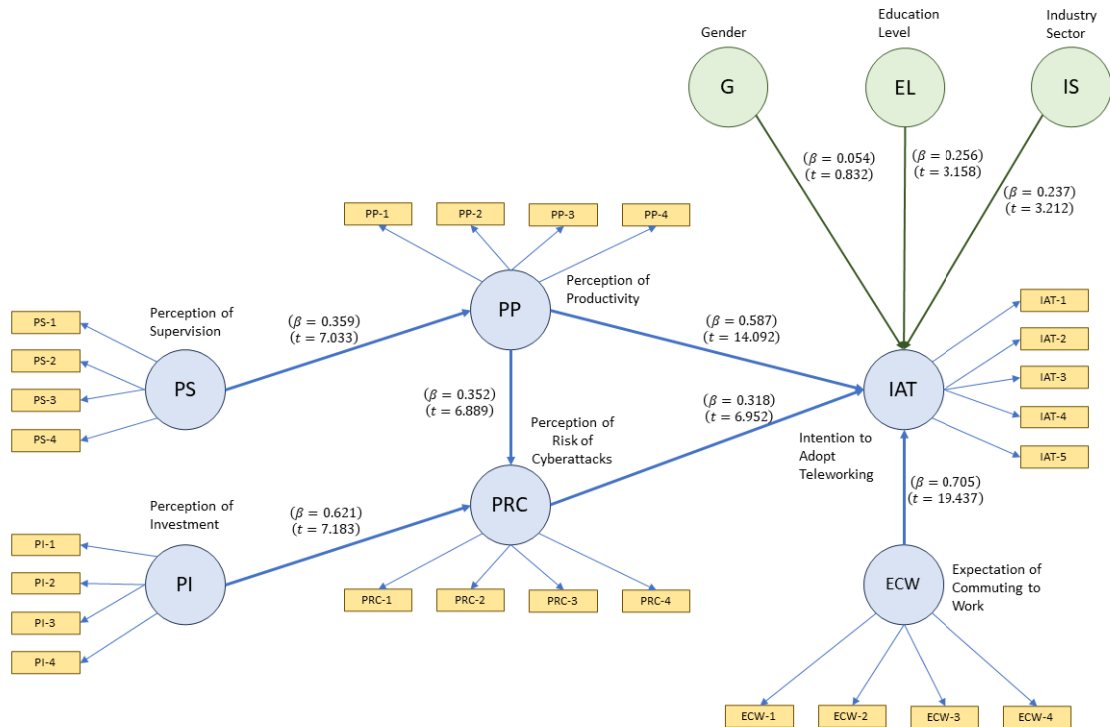


FIGURE 5. Structural Model Coefficients with Control Variables.

Our study highlights the importance of perceptions such as productivity, risk of cyberattacks, supervision, and investment in shaping the intention to adopt teleworking. From an Industry 5.0 perspective, these perceptions are particularly relevant, as they reflect the dynamics of human-machine collaboration in the modern workplace. Teleworking, enabled by digital technologies, exemplifies the blurring boundaries between physical and digital realms, emphasizing the need for effective human-machine interaction.

A significant insight from the study is the mediating role of the perception of productivity and the risk of cyberattacks in influencing the adoption of teleworking. These perceptions are closely linked to the concepts of customization and flexibility, the core tenets of Industry 5.0. Organizations adopting teleworking practices must navigate concerns about data security while leveraging technology to customize work arrangements and enhance productivity. This research highlights the importance of addressing these concerns to facilitate the transition toward Industry 5.0.

Furthermore, the perception of investment emerges as a critical factor that influences the adoption of teleworking. Organizations investing in teleworking infrastructure and support systems demonstrate a commitment to agility and innovation, key characteristics of Industry 5.0. By strategically allocating resources to enable remote work capabilities, organizations can adapt to changing market demands and capitalize on opportunities for growth and competitive advantage.

From a practical point of view, our findings suggest that organizations aiming to embrace Industry 5.0 principles should prioritize initiatives that foster a culture of trust, autonomy, and technological readiness. This includes implementing robust cybersecurity measures, providing adequate supervision and support for teleworkers, and strategically investing in teleworking infrastructure. By aligning these efforts with the principles of Industry 5.0, organizations can create agile and resilient workplaces capable of thriving in an increasingly digitalized and interconnected world.

The integration of control variables such as educational level and industry sector has demonstrated their substantial impact on teleworking intentions. These results emphasize the importance for organizations aligned with Industry 5.0 to consider a variety of demographic and contextual factors when implementing teleworking strategies.

From an Industry 5.0 perspective, the strategic implementation of teleworking can significantly enhance organizational agility and employee autonomy, leading to greater innovation and productivity. The results obtained suggest that higher education levels correlate with a more favorable disposition toward teleworking, likely due to better technological literacy and adaptability among well-educated employees. This aligns with Industry 5.0 focus on leveraging advanced technologies and data-driven decision-making processes, highlighting the importance of educational initiatives to prepare the workforce for future industry demands.

In addition, the differential impact of industry sectors on the adoption of teleworking indicates that technology-centric sectors are particularly receptive to this modality of work. This receptiveness is essential to foster an organizational culture that supports rapid adaptation to technological changes, a core aspect of Industry 5.0. This adaptability not only enhances operational flexibility, but also positions companies to better manage cybersecurity risks associated with remote work, a critical consideration in our digital age.

The study also points to the absence of a significant influence of gender on teleworking intentions, suggesting that teleworking policies should be universally attractive and supportive, regardless of gender. This finding encourages a move towards more inclusive workplace practices, aligning with Industry 5.0 emphasis on social sustainability and human-centric technologies.

In conclusion, this work highlights the strategic importance of aligning teleworking practices with Industry 5.0 objectives. By creating an environment that supports teleworking, Industry 5.0 companies can enhance their competitive edge through improved flexibility, employee satisfaction, and innovation capacity. This approach not only capitalizes on the benefits of advanced technologies, but also addresses the human factors critical to successful digital transformation.

VII. CONCLUSION

This article has developed a causal model to assess the extent to which a series of factors can influence the adoption of teleworking in Industry 5.0. The results indicated that reduced commuting and improved productivity can be seen as benefits of this mode of work. Additionally, it was established that prior to the implementation of teleworking, companies must create policies and procedures to regulate and monitor compliance, so that teleworking does not compromise information security, does not lead to unnecessary investment losses, and, most importantly, allows the organization to maintain control of employees and all activities conducted outside the organization.

In addition, factors such as education level, industry sector, and concerns about productivity and cybersecurity have been shown to impact the adoption of teleworking. The integration of control variables into the structural model has provided a clearer understanding of what drives teleworking practices. For companies aiming to align with Industry 5.0, this research highlights the need to develop teleworking strategies that are technologically advanced but also sensitive to the diverse needs of their employees. This approach will help organizations leverage the full benefits of digital transformation, leading to greater flexibility, innovation, and better employee satisfaction, which are key to maintaining a competitive edge in an increasingly digital world.

Our study, while comprehensive in its approach to examining the adoption of teleworking in the context of Industry 5.0, acknowledges several limitations that may

affect the generalizability and applicability of our findings. In particular, psychological factors, such as stress, social isolation, and lack of socialization, that could affect employee experiences and outcomes related to teleworking were not explored. This decision was based on the initial objective of our research to specifically analyze the adoption of teleworking from a technological and demographic perspective, rather than a psychological one. On the other hand, given the focus on Industry 5.0, the study may inherently bias towards industries and populations that are already technologically advanced. This could limit the relevance of the findings to sectors where digital transformation is not as prevalent.

As a future work, it is intended to incorporate these psychological variables into the proposed causal model. These elements are closely related to the health and well-being of employees, and some authors have identified them as drawbacks of teleworking. Investigating how these factors can affect the decision to embrace teleworking will improve the comprehensive understanding of the psychological effects associated with this mode of work. Additionally, the study of emerging technologies is being analyzed to identify tasks suitable for teleworking in Industry 5.0. Future research is planned to address these gaps by incorporating a broader range of variables, including psychological aspects, to provide a more holistic view of the teleworking environment and its challenges within Industry 5.0 frameworks.

AUTHOR CONTRIBUTIONS

All the authors were involved in the foundation items. They wrote the article and read and approved the final manuscript.

COMPETING INTEREST

The authors declare no competing interests.

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