

Article

Evaluation of the Benefits Generated by Sustainability 4.0: A Study of the Perception of Banking Sector Customers

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Abstract: This paper aims to evaluate customer perceptions regarding the benefits generated by sustainability 4.0 in the banking sector through a survey. A structured questionnaire was developed with 55 factors divided into economic, social, and environmental dimensions. A total of 90 questionnaires were collected. Descriptive statistics and Kendall's coefficient of agreement were used with the intention of measuring the degree of agreement or disagreement between bank customers' responses. The results indicated a positive perception of customers regarding the relationship between sustainable practices and economic, social, and environmental aspects, with a relatively high agreement. The best-rated benefits were related to economic and environmental aspects, such as reducing service time and efficient use of digital resources. However, there was a diversity of opinions regarding social aspects, with some issues receiving lower ratings, especially related to the permanence of employees and the autonomy of elderly customers. This suggests concerns about the impact of technology on maintaining banking jobs and the accessibility of financial services for specific groups, such as the elderly. It is concluded that by focusing on customer perception, the study offers a holistic view of the implications of sustainability 4.0, going beyond traditional analyses focused on organizations.

Keywords: sustainability 4.0; industry 4.0; enabling technologies; banking sector; customer perception



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1. Introduction

Banks play a crucial role in contemporary society, establishing a direct connection between the economic growth of a region and the maturity of the banking sector [1]. Its relevance stems, in part, from its function as a financial intermediary, enabling it to provide capital to business entities in the economy [2]. Furthermore, current financial institutions assume a unique role as agents of public trust, sustaining the economy, facilitating payments, and improving the efficiency of the financial system, playing a determining role in economic and social aspects [3,4].

On the other hand, there is a marked digital transition in the banking sector, as technologies from the 4.0 era are incorporated by financial institutions [5]. Today's society increasingly demands the adoption of these innovations to meet its traditional financial needs, aiming to optimize customers' time and effort [6]. In this context, banking organizations face the challenge of dealing with huge volumes of data in their operations [7]. According to studies by the authors, the use of technology in the banking sector is not new, but rather a trend towards improvement, making financial processes more efficient for

customers who do not accept changes for the worse. When developing new relationship models with their customers, banks must consider challenges associated with the use of these more modern technologies, such as consumer trust and security in their use [6].

In this scenario of new technologies and social responsibility, Zabawa and Kozyra [3] highlight the importance of manufacturing and service companies, including financial services, addressing practical aspects of environmental responsibility. In the banking sector, historically focused on strategies aimed exclusively at generating value for shareholders and neglecting other interest groups [4], banks now face the need to adapt to environmental and social indicators. Sustainable development, as argued by [8], is not restricted to financial perspectives alone.

In this context, several studies have dedicated themselves to understanding the perspective of banking customers in the face of the transformation brought about by industry 4.0. Noreen et al. [9] sought to establish a connection between the perception of these consumers and the implementation of artificial intelligence in the banking sector. Lee and Lee [10] explore innovative customer service strategies through the application of these technologies, while the research by [11] focused on analyzing the relationship between the evolution towards banking 4.0 and customer loyalty, highlighting the importance of the quality of the experience.

Therefore, although the studies have addressed crucial aspects of the transition to industry 4.0 in the banking sector, to date, none of them have delved into the relationship between this technological transformation and sustainability from the perspective of banking customers. The intersection between industry 4.0 and sustainable practices represents a relevant field, and understanding how customers perceive and value these aspects can offer valuable insights into the future evolution of the sector [12].

That said, the question arises: “What is the perception of bank customers regarding the benefits that Sustainability 4.0 (S4.0) can generate?” According to [13], sustainability 4.0 can be defined with the integration of technologies enabling industry 4.0 and the social, environmental, and economic dimensions of sustainability. Thus, this article is relevant in three main aspects. First, it bridges the research gap between sustainability and 4.0 technologies, addressing the emerging concept of sustainability 4.0 (S4.0) while making it clearer to the literature. Second, it applies this new perspective to the banking sector, exploring the interactions between these topics that have received little attention in academic studies. And finally, it evaluates the perspective of banking customers in relation to S4.0 indicators, revealing new insights for the sector.

Therefore, this paper aims to evaluate customer perceptions regarding the benefits generated by sustainability 4.0 in the banking sector. For this, a questionnaire prepared based on the study by [13] was applied to a sample of 90 customers of commercial and investment banks located in the state of Pernambuco, located in the northeast of Brazil.

In this sense, 55 questions were identified to evaluate customer perceptions regarding the benefits generated by sustainability 4.0 in the banking sector, which were divided into 23 questions related to the economic aspect, 18 questions related to the social aspect, and 14 questions related to the environmental aspect. The non-parametric Kendall coefficient test was used in data analysis to assess the degree of agreement or disagreement between bank customers’ responses. This method was chosen based on the nature of the data obtained and the objective of the study. Finally, it was possible to verify varied perceptions about sustainability in the sector, especially in social aspects. The practical implications are relevant to both the banking sector and academia, offering valuable insights that can inform strategies and decisions aligned with social concerns and consumer expectations in the pursuit of sustainable development.

2. Theoretical Background

2.1. Banking Customers in Era 4.0

Information technology plays an essential role in society, causing transformations in different aspects of life. In the financial segment, for example, the adoption of electronic

payment methods is a growing demand from bank customers, due to the ease and convenience provided by this device [6]. However, the implementation of these modern means faces challenges related to customer trust and ensuring safety in their use.

Furthermore, Stefanovic et al. [14] highlight the importance of transparency in banking information since the complexity and lack of clarity in rates make it difficult for consumers to understand and compare. In this context, technological innovations, such as industry 4.0 and artificial intelligence, play a fundamental role in driving the creation of intelligent, personalized, and interconnected banking systems.

These approaches converge by recognizing the need to improve the customer experience, ensure information transparency, and promote the adoption of innovative technologies in the banking sector [15]. However, customer satisfaction and loyalty in financial institutions are influenced by several factors, such as service quality, product knowledge, and employee skills.

According to [16], advances in information technology allow companies to monitor customer use of the service and identify specific segments. In turn, Pakurár et al. [17] highlight the importance of employee skills in customer satisfaction, which requires investment in training and development. Furthermore, Iqbal et al. [18] highlight the need for high-quality services and product awareness to increase customer satisfaction and loyalty in financial institutions.

Therefore, the combination of these aspects, combined with the strategic use of information technology, can contribute to promoting customer satisfaction and loyalty in financial institutions, resulting in a lasting and beneficial relationship for both parties. In Table 1, it is possible to observe what customers expect when subscribing to services using 4.0 technologies in the banking sector.

Table 1. Banking perception in industry 4.0.

Technology 4.0 in the Banking Sector	Benefits Expected by Customers	Risks Faced by Customers	References
Open Banking	Improve customer satisfaction	Loss of privacy	[19]
Internet Banking	Increase satisfaction, ease of use, and reduction in time spent on banking demands	Integrity of the services provided; attention to business sustainability	[20,21]
Artificial Intelligence	Improved customer service	Loss of privacy and protection, lack of government regulation	[22]
Fintechs	Ease of use, perceived value, quality of support, reliability, perceived risk, innovation capacity, cost reduction.	Complexity in identification; Difficulty in use by older customers	[23–26]
Blockchain	A faster, cheaper, and more efficient service; risk reduction; interoperability	Limited information about data use; the granularity of privacy data	[26–29]
Big Data	More efficient and faster digital services	Privacy and data security	[19,30]

Source: The authors (2024).

Technology 4.0 is redefining the banking sector, providing significant opportunities and inherent challenges. Understanding customer perceptions regarding these innovations is crucial for effective implementation, so Table 1 presents banking customers' perceptions of the expected benefits and risks in relation to emerging technologies, such as Open Banking, Internet Banking, Artificial Intelligence, Fintechs, Blockchain, and Big Data.

Integrated services like Open Banking promote customer satisfaction by providing access to broader services. However, the risks of loss of privacy require strict security and regulatory measures to guarantee the trust and integrity of the financial system [19]. Using technologies such as Internet Banking, customers gain a key facilitator, increasing their satisfaction with the convenience and efficiency of the services provided. Ease of use and reduced time spent on banking demands improve the experience, however, risks to the integrity of services highlight the importance of sustainable approaches in the banking business [21,31].

Furthermore, customer loyalty plays a crucial role in the sustainable development of companies, generating not only continuous business opportunities but also contributing to the expansion of the bank's reputation. As highlighted by [31], customer satisfaction plays a vital role in this scenario. At the same time, financial institutions focused on Artificial Intelligence (AI) seek to reap the benefits of reduced operational costs, greater proximity to customers, higher revenues, and innovation in financial products and services. In a digitalized context, where financial operations are predominantly conducted by AI algorithms, capturing customer preferences and perceptions becomes an essential practice in the contemporary banking industry [22].

Fintechs, companies that combine finance and technology, have stood out in the contemporary financial scene. In essence, Fintechs offer ease of use, provide value perceived by customers, maintain high-quality standards in support, are considered reliable and innovative, and contribute to cost reduction in the financial sector. However, it is crucial to recognize the risks associated with using Fintechs. The complexity in identification and the difficulty in use by older customers are challenges inherent to these financial innovations, demanding attention to ensure broader and more inclusive adoption of these technologies in the financial sector. This combination of benefits and risks expected by banking customers was observed in studies by [23–26].

Furthermore, as observed in the studies by [26–29], blockchain technology presents a series of benefits in the financial sector, promoting faster, more economical, and efficient services, however, it is essential to consider the risks associated with its use. The lack of detailed information about data handling and the granularity of privacy-related aspects are critical issues to be faced in the implementation of this technology, as highlighted by the authors.

Finally, the implementation of Big Data in the banking sector represents a revolution in the management and analysis of large volumes of data, promoting more efficient and faster digital services to improve the customer experience. The ability to extensively analyze financial data allows for a deeper understanding of behavior patterns, enabling the personalization of services. However, the use of Big Data also brings challenges, notably in the sphere of privacy and data security, requiring measures to protect sensitive information against cyber threats and preserve customer trust. These themes are discussed by scholars such as [19,30].

Therefore, the future of banks will depend significantly on their willingness to modernize and, in some cases, fundamentally change the principles of organizing their activities [24]. Therefore, banks must adopt a strategic approach focused on increasing customer awareness about accepting new technologies, such as online banking, to gain a competitive advantage. Raza et al. [21] highlight the importance of ensuring accurate, timely, and fast transactions in an online banking environment, highlighting that the high quality of services provided can boost customer satisfaction, perceived value, trust, and loyalty. In this context, proactive measures are necessary to meet customer demands and ensure a successful transition to the banking 4.0 era.

In this way, academic works were selected that sought to understand the perspectives of this new context for banking customers. A search was conducted in the Web of Science database using the terms “Bank”, “Industry 4.0” and “Customers” through access to the CAPES Periodical Portal. The CAPES Periodicals Portal is one of the most extensive scientific platforms in the world, where it is possible to access and explore a wide range of up-to-date scientific and technological production. This feature offers online access from any computer connected to the Internet if it is at an authorized institution. The access in question was carried out at the University of Pernambuco. In this way, after searching with keywords, two filters were carried out by type of document: “text available” on the Platform and “article”, resulting in a total of 13 results from which 7 studies are linked to the theme of this work. This limited amount of research highlights the need to increase industry 4.0 literature in the banking sector, especially in the perception of its customers. The main findings are presented below.

Noreen et al. [9] investigated consumers' perspectives regarding the adoption of Artificial Intelligence (AI) in Asian countries. The results highlighted that factors such as awareness, attitude, subjective norms, perceived usefulness, and knowledge of AI technology presented a positive and significant relationship with the intention to adopt AI in the banking sector. Finally, the authors concluded that the banking sector also focuses on innovative AI technologies to improve customer services with the intention of generating greater profits.

Amiri et al. [32] address the issue of implementing digital banking services amid the transformations generated by industry 4.0, considering changes in customer needs. The study proposes an innovative approach to group decision-making. After a literature review and consultation with experts, DB implementation criteria are determined and prioritized in an uncertain environment. The results indicate that human resources, regulatory standards, and customer satisfaction are the most important criteria, while open, blockchain, and social banking models stand out in covering these digital banking implementation criteria.

Kuchciak and Warwas [33] aim to provide an advanced view of the practical applications of human resources management in the context of Bank 4.0. The study uses quantitative and qualitative methods. The results indicate that digitalization is transforming the qualifications required for professionals in the financial sector. Thus, the loss of traditional jobs is an impact of technological innovation. With technological advancement, a change in skills demands is expected, with an emphasis on skills such as data analysis, software development, digital marketing, and social media. Finally, the work concludes that human resource management practices, such as recycling, skills updating, and reallocation, emerge as strategic solutions to mitigate challenges in the Bank 4.0 era.

The study by [34] addresses digitalization and technical development in the financial services sector, aiming to guarantee security, increase quality, and meet the interests of current customers and financial institutions. The main objective is to offer a theoretical framework for digitalization and its drivers in the financial sector, introduce the phenomenon of Banking 4.0 in relation to the necessary skills, and identify gaps and barriers for faster and more effective development, through a review of the literature and data analysis. The work highlights the growing influence of digital technologies on employees, managers, and companies, highlighting the importance of systematically implementing approaches for developing digital skills at the strategic level of companies.

The article by [35] analyzes the trends and threats of digital transformation in the banking sector, addressing technologies such as cloud, blockchain, Big Data, artificial intelligence, biometrics, and open-source APIs. The authors conclude that there is an inequality in the digitalization of banks in different regions and that the main obstacles to digital transformation are not technological, but rather differences in the organizational culture of traditional banks and fintech, a different strategic vision of bank management, and a lack of qualified personnel, which makes it difficult for banks to transform towards cooperation. The use of digital technology increases systemic risks associated with cybersecurity, fraud, and ethical issues.

Xu et al. [36] proposed a new early warning model for credit card customer churn based on GSAIBAS-CatBoost. The authors concluded that with the increase in competition between large banks, it is necessary for financial agencies to prioritize a way to increase the value of existing customers and thus reduce the turnover of credit card customers.

The exploratory and qualitative study by [37] examined the perceived barriers to innovation and change in a commercial bank from the perspective of senior management. Using a systematic qualitative approach and interviewing eight managers, the study identified obstacles such as high bureaucracy, lack of communication, and employee involvement, negatively affecting the performance of middle managers. Resistance and risk aversion were highlighted as the main barriers to innovation and change in the banking sector.

Therefore, banks are challenged to increase customer awareness regarding the acceptance of new technologies, such as online banking, to gain a competitive advantage [21]. Customers seek accurate and fast transactions online, and the quality of services provided

can strengthen customers' gratification, value, faith, and obligation. Furthermore, the future of banks will depend on their readiness to modernize and, in some cases, fundamentally change organizational principles [24]. This strategic transformation is crucial to ensuring relevance and sustainability in the constantly evolving banking landscape.

2.2. Sustainability 4.0

The concept of sustainability in the banking sector encompasses a variety of approaches and challenges. Diener and Spacek [8] highlight that transparency is fundamental to promoting understanding of business relationships, responsibility, and decision-making, strengthening trust in companies. In this context, digitalization plays a crucial role in the transformation of financial services, leading to fundamental changes in the banking sector. In turn, banks are focusing their sustainability efforts mainly on operational issues, such as financial inclusion, financial education, and energy efficiency. However, the social dimension of sustainability deserves greater attention, along with aspects such as environmental management, green products and services, and sustainability reports [38].

Therefore, banks must expand their focus and start considering all dimensions of sustainability. To this end, redefining relations with society and adopting a more inclusive approach are essential to promote sustainable development. Although banks have advanced in defining the concept of sustainability and incorporating it, it is necessary to improve the approach to social dynamics in the process [39].

From this perspective, investment decisions in the banking sector are largely shaped by the complex intersection of innovation, sustainability, and competitive advantage, as highlighted by [12]. Kumar and Prakash [38] complement this perspective, highlighting the central role of the banking sector in the sustainable development of the economy, highlighting its role as an essential facilitator for the transition towards a more sustainable future. Therefore, the sustainability of the banking business is essential for long-term survival and productivity [20]. This concept is intrinsically linked to competitive advantage, a crucial factor for the success of the global differentiation of organizations [12].

In this way, customer loyalty plays a crucial role in the sustainable development of a banking company, considering that the cost of acquiring new customers is substantially higher than the cost of retaining existing ones [23], and developing and maintaining customer loyalty is a critical issue for companies, as customer loyalty not only contributes to the generation of new business but is also capable of engaging new customers, promoting the growth of the bank's reputation [31]. Furthermore, as highlighted by [22], customer perception is central to this process, because by understanding customer needs and demands, financial institutions can establish a long-term bank–customer connection based on the services provided to their consumers.

Customers, being a crucial part of the stakeholders in the banking sector, have their personal beliefs and values incorporated into their consumption preferences [40]. This perspective gains relevance when observing the notable fragmentation between new and traditional services from the customer's point of view. Innovative services, such as robo-advisors and social trading platforms, contrast with traditional services [26]. In this context, the bank's sustainability strategy, as also presented by [40], is inseparable from the primary objective of maximizing profits. This combination of views highlights the complexity of customer preferences and behaviors in the banking sector, which oscillate between tradition and innovation, as banks seek to balance sustainability with maximizing their returns.

Furthermore, customers, according to [21], are attracted to banks that offer faster transactions through online portals, ensuring ease of access. However, complexity arises with the need to deal with a variety of providers that have specific applications, identification procedures, and fee structures [26], reducing the ease of use of the service. Thus, Druhov et al. [24] raise the perspective that the future of banks will depend on the willingness to modernize and, sometimes, even to fundamentally change the principles of organizing their own activities, since customers' need for speed and ease of use faces challenges arising

from the complexity and variety of options, highlighting the critical need for modernization in the banking sector.

Consequently, given the rapid development of online payments, traditional bank branches are becoming inefficient, leading many foreign and domestic banks to reduce their branch networks [24]. While innovative fintech solutions such as robo-advisory and social trading platforms can attract a tech-savvy clientele and younger customers, most of these providers face challenges in generating sufficient revenues and sustaining their business models [26]. However, in a broader context, corporate environmental management and sustainability offer opportunities for differentiation and increased competitiveness in the market, with banks adopting sustainability management practices in different ways [40].

As a result, many banks approach sustainability in two main aspects: first, by integrating sustainable criteria into their services, such as loans, for example, creating new financial products to encourage ecological investments. Second, they adopt sustainability practices in organizational operations, seeking to improve their sustainable performance as institutions [40]. Therefore, sustainability in the banking context aims to mitigate the negative environmental, economic, and social impacts arising from the activities of this dynamic sector. From this perspective, the importance of identifying barriers and levers that shape the trajectory toward a more sustainable banking system stands out.

With the evolution of services and the arrival of industry 4.0 technologies, a new concept of sustainability emerges, sustainability 4.0. Globally, sustainability 4.0 in the service sector was defined by [13] as the integration of technologies enabling industry 4.0 and the triple bottom line (TBL) (social, environmental, and economic dimensions) of sustainability. For [41] sustainability 4.0 in the fashion industry is a new mentality that is based on the positive correlation between the enabling technologies of industry 4.0 and the three dimensions established by TBL, aiming for sustainable solutions in the production chains. Despite being different sectors (the service sector and the manufacturing sector), both studies converge on the link between enabling technologies and TBL.

After presenting the concept of sustainability 4.0, we sought to carry out a query in the Web of Science database using the terms “Sustainability 4.0” through access to the CAPES Periodicals Portal, this search resulted in a total of eight articles, however, no articles were identified in the banking sector. Table 2 presents a compendium of the results of this research.

From the brief review of the literature, it was possible to identify eight studies focused on sustainability 4.0, with the first article being published using the nomenclature sustainability 4.0 in 2021. Six of the eight articles are related to the bibliometric analysis or systematic literature review method and only two articles are from the service sector. This limited amount of research highlights the need to advance the literature on sustainability 4.0 in the banking sector.

Table 2. Literature review with the term “Sustainability 4.0”.

Title	Sector	Method	Year	Results	Reference
Striding towards Sustainability: A Framework to Overcome Challenges and Explore Opportunities through Industry 4.0	Service and Manufacturing	Bibliometric and content analysis	2021	The aim of the article was to develop a framework aiming at sustainability 4.0 for government, organizations, and academia. The results presented 19 proposals for the development of sustainability through I4.0, 8 for the government, 6 for organizations, and 5 for the academy.	[42]

Table 2. Cont.

Title	Sector	Method	Year	Results	Reference
Mapping Sustainability 4.0: contributions and limits of the symbiosis between technology and sustainable development	Manufacturing	Bibliometric analysis	2022	The article aimed to identify research trends related to “Industry 4.0 and Business Sustainability”. Thus, the authors identified four trends: 1. Industry 4.0 as a tool to support sustainability; 2. Intersection and borders between sustainability and industry 4.0; 3. Development of industry 4.0 along the lines of sustainability and 4. Management applied in sustainable industry 4.0.	[43]
Sustainability 4.0 and its applications in the field of manufacturing	Manufacturing	Literature review	2022	The article aimed to identify the applications of sustainability 4.0 in the manufacturing sector. As a result, 17 applications linked to environmental, social, and economic dimensions were identified.	[44]
The COVID-19 Impact on Supply Chain Operations of Automotive Industry: A Case Study of Sustainability 4.0 Based on Sense–Adapt–Transform Framework	Manufacturing	Case study research	2022	Through a case study, the article sought to determine the impact of COVID-19 on supply chain operations at a Turkish automobile manufacturer. Several disruptions were identified, such as: scarcity of raw materials, availability of transport and labor, fluctuations in demand, increase in sick leave, new health and safety regulations.	[45]
Sustainability 4.0 in services: a systematic review of the literature	Service	Systematic literature review	2023	The systematic literature review aimed to identify the benefits for sustainability 4.0 from the enabling technologies of industry 4.0 in the service sector. A total of 100 benefits were categorized, 54 in the economic aspect, 25 in the social aspect, and 21 in the environmental aspect.	[13]
Deep learning applications in manufacturing operations: a review of trends and ways forward	Manufacturing	Bibliometric analysis and Systematic literature review	2023	The article aimed to identify deep learning trends in manufacturing operations. The results showed that deep learning has wide applications in the areas of maintenance 4.0, quality 4.0, logistics 4.0, manufacturing 4.0, sustainability 4.0, and supply chain 4.0.	[46]

Table 2. Cont.

Title	Sector	Method	Year	Results	Reference
Application of ISM to Identify the Contextual Relationships between the Sustainable Solutions Based on the Principles and Pillars of Industry 4.0: A Sustainability 4.0 Model for Law Offices	Service	Simulation	2023	The article sought to identify the contextual relationships between sustainable I4.0 solutions in law firms, using interpretive structural modeling. The results showed that the sustainable solutions increased security, improved quality, service personalization, flexibility in service delivery, end of waste, infrastructure and smart services were the most relevant.	[47]
Sustainability 4.0 in the fashion industry: a systematic literature review	Manufacturing	Systematic literature review	2024	The article aimed to identify the factors that affect sustainability 4.0 in the fashion industry. The results listed a total of 46 factors, 19 of which were related to the economic dimension, 12 to the social dimension, and 15 to the environmental dimension.	[41]

Source: The authors (2024).

3. Materials and Methods

Scientific research can be categorized into several dimensions, covering the approach adopted, the nature of the study, the intended objectives, and the methodological procedures used [48]. Thus, this research is defined as quantitative in terms of its approach, as it uses mathematical data to generate statistical inferences. In terms of its nature, it is defined as applied due to its practical nature. As for its objectives, it is defined as exploratory and descriptive, as it investigates little-known phenomena while seeking to describe and analyze them [48]. Finally, regarding methodological procedures, this work used the survey research method through online questionnaires via the Google Forms platform for bank customers anonymously and with the aim of collecting their opinions.

Thus, participants were given an online questionnaire (Appendix A) and asked to express their responses using a five-point Likert scale, where 1 means “strongly disagree” and 5 means “strongly agree”. Thus, the only requirement requested was to have an account at a commercial or investment bank, which ended up resulting in a total of 90 completed questionnaires.

Furthermore, the banking sector traditionally uses online surveys to collect its customers’ perceptions about its themes with a view to developing scientific knowledge in the area, as seen in studies by [49–51]. Similarly, the Likert scale is used in addition to questionnaires aimed at customers and bank employees with the intention of better collecting and analyzing data related to their opinions [52–55].

The questionnaire used in this study consisted of a total of 74 questions, subdivided into three distinct parts. The first covered the analysis of the profile of bank customers, consisting of 8 questions. The second part included 11 questions related to the perception of sustainability in bank branches. Finally, the third part assessed customer perception regarding industry 4.0 (I4.0), sustainability, and the benefits provided by these technologies in the banking sector. This last stage, based on the study by [13] in the services sector, totaled 55 questions. The 55 questions were divided into 23 questions related to the economic dimension, 18 questions linked to the social dimension, and 14 questions related to the environmental dimension.

The first part of the questionnaire sought to understand the profile of the respondents and their relationships with the banking segment, and they were asked about the nature of the banks that hold current accounts and the number of institutions that have a link. In addition, the comprehensive profile of the participants was analyzed, addressing variables such as gender, age group, level of education, and data related to remuneration. In addition, at the end of this section, two opinion surveys were carried out related to the theme of this study. The second part sought to evaluate the integration of sustainability in banking institutions, exploring the participants' perspectives to deepen the understanding of their opinions on banking sustainability, especially about technological and managerial factors. Participants were asked to express their opinions using a 5-point Likert scale, ranging from 1 (totally disagree) to 5 (totally agree). In total, 11 questions were asked.

Finally, based on the studies of [13] who carried out a systematic review of the literature to understand the impact of industry 4.0 (I4.0) on the services sector and its contribution to sustainability 4.0, under the principles of the triple bottom line (economic, social, and environmental dimensions). The research by the authors identified 100 general benefits at this intersection, which were categorized into 54 benefits for the economic dimension, 25 for the social dimension, and 21 for the environmental dimension. Thus, the third section of the questionnaire used the authors' results to prove their findings in the service sector of the economy aimed at the banking segment.

The questionnaire was distributed using the snowball method so that non-random respondents invited other participants to the study. Furthermore, the questionnaire was also distributed via email and WhatsApp to the public randomly on social networks and academic communities. The distribution accompanied the Google Forms link, to allow online and anonymous responses. Before its application, 4 experts in the field of banking management with *stricto sensu* academic training were invited to carry out pre-tests with the intention of improving the questions in a clearer and more objective way. The data were analyzed using the statistical techniques presented below.

4. Results

4.1. Profile Studied

The study in question sought to comprehensively analyze the profile of the respondents, considering variables such as gender, age group, level of education, and their relationship with the banking sector (Table 3). In relation to gender, the data revealed a diverse distribution, with 43.33% of participants identified as male, 55.56% as female, and 1.11% choosing not to declare. This indicator demonstrated a well-divided gender representation among this group, allowing an unbiased analysis of the observed analyses.

Table 3. Profile of respondents.

Variable	Feature	Occurrence	Total	Percentage (%)
Gender	Masculine	39	90	43.33%
	Feminine	50		55.56%
	Not declared	1		1.11%
Age	18 to 25 years old	6	90	6.67%
	26 to 30 years old	18		20.00%
	31 to 35 years old	16		17.78%
	36 to 40 years old	18		20.00%
	41 to 45 years old	11		12.22%
	46 to 50 years old	8		8.89%
	51 to 55 years old	8		8.89%
	Over 56 years old	5		5.56%
Education	High school	10	90	11.11%
	Graduation	29		32.22%
	Postgraduate	51		56.67%

Source: The authors (2024).

Regarding the age group, there was great variability, with the most represented age group appearing to be 26 to 30 years old and 36 to 40 years old, with 20.00% of the sample. On the other hand, younger age groups, such as 18 to 25 years old, and more mature age groups, over 56 years old, have smaller shares, representing 6.67% and 5.56%, respectively. In this way, it was observed that more than 64% of participants were between 18 and 40 years old, while more than 35% were over 41 years old. This age distribution highlights the importance of considering different generational groups in subsequent analyses, recognizing the possible influences of different stages of life in the relationship with banking institutions.

Regarding the level of education, the results indicated a predominance of qualified respondents, with 11.11% having secondary education, 32.22% graduates, and a significant 56.67% holding postgraduate degrees. This trend suggests a potential relationship between the level of education and banking engagement, triggering reflections on possible social and economic implications.

Regarding relations with the banking segment, Table 4 presents the main results. In the banking scenario, a significant distribution was revealed in the type of bank in which they maintain their accounts. Among the respondents, 30% have accounts in private banks, 25.56% in public institutions, and a group of 40% maintain accounts in both types of banks. This diversification suggests a customer seeking different services and benefits offered by these entities, as suggested by [21,24].

Table 4. Relationship with the banking segment.

Variable	Feature	Occurrence	Total	Percentage (%)
Type of bank	Private	27	90	30.00%
	Public	23		25.56%
	Both	40		44.44%
Time as a bank customer	Less than 1 year	1	90	1.11%
	Between 1 and 5 years	11		12.22%
	Between 5 and 10 years	22		24.44%
	Over 10 years	56		62.22%
Number of bank accounts in different institutions	1 bank account	17	90	18.89%
	2 bank accounts	27		30.00%
	3 bank accounts	25		27.78%
	4 bank accounts	14		15.56%
	5 bank accounts	2		2.22%
	More than 5 bank accounts	5		5.56%
Bank occurrence	Traditional banks	113	198	57.07%
	Fintechs	81		40.91%
	Other banks	4		2.02%
Main bank account	Traditional banks	66	90	73.33%
	Fintechs	23		25.56%
	Other banks	1		1.11%

Source: The authors (2024).

When considering the length of their relationship as a bank customer, the data indicates considerable loyalty, with 62.22% of participants maintaining their relationship with their branches for more than 10 years. Additionally, 24.44% have had a relationship between 5 and 10 years, while 12.22% are in the range of 1 to 5 years, and only 1.11% have been customers of their banks for less than a year. These results highlight the stability and trust established over time by customers in relation to banking institutions, a perception that is in line with the analyses by [22,23,31].

Regarding the number of accounts in different institutions, diversification stands out, with 30% of participants maintaining relationships with two banks, 27.78% with three, 15.56% with four, and 5.56% with more than five financial institutions. Regarding the occurrence of bank accounts, traditional banks emerged as leaders, representing 57.07%

of participants' choices. Notably, 73.33% of customers named traditional banks as their main bank account, a possible explanation for these findings would be the challenges presented by [14] regarding traditional banks, as customers begin to adopt digital banks in their secondary accounts, but also cautiously, due to the possible risks of this new scenario [19–30].

Fintechs, in turn, were chosen by 40.91% of respondents, being the main account for 25.56% of them. Non-traditional banks, which are not fully digital, had an occurrence of 2.02% but were the main account for only 1.11% of customers. This differentiation in preferences suggests a complex dynamic in the choice of banking institutions, considering both the variety of services and perceived reliability.

Finally, at the end of the first part of the questionnaire, we sought a more in-depth understanding of customers' willingness to adopt digital services and general satisfaction with the banking services provided. To this end, a descriptive statistics approach was adopted, using two specific questions to assess the respondents' perception of banking services. The first question asked about participants' tendency to replace face-to-face services with digital channels, while the second aimed to assess satisfaction in relation to the needs met by the bank. Both questions were scored on a five-point Likert scale.

In the first question, "Am I willing to replace the use of face-to-face services/products from my bank with their use on digital channels", the average response was calculated at 4.3, indicating a positive inclination in relation to the willingness to adopt digital channels, as pointed out by [20,21,23–26]. Furthermore, the standard deviation was calculated at 1.194, suggesting a certain variability in the responses and indicating the dispersion of the data in relation to the mean.

In the second question, "Does my bank satisfy my needs", the average response was calculated at 4.12, reflecting a generally positive perception regarding satisfaction with the needs met by the bank, which is in line with research studies [20,22]. The standard deviation, in turn, was calculated at 0.934, indicating less dispersion compared to the first question and suggesting greater agreement between the answers.

The descriptive statistics data are in line with current trends in the banking scenario, reflecting the growing willingness of consumers to adopt digital channels, as observed in the works of [9,34]. The high average in the question about replacing face-to-face services (4.3) suggests an acceptance of this transition, in line with the growing digitalization in several sectors. On the other hand, the consistency in the positive perception of satisfaction with services (average of 4.12) indicates a banking offer that meets expectations, strengthening customer confidence. These trends suggest that the evolution to digital services is increasingly relevant, while ongoing customer satisfaction is crucial to maintaining competitiveness in today's market.

4.2. Sustainability and Technology

The second part of the questionnaire sought to understand customers' views on the fundamental pillars of sustainability, the implications of innovation in sustainable practices, and the role of technology in this context, to identify areas of convergence and potential gaps in understanding.

The diverse approach to questions in this study was designed to capture crucial nuances in bank customers' perceptions of sustainability. Questions such as (S and T1) and (S and T2) seek to understand customer perceptions of the fundamentals and interaction between innovation and sustainability. At the same time, questions (S and T4) and (S and T5) aim to assess customers' knowledge about their banks' sustainable initiatives and the perceived effectiveness of these policies in their branches. Furthermore, the importance of questions such as those asked in alternatives (S and T7) and (S and T8) lies in understanding the importance attributed by clients to the knowledge and presence of sustainable policies in their financial institutions. Thus, each question was strategically formulated to explore specific aspects that are fundamental to the holistic understanding of customers' knowledge regarding sustainability in the banking sector, therefore, Table 5 details the results.

Table 5. Frequency, mean, and standard deviation for sustainability and technology.

Factor	Response Frequency					Mean	Standard Deviation
	1	2	3	4	5		
S and T1	0	0	5	18	67	4.69	0.574
S and T2	0	1	6	22	61	4.59	0.669
S and T3	1	0	9	19	61	4.54	0.767
S and T4	28	18	30	10	4	2.38	1.167
S and T5	13	12	46	14	5	2.84	1.038
S and T6	21	12	31	13	13	2.83	1.335
S and T7	3	5	19	21	42	4.04	1.101
S and T8	2	3	7	15	63	4.49	0.939
S and T9	0	2	12	25	51	4.39	0.803
S and T10	3	6	38	25	18	3.54	0.996
S and T11	4	6	26	28	26	3.73	1.089

Source: The authors (2024).

The results of this section of the questionnaire offer an analysis of customer perceptions regarding sustainability in the banking sector, highlighting significant nuances in this segment's opinions on sustainable practices. Regarding the understanding of the pillars of sustainability, a positive trend was observed, with most participants expressing agreement (approximately 94%) with the vision of the triple bottom line, which encompasses environmental, economic, and social aspects. Furthermore, innovation and technology were perceived positively, showing customers' recognition of their potential impact on sustainable practices, with only 7.78% of respondents showing indifference or disagreement.

However, a significant portion of participants are not aware of their banks' sustainability plans, with only 4.44% of respondents completely agreeing, while approximately 85% showed indifference or disagreement. These results suggest possible gaps in communication about sustainable initiatives or a lack of knowledge on the part of customers about their banks' sustainable practices. Furthermore, opinions regarding the perception of sustainable policies in bank branches showed considerable diversity, with 51.11% of participants remaining neutral in this aspect.

The view on the application of sustainable practices in banking organizations revealed divided opinions, indicating varied understandings about the viability and challenges associated with these practices. While 28.89% of respondents agreed to some degree, 36.67% reported partial or total disagreement. However, participants demonstrated agreement on the importance of customer knowledge regarding sustainable practices and the need for policies to encourage sustainability in bank branches, with approximately 70% of customers agreeing to some degree with these statements.

In the financial sphere, the survey revealed a positive perception among participants, with the majority agreeing that a bank branch can increase their income by being more sustainable (84% of responses agreed). However, knowledge about the use of new technologies to improve sustainability (approximately 43% of respondents agree to some degree to the detriment of the 42.2% who are indifferent) and the perceived relationship between a more sustainable banking institution and a more technological one (approximately 60% of respondents agree to some degree to the detriment of the 28.89% who are indifferent) presented more divided responses, indicating uncertainty or a lack of clarity about how technologies can contribute to sustainable practices.

This comprehensive analysis of results provides insight into customer attitudes towards sustainability in the banking sector, highlighting areas of convergence, such as understanding the concept of sustainability and the importance of innovation and technologies to achieve it, and divergences, such as the relationship between technological improvement, sustainable development, the use of these technologies within banks and sustainable practices in their branches. These conclusions can also be inferred by observing the means and standard deviations of the responses, where the factors (S and T1), (S and

T2), and (S and T3) presented the highest means (4.69; 4.59; 4.54) and the smallest standard deviations (0.574; 0.669; 0.767), respectively. In contrast, questions (S and T4), (S and T5), and (S and T6) presented the lowest means (2.38; 2.84; 2.83) and the most prominent standard deviations (1.167; 1.038; 1.335), suggesting non-homogeneous perceptions among bank customers. Questions (S and T10) and (S and T11) showed indicators close to the central index, with averages of 3.54 and 3.74, while questions (S and T7), (S and T9), and (S and T8), with a tendency towards agreement, presented an average of 4.04; 4.39; 4.49, respectively.

4.3. Perception of Sustainability 4.0

In this third part of the questionnaire, we sought to capture customers' perceptions regarding these adapted benefits, providing valuable insight into how customers in the banking sector perceive the integration of sustainability 4.0 in their environment, and thus, contribute to a more comprehensive understanding of the implications of these benefits in the specific context of banking services. The adaptation of items for the questionnaire reflects a strategic approach. The respondents' responses were subjected to descriptive analysis, and the results can be seen in Table 6.

Table 6. Descriptive analysis.

Ranking	Question (Factor)	Response Frequency					Average (x)	Standard Deviation (SD)
		1	2	3	4	5		
1	Q-04 (ECO)	0	1	3	22	64	4.66	0.60
2	Q-07 (ECO)	0	0	10	21	59	4.54	0.69
3	Q-46 (ENV)	0	0	11	24	55	4.49	0.71
4	Q-18 (ECO)	0	1	13	24	52	4.41	0.78
5	Q-53 (ENV)	1	4	8	21	56	4.41	0.91
6	Q-02 (ECO)	2	1	10	26	51	4.37	0.89
7	Q-19 (ECO)	1	3	11	26	49	4.32	0.90
8	Q-21 (ECO)	2	2	13	21	52	4.32	0.96
9	Q-22 (ECO)	1	0	14	30	45	4.31	0.82
10	Q-06 (ECO)	2	3	11	24	50	4.30	0.97
11	Q-23 (ECO)	1	2	12	30	45	4.29	0.86
12	Q-40 (SOC)	1	3	12	28	46	4.28	0.90
13	Q-20 (ECO)	3	3	9	26	49	4.28	1.01
14	Q-25 (SOC)	3	2	11	26	48	4.27	0.99
15	Q-14 (ECO)	1	3	15	24	47	4.26	0.93
16	Q-42 (ENV)	1	1	16	31	41	4.22	0.86
17	Q-08 (ECO)	4	4	9	25	48	4.21	1.09
18	Q-28 (SOC)	2	2	17	24	45	4.20	0.97
19	Q-15 (ECO)	3	2	14	27	44	4.19	1.00
20	Q-47 (ENV)	0	3	17	32	38	4.17	0.85
21	Q-10 (ECO)	2	3	14	30	41	4.17	0.96
22	Q-05 (ECO)	4	4	13	22	47	4.16	1.11
23	Q-55 (ENV)	2	1	16	33	38	4.16	0.91
24	Q-54 (ENV)	0	4	16	34	36	4.13	0.86
25	Q-03 (ECO)	2	0	19	33	36	4.12	0.90
26	Q-52 (ENV)	0	3	18	36	33	4.10	0.84
27	Q-09 (ECO)	7	3	12	22	46	4.08	1.22
28	Q-11 (ECO)	3	5	15	28	39	4.06	1.06
29	Q-17 (ECO)	2	2	20	31	35	4.06	0.95
30	Q-49 (ENV)	2	5	16	30	37	4.06	1.01
31	Q-31 (SOC)	4	3	13	34	36	4.06	1.04
32	Q-38 (SOC)	1	1	21	37	30	4.04	0.85
33	Q-44 (ENV)	2	4	18	30	36	4.04	0.99
34	Q-51 (ENV)	0	6	17	36	31	4.02	0.90

Table 6. Cont.

Ranking	Question (Factor)	Response Frequency					Average (x)	Standard Deviation (SD)
		1	2	3	4	5		
35	Q-45 (ENV)	4	2	17	32	35	4.02	1.04
36	Q-16 (ECO)	3	2	20	30	35	4.02	1.01
37	Q-26 (SOC)	4	1	21	28	36	4.01	1.04
38	Q-39 (SOC)	1	3	25	27	34	4.00	0.95
39	Q-12 (ECO)	4	7	16	22	41	3.99	1.17
40	Q-43 (ENV)	4	4	16	32	34	3.98	1.07
41	Q-24 (SOC)	4	5	19	25	37	3.96	1.12
42	Q-01 (ECO)	2	8	15	34	31	3.93	1.04
43	Q-36 (SOC)	3	5	18	34	30	3.92	1.03
44	Q-48 (ENV)	3	7	18	29	33	3.91	1.09
45	Q-41 (SOC)	4	3	23	29	31	3.89	1.06
46	Q-33 (SOC)	5	5	19	27	34	3.89	1.15
47	Q-37 (SOC)	4	5	22	29	30	3.84	1.09
48	Q-13 (ECO)	3	9	21	27	30	3.80	1.11
49	Q-30 (SOC)	1	8	23	36	22	3.78	0.96
50	Q-50 (ENV)	8	6	18	27	31	3.74	1.25
51	Q-29 (SOC)	6	7	23	24	30	3.72	1.20
52	Q-32 (SOC)	8	8	26	21	27	3.57	1.25
53	Q-35 (SOC)	12	6	28	22	22	3.40	1.30
54	Q-34 (SOC)	13	14	25	21	17	3.17	1.31
55	Q-27 (SOC)	19	13	23	16	19	3.03	1.43
Cronbach's alpha		0.969						
Kendall's W		0.115						
Chi-Square		560.121						
SD		54						

Source: The authors (2024).

The data presents a ranking with means and standard deviations, for each question related to the economic (ECO), social (SOC), and environmental (ENV) dimensions. The responses related to the economic dimension indicate a positive perception of the relationship between sustainable practices and economic aspects, with averages varying between 3.80 and 4.66 (0.86 points difference), demonstrating a relatively high agreement.

In social aspects, there is a positive assessment regarding the interaction between sustainability and social aspects, with averages varying from 3.17 to 4.28 (1.11 points difference), with a slightly wider fluctuation, indicating a diversity of opinions among participants. Finally, the perception of sustainability in relation to the environment is also positive, with averages varying between 3.74 and 4.49 (0.75 points difference). A level of agreement stands out in the responses regarding sustainable practices linked to the environment with the average of the responses, having the smallest difference and suggesting a positive assessment of 4.0 technologies to assist in the environmental pillars of TBL in the view of banking customers.

The ranking presented details that the factors Q-04 (ECO), Q-07 (ECO), and Q-46 (ENV), were those with the highest average in responses, with 4.66; 4.54, and 4.49 points, respectively. The first two factors are related to economic aspects and the last to environmental aspects. It is suggested that the points with greater agreement are precisely those to which the customer is already feeling the benefits, with the reduction in service time and the increased satisfaction and practicality in subscribing to financial services, which is in line with the main findings of studies by [9,32,34]. Furthermore, the use of digitalization in the banking segment makes a noticeable reduction in waste and unnecessary inputs for current demands.

On the contrary, the five questions that presented the worst averages were concentrated in the social benefits category, with the three worst evaluations being alternatives Q-27

(SOC), Q-34 (SOC), and Q-35 (SOC) with a score of 3.03, 3.17, and 3.40 demonstrating a certain difficulty among bank customers in reaching a consensual answer on the topic.

Thus, the questions, from worst to best, were: “I believe that 4.0 technologies can help the retention of employees who serve me in the banking sector”; “I believe that 4.0 technologies can increase the autonomy of elderly customers in the banking sector” and “I believe that 4.0 technologies can increase the quality of life of elderly customers in the banking sector”. Regarding the issue of banking jobs, it is suggested that disagreement is associated with the initial perception of unemployment associated with technological replacement, despite the studies by [32,33] reaching the conclusion that there will be changes in the demands on the skills of bank employees, without debating in depth the impact on the number of jobs. Another concern perceived by customers is linked to the use of digital devices by older people, suggesting that there is no agreement that 4.0 technologies can benefit them in the use of day-to-day financial demands, as partially discussed by [26].

Finally, in the descriptive analysis, the frequencies indicate the amplitude of the responses. It is noted that most questions present a complete range of answers, from the minimum to the maximum possible values (1 to 5). This suggests that participants are using the full Likert scale available, which enriches the analysis by capturing a variety of opinions. Therefore, the diversification in responses can indicate a degree of homogeneity in customer opinions, while at the same time allowing important nuances and divergences in perceptions about sustainability in the banking sector to be captured.

Cronbach’s alpha is among the methods that provide estimates of the degree of consistency of a measure with the confidence of most researchers [56]. It is a measure of internal reliability and was calculated to verify consistency between questions applied to customers. The value obtained, 0.969, reveals robust reliability in the questionnaire responses. According to the standard Cronbach’s alpha scale, this value indicates that the questions are highly correlated and consistent, suggesting that the questionnaire is capable of reliably measuring customers’ perception of sustainability in the banking sector.

With the intention of measuring the degree of agreement or disagreement between bank customers’ responses, the non-parametric test known as Kendall’s coefficient of agreement (Kendall’s W) was used. Kendall’s coefficient is preferred when dealing with ordinal data, such as rating defects on a scale of 1 to 5, as it considers order. Their values range from 0 to +1, indicating the strength of the association. A high or significant coefficient suggests that evaluators apply similar standards [57]. Therefore, values closer to 1 indicate a greater level of agreement between respondents, while values closer to zero suggest greater disagreement in responses. Thus, this approach becomes a valuable tool in academic research to assess coherence in classifications or rankings, especially when they involve multiple assessments.

Thus, indicating a moderate level of agreement between bank customers’ responses, Kendall’s coefficient of agreement resulted in 0.115. This result suggests that, although there is some degree of agreement in the responses, this agreement is not very strong, demonstrating diversity in the participants’ responses. This information is crucial to understanding the variability in customer perceptions of sustainability in the banking sector, highlighting nuances and differences in respondents’ opinions.

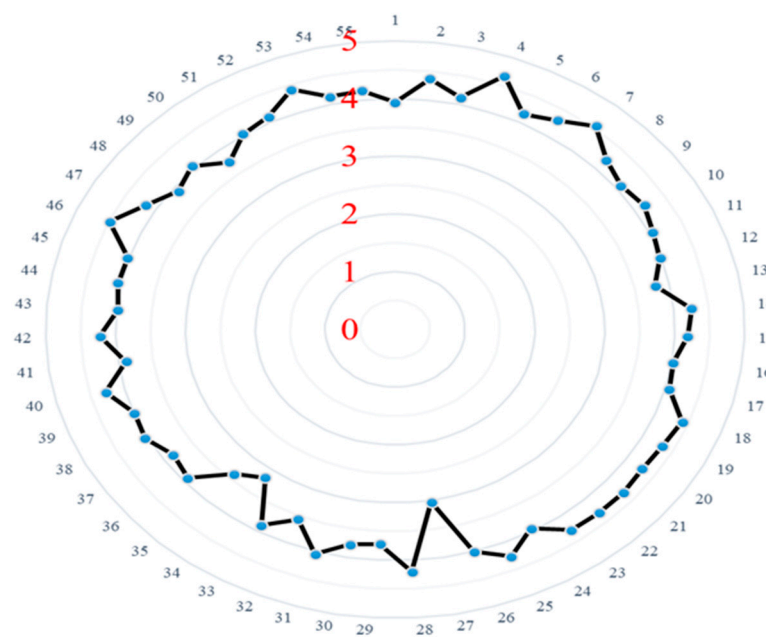
The choice of Kendall’s coefficient of agreement over other test statistics was made based on the nature of the data and the objectives of the study. When dealing with ordinal data, it is crucial to consider the order in which these classifications are made. Kendall’s coefficient is especially suitable for this, as it takes the order of ranks into account, unlike other measures that treat data as interval or proportional. However, it is important to recognize the limitations of this approach. Kendall’s coefficient is sensitive to sample size and may not fully capture nuances in responses. Furthermore, like any statistical method, it has its premises and assumptions, which must be considered when interpreting the results. Although other test statistics may be useful in different contexts, the specific choice of the Kendall coefficient reflects the suitability of this method to deal with the specific data and

objectives of the study in question, as it is designed to precisely measure the agreement between ordered classifications.

The chi-square indicator, or chi-square, is a statistic used to evaluate the association between categorical variables in a set of data. In the context of this study on S4.0 in the banking sector, chi-square was applied to analyze the relationship between different categories of bank customers' responses. The chi-square value obtained was 560.121, with 54 degrees of freedom (N-1). This result suggests that there is a statistically significant association between customer responses and the categories analyzed in the questionnaire.

This significant association indicates that customer responses did not occur by chance and are related to some specific pattern. The chi-square test allows us to understand the statistical dependence between variables, contributing to a deeper understanding of the factors that influence customer perceptions about sustainability in the banking context. In this way, chi-square strengthens the statistical validity of the study, supporting the relevance and reliability of the results obtained.

The radar chart, which can be seen in Figure 1, was built based on the averages of the benefits evaluated in different questions and provides a visual representation of customer perceptions about the benefits of S4.0 in the banking sector. Each question is associated with a line on the graph, and the position of the line indicates the average attributed by customers to the importance of the benefits. When analyzing the graph, it is possible to identify areas of greater consensus, represented by lines further from the center, indicating a more positive perception. On the other hand, lines closer to the center suggest areas where opinions may vary more.



When analyzing the willingness to adopt digital services, the high mean and standard deviation indicate a positive slope, in line with digitalization trends. General satisfaction with banking services is perceived as positive, reinforcing the continued importance of a competitive banking offering in the current scenario [21,22]. These trends suggest that the transition to digital services is increasingly relevant, emphasizing the importance of continuous customer satisfaction to maintain competitiveness in the current market.

The second section of the questionnaire demonstrated variation in means and standard deviations suggesting non-homogeneous perceptions among bank customers, highlighting the complexity and diversity of points of view in this specific context. The results reveal a positive attitude among customers in relation to sustainability in the banking sector, with a majority expressing agreement with the triple bottom line principles, highlighting the perception of sustainability with environmental, economic, and social aspects. Similarly, innovation and technology were assessed with consensus for their potential impact on sustainable banking practices.

However, the lack of knowledge about banks' sustainability plans indicates possible gaps in communication or lack of knowledge on the part of customers. Divergent opinions on the perception of sustainable policies in branches and the application of these practices in banking organizations highlight the complexity and diversity of understandings about the viability and challenges associated with these initiatives, suggesting organizational policies for disclosing banking sustainability.

The research indicates a positive view regarding the ability of bank branches to increase their income through sustainability. However, there are divided opinions about the role of new technologies in this context, reflecting uncertainty or lack of clarity about the contribution of these technologies to sustainable practices.

As for the questions asked based on the study by [13] regarding the economic dimension, their averages indicated relatively high agreement, suggesting that participants perceive the relationship between sustainable practices and economic aspects in a positive way. The same pattern extends to issues related to the environment, with a consistent average, indicating a favorable perception of 4.0 technologies in benefit of the environmental pillars of the triple bottom line. Both dimensions had the benefits with the greatest perception by bank customers, which were the improvement in the efficiency of banking services linked to the reduction in time spent in branches, ease of access to banking services through digital channels, and the reduction in waste.

However, the analysis reveals a diversity of opinions in the social dimension, with more varied averages. Questions related to social benefits had the worst averages, suggesting a certain difficulty among bank customers in reaching a consensual answer on the topic. The specific questions about the permanence of employees, autonomy, and quality of life of elderly customers reflect a lack of consensus, possibly associated with concerns about unemployment and the adaptation of older people to 4.0 technologies in the banking sector.

These findings offer a solid basis to guide future strategies in the banking sector, guiding managers and public policymakers in decision-making in the banking sector. The importance of considering social concerns is highlighted for more effective adoption of 4.0 technologies [47]. In short, understanding the complexity of customer perceptions is fundamental to driving sustainable and technological advancement in the sector, promoting innovation and continuous satisfaction. These insights are crucial to guide future strategies in this regard.

6. Conclusions

This study plays a significant role in shedding light on customer perceptions regarding the benefits resulting from the implementation of sustainability 4.0 in the banking sector. His contributions are notable, starting with his customer-centric approach to evaluating how the adoption of sustainable technologies directly influences banking customers' experiences and perspectives. By focusing on customer perception, the study offers a holistic view of the implications of sustainability 4.0, going beyond traditional organization-centered analyses.

Despite the results obtained in this research, it is necessary to recognize some limitations inherent to the study. Firstly, the complexity of the financial services sector demands substantial complementation from sector specialists. While the data collected provides a comprehensive view of customer perceptions, a more in-depth analysis by professionals with practical experience can add additional perspectives and interpret the results considering the specific dynamics of the banking environment.

Furthermore, the intricate nature of financial services implies unique characteristics that may not be fully addressed in this study. The banking sector, due to its diversity of services and constant evolution, may present characteristics that require further investigation on a broader scale. The generalization of results to the entire financial sector may be limited, considering the variety of institutions, regulations, and market dynamics. Therefore, the need for more studies on a larger scale is evident, providing a more robust basis for generalizable insights applicable to different realities in the field of financial services.

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Appendix A. Questionnaire for Evaluation of the Benefits Generated by Sustainability 4.0

Part I: Information analysis of the profile of bank customers.

Variable	Feature
Gender	() Masculine
	() Feminine
	() Not declared
Age	() 18 to 25 years old
	() 26 to 30 years old
	() 31 to 35 years old
	() 36 to 40 years old
	() 41 to 45 years old
	() 46 to 50 years old
	() 51 to 55 years old
	() Over 56 years old
Education	() High school
	() Graduation
	() Postgraduate

Variable	Feature
Type of bank	() Private
	() Public
	() Both
Time as a bank customer	() Less than 1 year
	() Between 1 and 5 years
	() Between 5 and 10 years
	() Over 10 years
Number of bank accounts in different institutions	() 1 bank account
	() 2 bank accounts
	() 3 bank accounts
	() 4 bank accounts
	() 5 bank accounts
	() More than 5 bank accounts
Bank occurrence	() Traditional Banks
	() Fintechs
	() Other banks
Main bank account	() Traditional Banks
	() Fintechs
	() Other banks

Part II: Sustainability and technology in the banking sector.

Code	Factor	Evaluated Aspect	Likert Scale				
S and T1	Sustainability has three essential pillars: the environment, the economy and society.	Perception about Pillars of Sustainability.	1	2	3	4	5
S and T2	The Innovation Process in organizations can help with sustainable practices.	Relationship between Innovation and Sustainability.	1	2	3	4	5
S and T3	The use of technology in organizations can help with sustainable practices.	Impact of Technology on Sustainable Practices.	1	2	3	4	5
S and T4	I know the sustainability plans of my bank(s).	Knowledge about Sustainability Plans.	1	2	3	4	5
S and T5	I consider the sustainable policies applied in my bank branch(es) these days to be excellent.	Assessment of Sustainable Policies in Banking Agencies.	1	2	3	4	5
S and T6	I consider that sustainable practices are difficult to apply in banking organizations.	Perception on the Application of Sustainable Practices.	1	2	3	4	5
S and T7	I consider customers' knowledge of banks' sustainable practices to be essential.	Importance of Customer Knowledge about Sustainable Practices.	1	2	3	4	5

Code	Factor	Evaluated Aspect	Likert Scale				
S and T8	I consider it essential for bank branches to have policies to encourage sustainability.	Importance of Sustainability Incentive Policies in Banking Agencies.	1	2	3	4	5
S and T9	A bank branch can increase its revenue by being more sustainable.	Financial Perspective of Sustainability.	1	2	3	4	5
S and T10	My bank already uses new technologies to improve sustainability.	Knowledge about Using Technologies to Improve Sustainability.	1	2	3	4	5
S and T11	A more sustainable banking institution is necessarily a more technological institution.	Relationship between Sustainability and Technology in Banking Institutions.	1	2	3	4	5

Part III: Benefits of I4.0 in the banking services sector studied.

Benefits	Code	Factor Studied	Dimension	Likert Scale				
Efficiency	Q-01 (ECO)	Technologies 4.0 (such as Bradesco BIA's Artificial Intelligence or Mobile Banking) can mitigate losses due to internal and external failures (account security flaws, poorly explained contracts, etc.)	Economic	1	2	3	4	5
	Q-02 (ECO)	Technologies 4.0 can assist in the acquisition of a product/service in the banking sector, such as loans, opening accounts, applying for cards, etc.	Economic	1	2	3	4	5
	Q-03 (ECO)	Technologies 4.0 can improve the human service offered in the banking sector, such as forwarding to management, SAC, requests for help at the branch and ombudsman.	Economic	1	2	3	4	5
	Q-04 (ECO)	Technologies 4.0 can make service in the banking sector more efficient, reducing the time the customer spends in your branch.	Economic	1	2	3	4	5
	Q-05 (ECO)	It is easier to purchase a product/service from a more digitalized and technological bank that uses artificial intelligence, chatbots and cybersecurity than from another bank that does not use these technologies.	Economic	1	2	3	4	5
Innovation	Q-06 (ECO)	Technologies 4.0 can make a financial institution more modern, using services and technologies that are more attractive to customers.	Economic	1	2	3	4	5
	Q-07 (ECO)	Technologies 4.0 can facilitate the use of smartphones, tablets, computers, and notebooks in the daily use of financial services, such as checking your bank account, requesting loans, or making investments.	Economic	1	2	3	4	5
	Q-08 (ECO)	Technologies 4.0 can replace traditionally face-to-face banking services, such as bill payments at physical branches or account openings, making these channels entirely digital.	Economic	1	2	3	4	5

Benefits	Code	Factor Studied	Dimension	Likert Scale				
Innovation	Q-09 (ECO)	Technologies 4.0 can generate new solutions to existing problems in the banking sector, such as reduced waiting times for service, abusive interest rates and lack of clarity regarding fees and services.	Economic	1	2	3	4	5
	Q-10 (ECO)	Technologies 4.0 can generate new solutions to unexpected problems in the banking sector, such as security flaws and lack of information provided by the bank.	Economic	1	2	3	4	5
Performance	Q-11 (ECO)	Technologies 4.0 can guarantee greater quality for bank branches.	Economic	1	2	3	4	5
	Q-12 (ECO)	Technologies 4.0 can offer a more personalized service for my needs in the banking sector.	Economic	1	2	3	4	5
	Q-13 (ECO)	Technologies 4.0 can reduce risks in the banking sector, such as financial fraud.	Economic	1	2	3	4	5
Financial	Q-14 (ECO)	The use of technologies 4.0 can increase the organization's profits in the banking sector.	Economic	1	2	3	4	5
	Q-15 (ECO)	Technologies 4.0 can reduce banking costs for customers, such as administrative fees and loan interest.	Economic	1	2	3	4	5
	Q-16 (ECO)	Technologies 4.0 can help me acquire better financial investments.	Economic	1	2	3	4	5
Macro	Q-17 (ECO)	Technologies 4.0 can increase the price of my bank's shares in the capital market.	Economic	1	2	3	4	5
	Q-18 (ECO)	Technologies 4.0 can make it easier for my bank to operate and provide services/products in other countries.	Economic	1	2	3	4	5
	Q-19 (ECO)	Technologies 4.0 can influence my choice of which bank I will use for my daily demands in the long term.	Economic	1	2	3	4	5
	Q-20 (ECO)	Technologies 4.0 can encourage me to permanently use digital channels to solve my banking needs.	Economic	1	2	3	4	5
Management	Q-21 (ECO)	Technologies 4.0 can collect data on consumer behavior in the banking sector.	Economic	1	2	3	4	5
	Q-22 (ECO)	Technologies 4.0 can make my main demands and requests clearer to my bank.	Economic	1	2	3	4	5
	Q-23 (ECO)	Technologies 4.0 can enable the development of unexplored solutions against fraud and security breaches in the banking sector.	Economic	1	2	3	4	5
Client	Q-24 (SOC)	Technologies 4.0 can make my bank's service environment more pleasant for me.	Social	1	2	3	4	5
	Q-25 (SOC)	Technologies 4.0 can speed up customer service in the banking sector.	Social	1	2	3	4	5
	Q-26 (SOC)	Technologies 4.0 can increase my quality of life when it comes to the banking sector.	Social	1	2	3	4	5

Benefits	Code	Factor Studied	Dimension	Likert Scale				
Client	Q-27 (SOC)	Technologies 4.0 can increase the autonomy of elderly customers in the banking sector.	Social	1	2	3	4	5
	Q-28 (SOC)	Technologies 4.0 can increase the quality of life of elderly customers in the banking sector.	Social	1	2	3	4	5
	Q-29 (SOC)	Technologies 4.0 can facilitate customer acceptance of technologies in the banking sector.	Social	1	2	3	4	5
Workplace	Q-30 (SOC)	Technologies 4.0 can help the retention of employees who serve me in the banking sector.	Social	1	2	3	4	5
	Q-31 (SOC)	Technologies 4.0 can improve my security at the branch, for example, reducing the risk of bank robberies.	Social	1	2	3	4	5
	Q-32 (SOC)	Technologies 4.0 could influence the widespread dismissal of workers in the banking sector.	Social	1	2	3	4	5
	Q-33 (SOC)	Technologies 4.0 can influence my agency's employees to be more capable and prepared for my needs.	Social	1	2	3	4	5
	Q-34 (SOC)	Technologies 4.0 can increase the digital security of services provided in the banking sector, thus preventing bank fraud, such as cloned cards, inappropriate purchases, suspicious connections.	Social	1	2	3	4	5
Society	Q-35 (SOC)	Technologies 4.0 may exclude a portion of the non-technological society from the banking sector.	Social	1	2	3	4	5
	Q-36 (SOC)	A bank that uses technologies 4.0 can offer a more digitalized service even to customers without digital devices, such as smartphones and notebooks.	Social	1	2	3	4	5
	Q-37 (SOC)	Technologies 4.0 can exclude economically more vulnerable customers from accessing the banking sector.	Social	1	2	3	4	5
	Q-38 (SOC)	Technologies 4.0 in the banking sector can allow for greater understanding of the technological impact on social changes.	Social	1	2	3	4	5
	Q-39 (SOC)	Technologies 4.0 in the banking sector can create value for society.	Social	1	2	3	4	5
	Q-40 (SOC)	Technologies 4.0 in the banking sector can encourage society to adopt digital services, thus making it more technological and modern.	Social	1	2	3	4	5
	Q-41 (SOC)	Technologies 4.0 in the banking sector can make services accessible to a larger part of society.	Social	1	2	3	4	5

Benefits	Code	Factor Studied	Dimension	Likert Scale				
Energy Yield	Q-42 (ENV)	Technologies 4.0 can improve energy efficiency in the banking sector.	Environmental	1	2	3	4	5
	Q-43 (ENV)	Technologies 4.0 can encourage my banking institution to generate sustainable business in my region.	Environmental	1	2	3	4	5
	Q-44 (ENV)	Technologies 4.0 can encourage my bank to associate economic development with better use of natural resources.	Environmental	1	2	3	4	5
Inputs	Q-45 (ENV)	Technologies 4.0 can improve e-waste management in the banking sector.	Environmental	1	2	3	4	5
	Q-46 (ENV)	Technologies 4.0 can reduce waste in the banking sector, such as the use of paper.	Environmental	1	2	3	4	5
Environmental Impact	Q-47 (ENV)	Technologies 4.0 can improve environmental monitoring and management mechanisms in the banking sector.	Environmental	1	2	3	4	5
	Q-48 (ENV)	Technologies 4.0 can reduce the emission of polluting gases in the banking sector.	Environmental	1	2	3	4	5
	Q-49 (ENV)	Technologies 4.0 can reduce my journey to bank branches, resulting in a reduction in my use of individual and/or collective transport.	Environmental	1	2	3	4	5
	Q-50 (ENV)	Technologies 4.0 can encourage me to have teleservice in the banking sector with my manager.	Environmental	1	2	3	4	5
Organizational Effects	Q-51 (ENV)	Technologies 4.0 can develop a culture of conscious consumption of natural resources in my bank's internal processes.	Environmental	1	2	3	4	5
	Q-52 (ENV)	Technologies 4.0 can encourage lower interest rates for more sustainable businesses.	Environmental	1	2	3	4	5
	Q-53 (ENV)	Technologies 4.0 can help implement environmental standards in the banking sector.	Environmental	1	2	3	4	5
	Q-54 (ENV)	Technologies 4.0 can create sustainable competitive advantage in the banking sector.	Environmental	1	2	3	4	5
	Q-55 (ENV)	Technologies 4.0 can improve the quality of environmental management in the banking sector.	Environmental	1	2	3	4	5

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