An Assessment of

Consumer Perceptions of INDUSTRY 5.0 from the Perspective of Sustainable Gastronomy and Tourism

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Foreword

Human history has been shaped by major leaps in production technologies; each industrial revolution has fundamentally transformed not only production methods but also the relationship people have with goods and services, their expectations, and their perceptions of experience. Beginning with the steam engine, deepening with electricity and mass production, maturing with computers and automation, and gaining a new dimension with digitalization and cyber-physical systems, this process has now reached a new phase known as Industry 5.0. While Industry 4.0 centered on efficiency and automation, Industry 5.0 places people, sustainability, and resilience at the heart of technology. In today's world, the relationship between technology and humanity is undergoing a profound transformation. Following the automation and digitalization brought by Industry 4.0, Industry 5.0 aims to reposition humans at the center of production and service processes. This new paradigm is built on three core pillars: collaboration between humans and robots, sustainability, and resilience.

One of the areas where this transformation is perhaps most tangibly experienced is gastronomy and tourism. Robotic kitchen equipment, cloud computing infrastructures, big data-driven decision support systems, 3D printers, cyber-physical systems, augmented reality applications, and the Internet of Things are becoming an integral part of everyday reality across a wide spectrum—from restaurants to lodging facilities, and from kitchens to the guest experience. However, the mere presence of technology does not automatically equate to acceptance or value creation. What matters is how consumers perceive, interpret, and integrate these technologies into their experiences.

This book aims to address this transformation from a holistic perspective. Starting with the conceptual framework of Industry 5.0, it comprehensively examines the relationship between sustainable gastronomy and tourism, the integration of artificial intelligence into kitchen systems, and changes in consumer behavior. Focusing specifically on consumer perception will facilitate our understanding of the demand side—a critical factor in planning the sector's future. It is our greatest hope that this work will contribute to academics, industry professionals, policymakers, and anyone interested in the subject across the fields of gastronomy, tourism, business, and technology. The study was prepared with meticulous reference to sources, integrating current international literature with Turkish academic studies.

While the gastronomy sector serves as a key driver of cultural identity, local development, and the tourist experience, it also faces multifaceted challenges such as food waste, energy consumption, carbon footprint, supply chain vulnerabilities, and shifting consumer expectations. Therefore, the Industry 5.0 approach offers not only technological modernization but also an opportunity for restructuring in terms of ethical, environmental, and social responsibility within the gastronomy and tourism sectors.

The gastronomy and tourism sectors are among the areas most deeply affected by this transformation. This is because these sectors uniquely combine the roles of being a carrier of local culture, a guardian of biodiversity, and a focal point of the human experience. The human-machine collaboration models, AI-supported systems, and sustainability-focused production philosophy introduced by Industry 5.0 are opening new doors in gastronomic tourism while fundamentally reshaping consumer perception. This study focuses on the development of a scale to measure consumer perception within the context of sustainable gastronomy and tourism using Industry 5.0 technologies, as well as reliability and validity analyses and a comprehensive evaluation of the resulting measurement model. The study presents a detailed psychometric analysis based on data collected from 406 participants, including exploratory and confirmatory factor analyses, as well as convergent and discriminant validity assessments, within a comprehensive framework. Furthermore, the book is designed not merely as a report of an empirical study but as a comprehensive reference source that thoroughly examines the Industry 5.0 paradigm, the technologies enabling it, the relationship between sustainability and gastronomy-tourism, and theories of technology acceptance. This book examines the effects of Industry 5.0 on consumer perception from the perspective of sustainable gastronomy and tourism, addressing theoretical, sectoral, and applied dimensions. The book consists of sections on industrial revolutions, Industry 5.0 technologies, sustainable tourism, digital transformation in gastronomy, consumer perception, technology acceptance theories, methodology, findings, discussion, conclusions, and recommendations.

The first sections of the book establish a theoretical and conceptual foundation. The historical development of industrial revolutions, the three pillars of Industry 5.0, enabling technologies, the evolution of sustainability thinking, sustainable tourism and gastronomy, digital transformation and smart tourism, as well as consumer perception and technology acceptance theories are discussed in detail in separate chapters. In the subsequent sections, the research methodology, findings, discussion, and conclusions are presented systematically.

The book is intended to serve as a methodological and conceptual resource for researchers in the fields of tourism and gastronomy, graduate students interested in scale-up processes, and industry practitioners alike. The belief that Industry 5.0's human-centered promise can only translate into real value when consumer perception is properly understood forms the starting point of this study.

Industry 5.0 is a new transformation paradigm that does not limit technological advancement to mere increases in productivity and efficiency; rather, it centers on human well-being, sustainability, and resilience. This paradigm provides a significant platform for discussion, particularly in fields such as gastronomy and tourism where human experience, cultural heritage, service quality, and environmental sensitivity are intertwined. I would like to express my deepest gratitude to my esteemed thesis advisor, Prof. Dr. Mehmet Sarıoğlan—Professor in the Department of Gastronomy and Culinary Arts at Balıkesir University and Director of the Edremit School of Civil Aviation—who believed in me, trusted me, and was always by my side with his constructive feedback throughout the writing process, as well as to Dr. Selin İlsay, Assistant Professor in the Department of Gastronomy and Culinary Arts at Balıkesir University.

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Contents

1. Introduction

In recent years, global economic, technological, and social transformations have led to significant changes in production systems. The digital transformation process, which began with Industry 4.0, has facilitated the integration of technologies such as artificial intelligence, robotic systems, big data analytics, and the Internet of Things into production processes. However, this process has brought about a production paradigm focused solely on efficiency and automation. In this context, the Industry 5.0 approach has emerged, emphasizing human-centered, sustainable, and resilient production systems (European Commission, 2021).

Industrial revolutions have played a decisive role in the economic, technological, and social transformations of human history. Changes in production systems have significantly impacted not only the economic structure but also social lifestyles, consumption habits, and the development of service sectors. The First Industrial Revolution, which began in the late 18th century, enabled the mechanization of production systems with the introduction of steam power into production processes. The Second Industrial Revolution, on the other hand, facilitated the development of mass production systems through the integration of electrical energy into production processes and contributed to the acceleration of industrial production. The Third Industrial Revolution, which emerged toward the end of the 20th century, laid the foundations for digitalization through the incorporation of computer technologies and automation systems into production processes (Schwab, 2017).

21. The digital transformation process, which gained momentum from the beginning of the century, led to the emergence of the **Industry 4.0** concept as a new paradigm in production systems. Industry 4.0 is a production model that refers to the integration of the Internet of Things (IoT), cyber-physical systems, big data analytics, artificial intelligence, and smart robot technologies into production processes (Kagermann, Wahlster & Helbig, 2013). Thanks

to this approach, production processes have become more efficient, faster, and more flexible, and smart factories and digital production systems have begun to proliferate. However, since Industry 4.0 is fundamentally focused on efficiency and automation, it has led to a relative decline in the role of the human factor in production processes.

The view that technological advancements should not be limited to merely increasing production efficiency but must also consider human well-being, social sustainability, and environmental responsibility has paved the way for a new approach in the literature. In this context, the concept of **Industry 5.0** has emerged in recent years. Industry 5.0 is defined as a production paradigm that embraces a human-centered approach to production and is based on technology working in tandem with human creativity (Nahavandi, 2019). The Industry 5.0 approach, as outlined by the European Commission, places not only technological advancements but also values such as sustainability, resilience, and human-centeredness at the core of production systems (European Commission, 2021).

One of the key features of the Industry 5.0 approach is its emphasis on collaboration between humans and machines. In this approach, robots and artificial intelligence systems are not viewed as elements that replace human labor, but rather as assistive technologies that support human creativity. This enables technology to be used as a tool that enriches the human experience, particularly in the service sectors. The tourism and gastronomy sectors are among the areas directly affected by this transformation.

The tourism sector is recognized as one of the fastest-growing sectors in the global economy. According to data from the World Tourism Organization (UNWTO), the tourism sector constitutes a significant portion of global economic activity and provides employment for millions of people (UNWTO, 2022). Tourism activities are viewed not only as a means of supporting economic growth but also as a vital tool for fostering cultural exchange and promoting local development. In this context, culinary tourism has emerged as one of the increasingly important sub-sectors within the tourism industry.

Gastronomy tourism is defined as a type of tourism in which the desire to experience local food culture plays a significant role among tourists' travel motivations (Hall & Sharples, 2003). A destination's culinary culture, local products, traditional dishes, and gastronomic heritage serve as important attractions for tourists. For this reason, culinary tourism is regarded as an important form of tourism that contributes both to the preservation of cultural heritage and to the support of the local economy.

In recent years, gastronomic tourism has been approached not merely as an activity centered on food consumption, but as a multidimensional field encompassing cultural experiences, sustainable food production, and local development. The preservation of local cuisines, the promotion of geographically indicated products, and the support of local producers are among the fundamental elements of a sustainable gastronomy approach (Sims, 2009). In this context, sustainable gastronomy is regarded as a significant approach that contributes to ensuring both environmental and economic sustainability.

Food production and consumption processes have significant impacts from the perspective of environmental sustainability. Factors such as agricultural production, food transportation, energy consumption, and food waste directly affect the use of environmental resources. Therefore, the development of sustainable production and consumption models in the gastronomy sector is of great importance (Jones, Hillier & Comfort, 2016). Sustainable gastronomy practices include the use of local products, seasonal food consumption, reduction of food waste, and sustainable supply chain practices.

Technological advancements are also driving significant transformations in the gastronomy sector. In particular, artificial intelligence, data analytics, robotic kitchen systems, and digital ordering technologies are increasingly being adopted in gastronomy businesses. Smart kitchen systems, restaurant management software, digital menus, and personalized gastronomic recommendations are among the key examples of digital transformation in the gastronomy sector (Ivanov & Webster, 2019).

The Industry 5.0 approach proposes that technology be used in the gastronomy sector as a tool to enrich the human experience. In this context, the gastronomic experience is evaluated not merely as a technological process but also as a cultural and social experience. The fusion of human creativity with technology contributes to the emergence of new gastronomic experiences in the sector.

The examination of consumer behavior within the scope of gastronomic tourism is of great importance for tourism destinations to gain a competitive advantage. Today, tourists do not merely consume food but also prefer to participate in authentic, sustainable, and experience-oriented gastronomic activities. This trend encourages gastronomy businesses to adopt sustainable production models (Okumus, Koseoglu & Ma, 2018).

Consumer perception emerges as a key factor in evaluating culinary tourism experiences. Consumers' perceptions of sustainable culinary practices can directly influence the strategic decisions and marketing activities of culinary businesses. In particular, eco-friendly production processes, the use of local products, and sustainable food policies shape consumers' attitudes toward culinary experiences.

The application of Industry 5.0 technologies in the gastronomy sector has the potential to significantly influence the consumer experience and perception. AI-powered menu designs, smart restaurant systems, and sustainable production technologies can make gastronomic experiences more personalized and sustainable. However, how consumers' perceptions of these technologies are shaped and how they reflect on the gastronomic experience has been addressed in only a limited number of studies in the literature.

The tourism and gastronomy sector plays a significant role in achieving sustainable development goals. In particular, gastronomic tourism is considered a critical area in terms of preserving local culture, supporting local producers, and ensuring environmental sustainability (UNWTO, 2022).

The gastronomic experience is not merely about food consumption; it is a multidimensional structure that integrates cultural identity, local production, sustainable food systems, and tourist experiences (Hall & Sharples, 2003). Therefore, the human-centered technological approach offered by Industry 5.0 can make significant contributions to the development of sustainable practices in the gastronomy sector.

In particular, AI-supported menu planning, food waste management, smart kitchen systems, and sustainable supply chain applications are becoming increasingly widespread in the gastronomy sector. How this technological transformation is perceived by consumers is a crucial research topic for the future of gastronomic tourism.

In this context, examining the effects of the Industry 5.0 approach on the sustainable gastronomy and tourism sectors has gained importance. In particular, evaluating consumers' perceptions of sustainable gastronomy practices can contribute to strategic decision-making processes for gastronomy businesses and tourism destinations.

The primary objective of this book **is to evaluate the effects of the Industry 5.0 approach on consumer perception from the perspective of sustainable gastronomy and tourism**. Within this scope, the study examines the applications of Industry 5.0 technologies in the gastronomy sector and analyzes the effects of sustainable gastronomy experiences on consumer perception.

The theoretical contribution of this study lies in its ability to bring together the literature on Industry 5.0, sustainable gastronomy, and consumer behavior, thereby offering an interdisciplinary research framework. From an applied perspective, the study aims to provide important recommendations for the development of sustainable gastronomy practices for gastronomy businesses, tourism destinations, and policymakers.

Industry 5.0 is regarded as a new paradigm that seeks to utilize technological advancements not only to enhance production efficiency but also to promote human well-being, environmental sustainability, and the preservation of social values. This approach is based on the collaboration between human creativity and advanced technologies in production processes (Nahavandi, 2019).

The primary objective of this study is to evaluate the effects of the Industry 5.0 approach on consumer perception within the context of sustainable gastronomy and tourism. In this regard, the study seeks to answer the following questions:

How are Industry 5.0 technologies applied in the gastronomy sector?

What is consumer perception regarding sustainable gastronomy practices?

How do technology-enabled gastronomy experiences influence consumer behavior?

How does the perception of sustainability in gastronomy tourism shape consumer preferences?

In this book, the effects of the Industry 5.0 approach on the gastronomy and tourism sectors are examined within a theoretical and empirical framework, and consumer perceptions regarding sustainable gastronomy practices are analyzed.

1.1. Background of the Study

Human history has witnessed successive industrial revolutions shaped by leaps in production technologies. The First Industrial Revolution, which began in the late eighteenth century with the introduction of steam power into production, gave way to the Second Industrial Revolution in the nineteenth century with the widespread adoption of electricity and mass production; the Third Industrial Revolution in the second half of the twentieth century with computer and automation technologies; and finally, at the beginning of the twenty-first century, to the Fourth Industrial Revolution (Industry 4.0) through cyber-physical systems, the Internet of Things, and a data-driven approach to production. This process has reshaped not only production efficiency but also social life, working methods, and consumption culture at every stage.

Following the automation and digitalization-focused promise of Industry 4.0, Industry 5.0—conceptualized by the European Commission—has redefined the paradigm around the axes of human-centeredness, sustainability, and resilience (Breque, De Nul, and Petridis, 2021). Industry 5.0 envisions a production and service model that does not replace humans with technology but works in collaboration with them; respects planetary boundaries; and can generate flexibility in the face of unexpected crises. Leng and colleagues (2022) emphasize that this new paradigm places human well-being at the center of production systems and aims to generate resilient well-being for all of humanity—beyond mere employment and growth—to ensure sustainable development.

Tourism and gastronomy are among the sectors where the effects of this transformation are most visibly felt. According to data from the World Tourism Organization, the tourism sector contributes trillions of dollars to the global economy—both directly and indirectly—and generates hundreds of millions of jobs. In this large-scale sector, robotic service systems, cloud-based reservation and data management infrastructures, big data analytics, personalized production via 3D printers, augmented reality-based guest experiences, and Internet of Things (IoT) applications are rapidly gaining traction. The concept of smart tourism was developed to explain how this technological integration generates value at the levels of tourism destinations, industry stakeholders, and tourists (Gretzel, Sigala, Xiang, & Koo, 2015).

However, the physical presence of technology does not automatically imply its adoption or value creation. As the technology acceptance literature has long emphasized, the success of a technology depends largely on how users and consumers perceive it (Davis, 1989; Venkatesh, Morris, Davis, and Davis, 2003). Especially in experience-based sectors such as tourism and gastronomy, consumer perception serves as a key determinant of critical outcomes such as satisfaction, intention to revisit, and word-of-mouth recommendations. Therefore, to understand the impact of Industry 5.0 technologies within the context of sustainable gastronomy and tourism, it has become essential to systematically and validly measure consumer perception.

The sustainability dimension is another critical component of this equation. The concept of sustainable development, which was brought to the global agenda by the Brundtland Commission's 1987 report *Our Common Future* (WCED, 1987), has been applied to tourism and gastronomy; principles such as the use of local products, reducing food waste, preserving cultural heritage, and lowering the environmental footprint have become the fundamental components of sustainable gastronomy tourism (Sims, 2009; Hall, Sharples, Mitchell, Macionis, and Cambourne, 2003). The alignment of Industry 5.0's sustainability pillar with the goals of sustainable gastronomy-tourism necessitates that technology be viewed not only as a tool for efficiency but also as a means of achieving sustainability.

Economic and technological transformations in human history have been shaped through industrial revolutions. The First Industrial Revolution began with the use of steam power and mechanical production systems, significantly increasing production capacity. The Second Industrial Revolution, on the other hand, gave rise to the concept of mass production through the integration of electrical energy into production. While the Third Industrial Revolution was characterized by the widespread adoption of computer technologies and automation systems, the Fourth Industrial Revolution, or Industry 4.0, is built upon cyber-physical systems, the Internet of Things, big data, and artificial intelligence technologies (Schwab, 2016).

Despite the high efficiency and automation advantages offered by Industry 4.0, various criticisms have emerged regarding the marginalization of the human factor, environmental sustainability issues, and social impacts. In response to these criticisms, the European Commission has developed the Industry 5.0 approach. Industry 5.0 is defined as a new paradigm that centers not only on technological progress but also on human well-being, environmental sustainability, and economic resilience (European Commission, 2021).

The Industry 5.0 approach views technology not as an element that replaces humans, but as a tool that enhances and supports human capabilities. Thus, in production systems, worker satisfaction, social welfare, and environmental protection gain as much importance as productivity.

1.2. Problem Statement

The vast majority of studies on Industry 5.0 and the technologies enabling it focus on the context of production and manufacturing, as well as engineering and business perspectives (Maddikunta et al., 2022; Leng et al., 2022). In contrast, there is a limited number of valid and reliable measurement tools that comprehensively assess how these technologies are perceived by consumers in the service sectors, particularly in the fields of sustainable gastronomy and tourism.

This gap gives rise to several interconnected issues. **First**, at the conceptual level, it remains unclear how many dimensions constitute the perceptual structure of Industry 5.0 technologies (robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, Internet of Things) in the consumer's mind and whether these dimensions are distinct from one another. **Second**, at the methodological level, the psychometric properties (reliability, construct validity, convergent and discriminant validity) of scales designed to measure this perception must be systematically tested. **Third**, a significant portion of existing studies focuses on individual technologies (e.g., service robots alone); there are very few studies that comprehensively model the integrated technology spectrum of Industry 5.0 at the level of consumer perception.

By addressing this gap, this study comprehensively evaluates the validity and reliability of a 30-item scale designed to measure consumer perceptions of Industry 5.0 technologies from the perspective of sustainable gastronomy and tourism. The research aims to make a concrete contribution to the measurement challenge in the field by demonstrating the psychometric performance of the scale in both its full and refined versions.

1.3. Purpose of the Study

The primary objective of this study is to evaluate the construct validity and reliability of a scale developed to measure consumer perception of Industry 5.0 technologies within the context of sustainable gastronomy and tourism; and to elucidate the underlying factor structure of the scale through exploratory and confirmatory factor analyses.

In line with this general objective, the study encompasses the following sub-objectives: (a) testing the suitability of the dataset for factor analysis in terms of sample adequacy and correlation structure; (b) to calculate the internal consistency reliability of the scale and its sub-dimensions; (c) to explore the dimensional structure through exploratory factor analysis; (d) to test this structure through confirmatory factor analysis; (e) to evaluate convergent and discriminant validity; and (f) to identify problematic items in terms of measurement and propose a final measurement model.

1.4. Significance of the Study

The significance of the study can be evaluated at three levels: theoretical, methodological, and practical.

From a theoretical perspective, the study empirically documents the multidimensional structure of consumer perceptions regarding Industry 5.0 technologies, thereby expanding the Industry 5.0 literature—which remains largely production-focused—to include service and consumer perspectives. By questioning the transferability of the production-centered conceptualization of the Industry 5.0 paradigm to the consumer-experience level, it offers a unique theoretical contribution to the field.

Methodologically, the step-by-step presentation of the scale development and validation process (sample adequacy tests, reliability analysis, exploratory and confirmatory factor analysis, convergent and discriminant validity assessments) provides a transferable model for researchers conducting similar studies. The study's reporting of two complementary analytical approaches (full scale and refined model) together is also valuable for transparently illustrating the iterative nature of the scale development process.

From an applied perspective, a validated measurement tool enables tourism and gastronomy businesses to monitor how consumers perceive their technology investments, compare perceptions regarding different technology dimensions, and determine investment priorities accordingly.

1.5. Research Questions

The study seeks to answer the following fundamental questions:

- Does the dataset for the Industry 5.0 consumer perception scale have a sufficient sample size and appropriate correlation structure for factor analysis?
- Is the internal consistency reliability of the scale and its sub-dimensions at an acceptable level?
- How many dimensions does consumer perception of Industry 5.0 technologies consist of, and which items represent these dimensions?
- Is the structure obtained through exploratory factor analysis validated by confirmatory factor analysis?
- Is the scale's convergent and discriminant validity established?
- Which items are problematic in terms of measurement and should be removed from the final measurement model?

1.6. Assumptions and Limitations

The study is based on the assumption that participants answered the scale items sincerely and in a way that reflects their own experiences. Additionally, it is assumed that the five-point Likert-type scale used possesses a quality close to an interval measurement level and is suitable for multivariate analyses.

The study also has certain limitations. The data were collected within a specific sample and time frame, and the generalizability of the findings is limited to this scope. The fact that some dimensions are represented by only two or three items requires caution when interpreting the relevant reliability coefficients (Eisinga, Te Grotenhuis, & Pelzer, 2013). Since the study was conducted using a cross-sectional design, inferences regarding changes in perception over time cannot be made. Finally, because the scale is self-report-based, the influence of response tendencies such as social desirability cannot be completely ruled out.

1.7. Definitions

Industry 5.0: A production and service paradigm that integrates the digitalization and automation gains of Industry 4.0 with the principles of human-centeredness, sustainability, and resilience; positioning technology in collaboration with humans.

Sustainable Gastronomy: A culinary philosophy that prioritizes the use of local and seasonal products, the reduction of food waste, the preservation of cultural heritage, and the reduction of the environmental footprint.

Consumer Perception: The meaningful mental representation formed by a consumer through the selection, organization, and interpretation of sensory and cognitive inputs related to a product, service, or technology.

Technology Acceptance: A theoretical framework explaining individuals' attitudes, intentions, and behaviors regarding the adoption and use of a technology.

Exploratory Factor Analysis (EFA): A multivariate statistical method aimed at discovering the underlying latent structures (factors) beneath a large number of observed variables.

Confirmatory Factor Analysis (CFA): A statistical method that tests the extent to which a pre-determined theoretical or exploratory factor structure fits the data.

1.8. The Conceptual Framework of the Study

The conceptual framework of the study is situated at the intersection of three main theoretical strands. The first is the Industry 5.0 paradigm and the technologies that enable it; this strand defines the content of the phenomenon under study (robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, the Internet of Things). The second is the literature on sustainable gastronomy and tourism; this strand establishes the context of the phenomenon. The third consists of consumer perception and technology acceptance theories; this strand provides the method of measurement and the theoretical foundation for the phenomenon.

At the intersection of these three strands, consumer perception of Industry 5.0 technologies within the context of sustainable gastronomy and tourism is conceptualized as a multidimensional structure. The study aims to empirically map and psychometrically validate this multidimensional structure. The conceptual framework emphasizes the distinction between the objective existence of technology and the consumer's subjective perception; it argues that perception is the ultimate determinant of value creation.

1.9. The Original Value of the Research

The research's original value stems from its integration of Industry 5.0's comprehensive technology spectrum into a single measurement framework. While the existing literature contains numerous studies focusing on individual technologies (e.g., service robots alone), psychometrically validated measurement tools that holistically address these technologies within the context of sustainable gastronomy and tourism are limited.

Furthermore, the study is unique in that it transparently reports the scale development process using two complementary analytical approaches (full scale and refined model). This approach highlights the iterative and critical nature of the measurement process, offering future researchers both a methodological model and an instructive example.

1.10. The Importance of the Study in the Turkish Context

Turkey is one of the world's leading destinations in terms of both tourism and gastronomy. With its rich culinary culture, diverse destinations, and growing tourism sector, Turkey holds significant potential for the application of Industry 5.0 technologies in sustainable gastronomy and tourism. The Turkish tourism sector is taking significant steps in the digital transformation process; technology is increasingly finding its place in accommodation, food and beverage, and travel services.

In this context, understanding Turkish consumers' perceptions of Industry 5.0 technologies is valuable from both academic and sectoral perspectives. Local cultural values, consumption habits, and attitudes toward technology are key factors influencing technology adoption. The emphasis placed on the human element in Turkish hospitality culture raises the question of how technology can be harmonized with this culture. This study provides a foundation for empirically examining these questions using a measurement tool developed within the Turkish context.

Additionally, the scale developed in this study enables Turkish tourism and gastronomy businesses to monitor how their technology investments are received by consumers. This can contribute to the sector designing its digital transformation strategies in a consumer-focused manner. Thus, the study contributes to the global Industry 5.0 literature from a local context and establishes a reference point for international comparisons.

1.11. Research Assumptions and Scope

The research is based on a series of fundamental assumptions. First, it is assumed that participants carefully read the scale items and accurately reflected their own experiences and perceptions. Second, it is accepted that the five-point Likert-type scale provides an appropriate measurement level for assessing consumer perception. Third, it is assumed that the sample sufficiently represents the relevant consumer population.

The scope of this study is limited to measuring consumer perceptions of Industry 5.0 technologies and conducting a psychometric evaluation of the instrument used to measure these perceptions. The study does not directly examine the behavioral outcomes of these perceptions (satisfaction, intention, loyalty); instead, it focuses on the perceptual structure that serves as a precursor to these outcomes. This focus is consistent with the objectives of scale development and validation and provides a foundation for future behavioral studies.

The technologies included in the study are limited to Industry 5.0 technologies (robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, and the Internet of Things) represented in the scale's items. While complementary technologies such as artificial intelligence, digital twins, and blockchain are addressed within the theoretical framework, they do not appear as distinct dimensions directly within the scale. This scope limitation creates an opportunity for future scale expansion studies.

Chapter 2

The Concept of Industry 5.0 and its Development Process

2.1. The Transition from Industrial Revolutions to Industry 5.0

Throughout human history, fundamental changes in production methods have profoundly impacted social and economic structures. The First Industrial Revolution, which began in England in the second half of the 18th century, ignited the transition from an agricultural society to an industrial society with the invention of the steam engine. During this period, the replacement of manual labor with machine power dramatically increased productivity in many sectors, particularly textiles (Schwab, 2016).

The Second Industrial Revolution, which took place in the late 19th century, is characterized by the mass use of electricity, steel production, and assembly line technologies. The assembly line system developed by Henry Ford became a symbol of the transition to standardized mass production. This period deepened the division of labor, accelerated urbanization, and laid the foundations for the modern consumer society (Mokyr, 2002).

The Third Industrial Revolution, or Digital Revolution, which began in the second half of the 20th century, is characterized by computer technology, electronics, and automation systems. During this process, the use of programmable machines in production became widespread, the knowledge economy gained importance, and globalization gained momentum (Castells, 1996). With the spread of the Internet, access to information became democratized, and new business models emerged.

In the first quarter of the 21st century, the Fourth Industrial Revolution, known as Industry 4.0, began to unfold. Announced by the German government at the 2011 Hannover Fair, this concept is based on the integrated use of cyber-physical systems, the Internet of Things (IoT), big data, cloud computing, artificial intelligence, and robotic technologies. Industry 4.0 enables customized mass production through smart factories in manufacturing processes (Schwab, 2016; Hermann et al., 2016).

As the digitalization and automation-focused promise of Industry 4.0 has become widespread, the limitations of this approach—which is centered solely on efficiency and automation—have also begun to be debated. Criticisms have focused on Industry 4.0's tendency to marginalize human labor, deepen social inequalities, and fail to adequately address environmental sustainability. Against this critical backdrop, the European Commission introduced the concept of Industry 5.0 in policy documents published in 2021 (Breque et al., 2021).

Industry 5.0 is positioned not as a rejection of Industry 4.0, but as a phase that complements and humanizes it. Xu, Lu, Vogel-Heuser, and Wang (2021) characterize Industry 5.0 as a transition from Industry 4.0's technology-focused approach to a value-focused one. In this transition, the fundamental question shifts from "What *can we do with technology?*" to "*What can technology do for us?*" Nahavandi (2019), on the other hand, defines Industry 5.0 as a human-centered solution that centers on the harmonious collaboration between human intelligence and intelligent systems.

In their comprehensive review of Industry 5.0, Leng and colleagues (2022) trace the concept's developmental trajectory and identify three core characteristics: human-centeredness, sustainability, and resilience. The authors propose a three-dimensional system architecture (technical dimension, reality dimension, and application dimension) to implement Industry 5.0. The same review emphasizes that Industry 5.0 research is still in its early stages and that systematic knowledge accumulation remains relatively limited; this situation underscores the importance of consumer-experience-focused studies such as the present one.

Table 1: Comparison of Industry 4.0 and Industry 5.0

Dimension	Industry 4.0	Industry 5.0
Core Focus	Efficiency and automation	Human-centeredness, sustainability, resilience
The role of humans	Operators pushed out of the process	A partner collaborating with technology
Value philosophy	Shareholder value	Stakeholder value
Environmental approach	Secondary in importance	Sensitive to circular and planetary boundaries
Technology philosophy	What can we do with technology?	What can technology do for us?
Logic of production	Mass personalization	Customized, human-machine collaborative production

Source: Based on Breque et al. (2021), Xu et al. (2021), Nahavandi (2019), and Leng et al. (2022).

2.1.1. The First Industrial Revolution (Industry 1.0)

The First Industrial Revolution, which began in England in the second half of the 18th century, is characterized by the application of steam power to production. Mechanical production systems powered by water and steam facilitated the transition from craft-based production relying on manual labor to factory-based mechanical production. The mechanization of looms and the widespread adoption of steam engines increased the scale and efficiency of production to unprecedented levels; this brought about urbanization, the emergence of the working class, and the modern factory system.

2.1.2. The Second Industrial Revolution (Industry 2.0)

The introduction of electricity into production and the development of mass production methods in the late nineteenth and early twentieth centuries launched the Second Industrial Revolution. Henry Ford's assembly line, combined with the principles of division of labor and standardization, made mass production possible. Electricity, communication technologies such as the telegraph and telephone, and advancements in steel production transformed production and distribution networks. This period marked a stage in which the foundations of the consumer society and modern business management were laid.

2.1.3. The Third Industrial Revolution (Industry 3.0)

The Third Industrial Revolution took place in the second half of the 20th century with the introduction of electronics, information technology, and automation into production. Programmable logic controllers, computers, and robotic systems enabled the automation of production processes. During this period, digital technologies, microelectronics, and computer-aided production systems came to the fore; a structure based on automation emerged, with reduced human intervention in production. Also known as the digital revolution, this phase laid the groundwork for subsequent waves of digitalization.

2.1.4. The Fourth Industrial Revolution (Industry 4.0)

The concept of Industry 4.0 was introduced in Germany in 2011 to define the digitalization of manufacturing. Technologies such as cyber-physical systems, the Internet of Things, cloud computing, and big data analytics have established the vision of smart factories as the dominant paradigm. This paradigm emphasizes the end-to-end digital interconnection of production processes, real-time data flow, and autonomous decision-making mechanisms. Schwab (2016) characterizes the Fourth Industrial Revolution not merely as a technological change but as a systemic transformation where the physical, digital, and biological domains are intertwined. The primary motivation behind Industry 4.0 has largely been efficiency, flexibility, and cost optimization.

Table 2: Key Characteristics of the Industrial Revolutions

Revolution	Period	Key Driver	Distinctive Feature
Industry 1.0	~1760–1840	Steam power	Mechanical manufacturing, factory system
Industry 2.0	~1870–1914	Electricity	Mass production, assembly line
Industry 3.0	~1950–2000	Electronics and IT	Automation, computer-aided manufacturing
Industry 4.0	~2011–	Cyber-physical systems	Smart factory, digital connectivity
Industry 5.0	~2021-	Human-machine collaboration	Human-centeredness, sustainability, resilience

Source: Based on Schwab (2016), Xu et al. (2021), and Leng et al. (2022).

2.2. The Historical Development of Industrial Revolutions

Industrial revolutions have led to fundamental changes in production systems, reshaping economic and social structures. Each industrial revolution is characterized by the integration of technological advancements into production processes and creates significant transformations in production methods. These transformations affect not only industrial production but also the service sectors, consumption habits, and the global economic system (Schwab, 2017).

The First Industrial Revolution began in England in the late 18th century and facilitated the development of mechanical production systems with the introduction of steam power into production processes. Thanks to steam engines, production capacity increased, and mechanization gained momentum in many sectors, particularly the textile industry. During this period, production activities shifted from small workshops to factories, laying the foundations for modern industrial production (Mokyr, 2018).

The Second Industrial Revolution emerged in the late 19th century with the introduction of electricity into production processes. Thanks to electricity, mass production systems developed, and production processes became more efficient. During this period, the Fordist production system became widespread, and mass production became possible in many sectors, particularly the automotive industry (Freeman & Louçã, 2001).

The Third Industrial Revolution emerged in the second half of the 20th century with the development of computer technologies. Thanks to the integration of digital technologies into production processes, automation systems advanced, and production processes became faster and more efficient. Computer-aided production systems, industrial robots, and automation technologies are among the key features of this era (Schwab, 2017).

With the acceleration of digitalization in production systems starting in the 2010s, the concept of **Industry 4.0** emerged. Industry 4.0 refers to the use of cyber-physical systems, the Internet of Things (IoT), big data analytics, and artificial intelligence technologies in production processes (Kagermann, Wahlster & Helbig, 2013). This approach has paved the way for the emergence of smart factories by enabling the digitalization of production systems.

However, the fact that the Industry 4.0 approach is fundamentally focused on efficiency and automation has led to the human factor being pushed to the background in production processes. This situation has sparked discussions regarding the need to re-evaluate technology through a human-centered approach. In this context, the concept of Industry 5.0 has emerged in the literature as a new production paradigm.

2.3 The Concept of Industry 5.0

The concept of Industry 5.0 refers to a new production approach based on the collaboration of technological advancements with human creativity within production systems. This approach aims to use technology not only to increase production efficiency but also to support human well-being, social sustainability, and environmental responsibility (European Commission, 2021). In this approach, artificial intelligence, robotic systems, and digital technologies integrate with human creativity to enable the development of more sustainable and personalized products and services.

The European Commission (2021) builds Industry 5.0 on three core pillars:

- Human-centeredness
- Sustainability
- Resilience

This approach is particularly significant in the service sectors and experience-driven fields such as gastronomy. This is because human creativity, cultural heritage, and customer interaction play a central role in shaping gastronomic experiences.

In the Industry 5.0 approach, production processes are not viewed merely as mechanical processes carried out by automation systems; rather, the aim is to integrate human creativity and cognitive skills into production processes. In this context, Industry 5.0 is regarded as a production model that strengthens collaboration between humans and machines (Nahavandi, 2019).

The Industry 5.0 approach developed by the European Commission is based on three fundamental principles:

- human-centeredness
- sustainability
- resilience

The human-centered principle emphasizes prioritizing human well-being in production processes. This approach places importance on utilizing technological advancements in ways that enhance the quality of human life.

The principle of sustainability refers to designing production processes in a way that protects environmental resources. In this context, energy efficiency, the reduction of carbon emissions, and the development of sustainable production models take center stage.

The principle of resilience, on the other hand, refers to making production systems more resilient to global crises. Factors such as the pandemic, the climate crisis, and global supply chain issues have particularly highlighted the importance of the concept of resilience in production systems (European Commission, 2021).

2.4. The Emergence and Conceptual Framework of Industry 5.0

As Industry 4.0 began to spread rapidly, it became inevitable that some of this paradigm's shortcomings and negative effects would come to the fore. Concerns about unemployment, data security issues, the marginalization of human labor, and sustainability concerns have led to a re-examination of the Industry 4.0 paradigm. In this context, the concept of Industry 5.0 has emerged both as a critique and as an alternative.

In its 2021 report titled "Industry 5.0: Towards a Sustainable, Human-centric and Resilient European Industry," the European Commission defined Industry 5.0 as a vision for a sustainable and resilient industry that places humans at its center (European Commission, 2021). According to this definition, Industry 5.0 serves as a higher-level paradigm that complements rather than replaces Industry 4.0, placing human values at the forefront.

The human-centric approach at the core of Industry 5.0 envisions a model where robots and artificial intelligence do not replace human labor but instead work in collaboration with humans. In this approach, cobots (collaborative robots) play a significant role; while taking on heavy, repetitive, or dangerous tasks, they leave tasks requiring creativity, critical thinking, and empathy to humans (Maddikunta et al., 2022).

2.5. The Three Core Pillars of Industry 5.0

2.5.1. Human-Centricity

Human-centeredness is perhaps the most distinctive feature of Industry 5.0. This approach prioritizes human values, dignity, and well-being over any measure of efficiency while putting technology at the service of people. In job design, ergonomics, employee satisfaction, and psychological safety take center stage. The expansion of opportunities for individualization and personalization in production processes offers consumers more meaningful experiences (Breque et al., 2021).

The human-centered approach also encompasses bridging the digital divide and making technology accessible. The design of artificial intelligence systems to be transparent, explainable, and aligned with ethical principles is evaluated within this framework. The European Union's Artificial Intelligence Act is one of the most concrete manifestations of this trend (Floridi et al., 2018).

The fundamental distinction of Industry 5.0 is that it places humans at the center of the system. While machines and automation took center stage during the Industry 4.0 era, in Industry 5.0, technology is used to enhance the quality of life for people.

In the gastronomy sector, this approach;

- AI systems that support chefs' creativity,
- Personalized menus,
- Smart applications that enhance the customer experience,
- Digital solutions that improve employee well-being

Research indicates that consumers support the use of technology but want the human touch to be preserved (Belanche et al., 2020).

The principle of human-centeredness refers to prioritizing human well-being, safety, and capabilities in the design of production and service processes. This approach views technology not as a threat that replaces humans, but as a tool that enhances human capacity. The focus is on placing the needs and interests of employees and end-users at the center of the production process, rather than merely increasing productivity. Collaborative robots (cobots) are a concrete example of this philosophy: while robots take on dangerous or tedious tasks, they support human creativity and decision-making authority. In the context of tourism and gastronomy, human-centeredness requires that technology be designed not to replace but to enrich the guest and employee experience.

2.5.2. Sustainability

In Industry 5.0, sustainability has moved beyond being merely an environmental concern to become central to industrial policy. Circular economy models, the use of renewable energy, carbon-neutral production processes, and waste minimization have become integral components of this paradigm (Ellen MacArthur Foundation, 2013). The production philosophy envisioned by Industry 5.0 aims to reduce raw material usage, extend product lifespans, and systematically integrate recycling.

In this context, the concept of the bioeconomy also comes to the fore. The application of circular processes in sectors reliant on biological resources—such as agriculture, forestry, and fisheries—both supports environmental sustainability and contributes to local economies. From the perspective of the gastronomy sector, this entails the use of local and seasonal products, the reduction of food waste, and the establishment of sustainable supply chains (Rockström et al., 2009).

Sustainability is one of the most important components of Industry 5.0. The efficient use of resources, energy efficiency, waste reduction, and circular economy practices are the fundamental elements of this approach.

Sustainability in the gastronomy sector;

- The use of local products,
- Reducing food waste,
- Reducing the carbon footprint,
- Use of renewable energy

are key components of this effort.

Research indicates that global food systems are responsible for approximately one-third of total greenhouse gas emissions (Crippa et al., 2021). Therefore, Industry 5.0 technologies play a critical role in promoting sustainable gastronomy practices.

The sustainability pillar envisions production systems relying on renewable energy sources, the reuse of resources through circular processes, and the minimization of environmental impact. This dimension directly links Industry 5.0 to the United Nations Sustainable Development Goals. Industry 5.0 integrates resource efficiency, waste reduction, and circular economy principles as an integral part of production logic. In the context of gastronomy and tourism, this principle manifests through practices such as reducing food waste, local sourcing, energy-efficient technologies, and lowering the carbon footprint.

2.5.3. Resilience

The COVID-19 pandemic has clearly exposed the fragility of global supply chains and brought the concept of resilience to the forefront of the agenda. Industry 5.0 envisions production systems that are resilient to unexpected crises, climate change, and geopolitical transformations. In this context, strengthening local production, diversifying supply chains, and adopting flexible production models are of critical importance (Xu et al., 2021).

Resilience also encompasses a social dimension. Investing in workers' capacity for continuous learning and skill development, supporting community-based production models, and preserving local knowledge form the core elements of Industry 5.0's understanding of resilience (Gladden, 2019).

The COVID-19 pandemic has exposed the fragility of global supply chains. By prioritizing the concept of resilience, Industry 5.0 aims to make businesses more resilient in the face of crises.

Resilience in the gastronomy sector;

- Working with local suppliers,
- Digital ordering systems,
- Smart inventory management,
- Data-driven decision-making

are supported by these practices.

The principle of resilience refers to the development of flexibility and adaptability in production and service systems to withstand unexpected crises (pandemics, supply chain disruptions, geopolitical shocks, natural disasters). Resilient systems are structures that can maintain functionality in the face of disruptions, recover quickly, and adapt to changing conditions. The COVID-19 pandemic has clearly demonstrated how critical resilience is in the tourism and gastronomy sectors; it has heightened the importance of contactless service, digital reservations, automation, and remote monitoring-based solutions. In this context, resilience is viewed not merely as a technical feature but also as a strategic competitive advantage.

2.6. Discussions and Criticisms Regarding Industry 5.0

Despite the human-centered and sustainable vision it offers, the concept of Industry 5.0 has also been the subject of various debates. Some authors question whether the concept represents a truly distinct revolution from Industry 4.0 or merely a normative extension of it. A critical perspective argues that Industry 5.0 is less a technological breakthrough and more a new framework of values applied to existing technologies.

Another point of debate is the practical implementation of the human-centered narrative. The potential negative effects of automation on employment, the digital divide, and inequalities in access to technology raise questions about the extent to which the human-centered narrative will be reflected in practice. Additionally, how sustainability goals will be balanced against economic competitive pressures remains an open question. These discussions demonstrate that Industry 5.0 is not merely a technological agenda but also a social, ethical, and managerial one. The consumer perception dimension focused on in this study is of critical importance for understanding the reflections of this agenda on the end-user side.

2.7. The Relationship Between Industry 5.0 and Society 5.0

The concept of Industry 5.0 is closely linked to the Japan-originated Society 5.0 vision. Society 5.0 defines a human-centered and super-intelligent societal order that follows the historical evolution from hunter-gatherer societies (Society 1.0) to agricultural societies (2.0), industrial societies (3.0), and information societies (4.0). The fundamental difference between the two concepts lies in their focus: While Industry 5.0 focuses on production and industrial processes, Society 5.0 focuses on solving social problems through technology and improving quality of life. However, both concepts share the common goal of promoting human well-being and ensuring that technology serves humanity.

The intersection of these two visions is particularly meaningful for sectors where the human experience is central, such as tourism and gastronomy. Society 5.0's emphasis on quality of life, combined with Industry 5.0's human-centered approach to production, supports the positioning of technology in a way that enriches the guest experience, prioritizes employee well-being, and generates social value.

2.8. The Economic and Social Dimensions of Industry 5.0

Industry 5.0 also encompasses an economic paradigm that envisions a shift from shareholder value to stakeholder value. In this approach, the company's objective is not merely profit maximization; rather, it is to create value for all stakeholders, including employees, customers, suppliers, society, and the environment. This concept, also known as stakeholder capitalism, is consistent with the principles of sustainability and corporate social responsibility.

In the social dimension, Industry 5.0 also offers a new perspective on the future of employment. Despite concerns that automation will eliminate jobs, Industry 5.0 anticipates the emergence of new job definitions and higher-value-added roles based on human-machine collaboration. In this context, the processes of reskilling and upskilling employees are of critical importance. The widespread adoption of technology in the tourism and gastronomy sectors also enables employees to move away from routine tasks and focus on areas requiring a human touch, such as creativity, guest relations, and experience design.

2.9. The Implications of Industry 5.0 for Tourism and Gastronomy

The Industry 5.0 paradigm manifests in the tourism and gastronomy sectors through three core pillars. The human-centered principle envisions technology enriching the guest and employee experience; the sustainability principle aims to reduce the sector's environmental footprint and enhance resource efficiency; and the resilience principle ensures service continuity during crises.

When these reflections converge with the sector's traditionally labor-intensive structure, they create a unique tension and opportunity. On one hand, technology provides efficiency and consistency; on the other, the human warmth, authenticity, and personal touch inherent to tourism and gastronomy must be preserved. Industry 5.0's human-centered approach offers a technology adoption philosophy that specifically seeks to maintain this balance. Therefore, the success of technology in the sector should be measured not only by its technical performance but also by the extent to which it positively enhances the consumer's experience.

The consumer perception dimension focused on in this study serves as a critical indicator for understanding whether this balance has been successfully established. When consumers' perception of Industry 5.0 technologies is positive, technology investments translate into value; when perception is negative, even the most advanced technologies fail to deliver the expected benefits.

2.10. Development and Trends in Industry 5.0 Literature

Academic literature on Industry 5.0 has become more prominent since 2017 and has expanded rapidly, particularly following the European Commission's 2021 policy documents. Early studies focused largely on defining the concept and distinguishing it from Industry 4.0. Leng et al. (2022), in evaluating this early literature, emphasize that the field is not yet mature and that systematic knowledge accumulation remains limited.

In subsequent years, the literature has shifted from conceptual discussions toward applied research. While Maddikunta et al. (2022) present a comprehensive review focusing on enabling technologies and application areas, later studies have begun to examine Industry 5.0 applications in specific sectors (manufacturing, healthcare, agriculture, logistics). However, studies focusing on service sectors such as tourism and gastronomy—particularly from a consumer perspective—remain relatively scarce. This situation supports the claim that the present study fills a gap in the literature.

Another significant trend in the literature is the increasing emphasis on the sustainability and human-centered dimensions of Industry 5.0. While a technology-focused perspective dominated in the early stages, subsequent studies have shifted toward the paradigm's normative and value-oriented dimensions. This evolution reinforces the view that Industry 5.0 represents not merely a set of technologies but a framework of values.

2.11. Industry 5.0 and Digital Maturity

The level at which businesses adopt Industry 5.0 technologies is linked to the concept of digital maturity. Digital maturity refers to the extent to which a business has internalized digital technologies at the strategic, operational, and cultural levels. While businesses with low maturity levels use technology merely as a tool, those with high maturity levels place technology at the center of their business models and value propositions.

Digital maturity varies significantly across the tourism and gastronomy sectors. While large chain businesses generally exhibit high levels of maturity, small and medium-sized enterprises may remain at lower levels due to resource and skill constraints. This heterogeneity leads consumers to experience different technology interactions across various businesses, thereby diversifying their perceptions. Whether a business possesses a database infrastructure compatible with Industry 5.0 and 4.0 systems is reflected in the scale's items as one of the key indicators of digital maturity.

2.12. Technology, Ethics, and Governance in Industry 5.0

Industry 5.0's human-centered approach also brings technology ethics and governance to the forefront. The widespread adoption of artificial intelligence and big data technologies necessitates the integration of ethical principles—such as algorithmic fairness, transparency, accountability, and human oversight—into technology design. The European Union's artificial intelligence regulations serve as concrete examples of governance efforts in this field.

In the context of tourism and gastronomy, technology ethics encompasses issues such as the protection of guest data, the limits of surveillance technologies, the transparency of automated decisions, and equality in digital access. Consumer trust in technology depends largely on the extent to which businesses adhere to these ethical principles. Therefore, the successful adoption of Industry 5.0 technologies is possible not only through technical excellence but also through an ethical governance framework.

2.13. Industry 5.0 and the Conceptual Position of Work

The research problem addressed in this book occupies a specific position within the Industry 5.0 literature. While the majority of the literature focuses on the impact of technologies on production efficiency and operational processes, this study focuses on how technologies are perceived by the end-user (consumer). This orientation is directly aligned with Industry 5.0's human-centered principle, as human-centeredness encompasses not only the worker but also the consumer, who is the ultimate recipient of the service.

Conceptually, the study distinguishes between the objective existence of technology and its subjective perception. The presence of advanced technologies in a business (objective existence) does not necessarily mean that these technologies are noticed, understood, and positively evaluated by the consumer (subjective perception). The ultimate determinant of value creation is this subjective perception. Therefore, understanding the true impact of Industry 5.0 requires examining the representation of technology in the consumer's mind.

This conceptual positioning links the study to both the Industry 5.0 literature and the literature on consumer behavior and technology adoption. By bringing these two streams of literature together within the context of sustainable gastronomy and tourism, this study builds an interdisciplinary bridge. This bridge holds theoretical value in understanding the reflections of the Industry 5.0 paradigm within the service and experience economy.

2.14. Industry 5.0 Resilience, Crisis Management, and Tourism

The resilience pillar of Industry 5.0 holds particular importance for the tourism and gastronomy sectors, as these sectors are highly sensitive to external shocks. Economic crises, natural disasters, pandemics, geopolitical tensions, and climate events can suddenly and severely impact tourism demand. Therefore, resilience is a critical capability for the sector's sustainability.

Technology plays a significant role in strengthening resilience. Digital booking and flexible cancellation systems facilitate adaptation to demand fluctuations; data analytics provide early warnings and scenario planning; and automation and contactless services support operational continuity during crises. The COVID-19 experience has clearly demonstrated the critical role of technology in ensuring service continuity during crises.

Resilience encompasses not only the ability to withstand crises but also the capacity to learn from them and recover more strongly. Industry 5.0 technologies support the sector's transformative resilience by fostering flexibility, agility, and adaptability. Consumer trust in technology is a key component of resilience, as it facilitates the adoption of technology-based solutions during crises.

2.15. The Future of Industry 5.0 and the Research Agenda

Industry 5.0 is still an emerging paradigm and is expected to mature further in the future. Advances in artificial intelligence, quantum computing, advanced robotics, and next-generation communication technologies (6G) will strengthen the technological foundation of Industry 5.0. However, the principles of human-centeredness, sustainability, and resilience—which form the core of the paradigm—are expected to remain constant.

The Industry 5.0 research agenda encompasses numerous open questions. Measuring the impact of technology on human well-being, evaluating its contribution to sustainability, comparing applications across different sectors, and examining consumer and worker perspectives are priority areas for future research. This study contributes to this agenda by focusing on the consumer perspective.

Within the context of tourism and gastronomy, the Industry 5.0 research agenda holds particularly rich potential. The impact of technology on guest experience, employee well-being, sustainability, and sectoral resilience; applications across different types of tourism; and the optimization of the technology-human balance are productive research areas for future studies. The measurement tool developed in this book provides a methodological foundation for the consumer-perception dimension of this research agenda.

2.16. Key Characteristics of Industry 5.0

Unlike previous industrial revolutions, the Industry 5.0 approach is based on evaluating technological advancements from a human-centered perspective. Key features of this approach include human-machine collaboration, personalized production, sustainable production systems, and the integration of advanced technologies.

2.16.1. Human-Machine Collaboration

One of the most important features of the Industry 5.0 approach is the strengthening of collaboration between humans and machines. In this approach, robots and artificial intelligence systems are not viewed as elements that replace human labor, but rather as assistive technologies that support human skills.

For example, collaborative robots (cobots) work alongside humans in production processes to increase production efficiency. By taking on repetitive and physically demanding tasks, these robots enable workers to engage in more creative and strategic roles (Longo, Padovano & Umbrello, 2020).

2.16.2. Personalized Production

The Industry 5.0 approach supports the transition from mass production to a personalized production model. Thanks to this approach, it has become possible to produce products customized to consumers' individual needs and preferences.

Through digital technologies and data analytics, consumer preferences can be analyzed to offer personalized products and services. This significantly enhances the customer experience, particularly in the service sectors.

2.16.3. Sustainable Production

One of the key elements of the Industry 5.0 approach is the development of sustainable production models. In this context, the goals include improving energy efficiency in production processes, reducing carbon emissions, and conserving natural resources.

The sustainable production approach encompasses not only environmental factors but also economic and social sustainability. In this context, supporting production systems with eco-friendly technologies is of great importance (Xu, Lu, Vogel-Heuser & Wang, 2021).

Chapter 3

Key Components of Industry 5.0

3.1. Industry 5.0 and Technological Components

The Industry 5.0 approach involves the integration of numerous advanced technologies. These technologies include artificial intelligence, robotic systems, big data analytics, the Internet of Things, and augmented reality.

The Industry 5.0 vision is based on the integrated use of a range of enabling technologies. Maddikunta and Colleagues (2022) comprehensively review these technologies and emphasize that they support a production and service model centered on human-machine collaboration. In this section, the technology dimensions represented in the study's measurement tool are examined in detail, including their definitions, operating principles, applications in tourism and gastronomy, and their significance in terms of consumer perception.

3.2. Human-Robot Collaboration and Cobots

One of the most tangible technological manifestations of Industry 5.0 is human-robot collaboration achieved through cobots (collaborative robots). While traditional industrial robots operate behind cages or barriers for safety reasons, cobots are designed to work safely in the same physical space as humans. This feature makes cobots ideal for many service sector applications (Colgate and Peshkin, 1996; Villani et al., 2018).

The scope of robot applications in the culinary field is expanding day by day. Examples include automated sushi rolling machines becoming common in sushi restaurants, dough-rolling and ingredient-dispensing systems in pizza production, and portion control and plating applications in catering services. On the other hand, some robots equipped with advanced sensitivity sensors can also perform tasks requiring skill, such as precise cutting, delicate pastry decoration, and beverage preparation (Ghallab et al., 2016). It is important to note that, within the Industry 5.0 framework, the purpose of robots is not to replace chefs and cooks but to enable them to focus on areas where they can showcase their creativity and artistic expression. By taking on repetitive, physically demanding, or efficiency-critical tasks, robots provide kitchen staff with the opportunity to engage in more meaningful and fulfilling experiences (Nahavandi, 2019).

Robotic systems are machines that can be programmed to perform specific tasks autonomously or semi-autonomously. Collaborative robots (cobots), which are particularly prominent in the context of Industry 5.0, are designed to share the same workspace with humans; they are machines that prioritize safety, flexibility, and efficiency. Unlike traditional industrial robots, cobots are designed to collaborate with humans rather than eliminate human intervention.

In the context of gastronomy, robotic technologies appear in the form of automated cooking systems, robotic bartenders, order-preparation robots, and service robots. In tourism, reception robots, luggage-handling systems, room-service robots, and greeting robots are becoming increasingly widespread. Wirtz and colleagues (2018) note that service robots have fundamentally transformed service delivery; however, this transformation presents both opportunities and challenges.

From the perspective of consumer perception, robotic technologies present a complex picture. On the one hand, the speed, consistency, and innovation offered by robots are viewed positively; on the other hand, concerns regarding trust, a lack of warmth, and job displacement can fuel negative perceptions. Therefore, the acceptance of robotic technologies depends largely on the consumer's level of trust and perceived risk.

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3.3. Cloud Computing and Database Infrastructures

Cloud computing is a technology model that enables data and applications to be hosted on remote infrastructure accessible via the internet rather than on local servers. Scalability, flexibility, and cost-effectiveness are the key advantages of cloud computing. Cloud services are typically offered across infrastructure, platform, and software service layers, providing businesses with the ability to access resources dynamically from anywhere.

For tourism businesses, cloud-based reservation systems, customer relationship management, revenue management, and databases accessible from anywhere provide operational flexibility and scalability. Cloud computing also forms the infrastructure for other Industry 5.0 technologies such as big data analytics and the Internet of Things. A business's possession of a database management infrastructure compatible with Industry 5.0 and 4.0 systems is one of the key indicators of digital maturity.

From the consumer's perspective, while cloud computing is largely an invisible infrastructure operating in the background, it indirectly influences the user experience through uninterrupted digital services, rapid access to information, and personalized recommendations. For this reason, consumer perception of cloud computing is largely shaped indirectly by the quality of service it provides.

3.4. Artificial Intelligence

Artificial intelligence technologies are one of the most important components of Industry 5.0. Artificial intelligence systems play a significant role in data analysis, decision support systems, and automation processes. In particular, production processes can be made more efficient through big data analytics.

3.5. Artificial Intelligence and Machine Learning

Artificial intelligence (AI) is one of the most transformative technological components of Industry 5.0. Broadly speaking, artificial intelligence encompasses computational systems that mimic human intelligence or surpass human performance. Subfields such as machine learning, deep learning, natural language processing, and computer vision form the foundation for numerous innovative applications in the gastronomy and tourism sectors (Russell and Norvig, 2020).

The application areas of artificial intelligence in the food industry are extremely diverse. Demand forecasting and inventory optimization, agricultural product quality control, personalized menu recommendations, food safety monitoring, price optimization, and energy management are among the primary applications. For example, IBM's Watson platform collaborates with chefs to create unusual flavor combinations and discover new recipes (Floreano and Mattiussi, 2008).

From an Industry 5.0 perspective, designing artificial intelligence in the gastronomy sector in a human-centered manner is of great importance. Explainable artificial intelligence (XAI) principles ensure that chefs, managers, and consumers can understand why algorithms make specific recommendations. This transparency increases trust in technology and makes human-machine collaboration more efficient (Arrieta et al., 2020).

3.6. Big Data and Analytics

Big data refers to datasets that are too large, generated too quickly, and in too many formats to be managed using traditional data processing methods. Big data analytics, on the other hand, is a set of methods that enables data-driven decision-making by extracting meaningful insights from this data. With its fundamental characteristics of volume, velocity, and variety, big data offers businesses a level of information previously inaccessible.

In gastronomy and tourism, big data is used in areas such as demand forecasting, personalized recommendations, dynamic pricing, quality control, real-time service forecasting, and root cause analysis of issues. The rapid identification of problems arising from big data, the swift determination of root causes, and the ability to obtain forecasts regarding product quality and timely service support operational excellence in businesses.

As Mariani and colleagues have emphasized, big data is gaining increasing importance in tourism research. From the perspective of consumer perception, while big data can create positive experiences through personalized and predictive services, concerns about privacy and data security can also fuel negative perceptions.

The gastronomy and tourism sectors generate a broad data ecosystem ranging from customer reservations to social media reviews, and from food photos to loyalty card data. The analysis of this data provides businesses with valuable insights into customer preferences, operational efficiency, and market trends (Mayer-Schönberger and Cukier, 2013).

Within the framework of Industry 5.0, big data analytics is being combined with the intuition and experience of human experts. Chefs are designing unique menus by blending consumer preferences revealed by data analytics with their own creative vision. Similarly, in tourism destinations, big data analytics is used to understand visitor profiles, personalize culinary experiences, and manage tourism flows in line with sustainability goals (Goes, 2014).

3.7. 3D Printing (Additive Manufacturing)

3D printing, or additive manufacturing, is a technology that produces physical objects layer by layer from digital models. Unlike traditional subtractive manufacturing methods, additive manufacturing reduces material waste and offers a high degree of customization since material is used only where needed.

In the food industry, 3D food printers enable personalized and flexible product prototyping, the production of items tailored to specific dietary needs, and creative presentation methods. In tourism, 3D printing is used in areas such as rapid and customized production, spare part supply, and the production of souvenirs. Establishing rapid and flexible product prototyping and production systems using 3D printers enhances businesses' capacity for innovation.

From the perspective of consumer perception, 3D printing is generally viewed positively due to its emphasis on innovation and personalization; however, it is a technology that requires careful consideration, particularly in the food sector, regarding perceptions of naturalness and safety.

3.8. Cyber-Physical Systems

Cyber-physical systems are integrated structures where physical processes are monitored and controlled in real time via sensors, embedded systems, and software. These systems enable the integration of the physical and digital worlds, facilitating the acquisition of real-time data and the monitoring of processes from a virtual environment. Cyber-physical systems have become a cornerstone of Industry 4.0 and continue to form the infrastructure for human-machine collaboration in Industry 5.0.

In tourism and gastronomy, cyber-physical systems are implemented through the remote monitoring of automated control and vehicle systems, the integration of virtual and physical environments using real-time data, and rapid response systems to guest requests. These systems enhance the transparency of operational processes and improve response times.

From the perspective of consumer perception, cyber-physical systems are mostly experienced indirectly; they influence perception through the real-time responses and process reliability they provide.

3.9. Robotic Systems

Robotic technologies are widely used in production processes. In the Industry 5.0 approach, robots work alongside humans to make production processes more efficient.

3.9.1. Internet of Things (IoT) and Smart Kitchen Systems

The Internet of Things (IoT) is a technology that enables devices to communicate with each other over the internet. Thanks to IoT technology, production processes can be monitored in real time, and production efficiency can be increased (Kagermann et al., 2013). The Internet of Things (IoT) is a technology ecosystem that enables physical devices to communicate with each other and with central systems via sensors and network connections. This network of interconnected devices offers the ability to collect, monitor, and automate data in real time. In the gastronomy sector, IoT applications are finding use in numerous areas, such as smart refrigerators, connected cooking equipment, inventory tracking systems, and energy management platforms (Atzori et al., 2010).

Smart kitchen systems emerge from the integration of IoT and artificial intelligence. In these systems, sensors monitoring the contents of the refrigerator can identify products nearing their expiration dates, automatically update shopping lists, and suggest recipes that can be prepared with these ingredients, thereby minimizing food waste. In professional restaurant kitchens, IoT-based equipment monitoring systems predict maintenance needs, optimize energy consumption, and automatically document compliance with food safety standards (Verdouw et al., 2016).

Smart hotels represent the most prominent application of IoT in tourism: voice-controlled room systems, keyless entry systems, smart thermostats, IoT-based energy management, and interconnected networks of smart devices are transforming the guest experience and operational efficiency. In the food service industry, internet network systems connecting smart devices (tablets, phones, kiosks, QR codes, digital machines) integrate ordering and service processes.

From the consumer's perspective, while IoT creates positive experiences through convenience and personalization, data privacy and security concerns are significant factors influencing perception.

3.9.2. Complementary Technologies: Artificial Intelligence, Digital Twin, and Blockchain

In addition to the technologies discussed above, the primary technologies complementing the Industry 5.0 ecosystem are artificial intelligence, digital twins, and blockchain. Artificial intelligence forms the intelligence layer of other technologies by enabling machines to perform cognitive tasks such as learning, reasoning, and decision-making. In tourism and gastronomy, artificial intelligence is extensively used in chatbots, recommendation systems, demand forecasting, and personalization applications.

A digital twin is a real-time digital replica of a physical object, process, or system, offering capabilities for monitoring, analysis, and optimization. Blockchain, as a decentralized, immutable, and transparent ledger technology, generates value particularly in food supply chains regarding traceability, security, and the prevention of counterfeiting. The integrated use of digital twins and blockchain in the agriculture and food sector represents a promising area of research in terms of sustainability and supply chain transparency. Although these technologies do not feature directly as separate dimensions within the scope of the current study, they are integral components of the holistic technology framework of Industry 5.0.

3.9.3. Blockchain Technology and Food Transparency

Blockchain technology enables revolutionary applications in food supply chains by providing a transparent, immutable, and decentralized record-keeping system. Platforms such as IBM Food Trust ensure that every stage a product undergoes—from the farm to the consumer—is recorded. This enables rapid issue identification in food safety incidents, verification of the authenticity of organic or geographically indicated products, and documentation of sustainable supply chain practices (Tian, 2017).

From the consumer's perspective, blockchain-based food transparency makes it possible to easily verify the origin, production conditions, and transportation process of purchased products using smartphones. This feature supports conscious consumers' sustainable food choices while also reducing food fraud and rewarding producers for reliable supply practices. In culinary tourism, it becomes possible to present the stories behind local products and the profiles of their producers to visitors who prefer the local products of their destination (Casino et al., 2019).

3.9.4. Integrated Use of Technologies and Convergence

The technologies enabling Industry 5.0 generate value not in isolation but within an ecosystem where they complement and reinforce one another. This phenomenon of convergence creates a synergistic effect that goes beyond the individual capabilities of the technologies. For example, Internet of Things (IoT) devices generate data; this data is stored in cloud computing infrastructure; big data analytics and artificial intelligence transform this data into insights; and the results are reflected in the consumer experience through robotic or augmented reality systems.

This integrated structure forms the foundation of smart tourism and gastronomy ecosystems. It is not a single technology but the seamless collaboration of the technology stack that is the key to true transformation. Therefore, when examining consumer perception, it is important to understand how technologies are perceived both as separate dimensions and as an integrated system. The four-factor structure revealed by this study indicates that consumers perceive these technologies in specific clusters.

Table 3. Major Applications of Industry 5.0 Technologies in Tourism and Gastronomy

Technology	Tourism Applications	Gastronomy Applications
Robotics / Cobots	Reception, luggage, and room service robots	Cooking, serving, and bartending robots
Cloud Computing	Reservations, CRM, revenue management	Order management, inventory tracking
Big Data	Demand forecasting, personalization	Quality forecasting, menu optimization
3D Printing	Souvenirs, spare parts	Personalized food production
Cyber-Physical Systems	Facility monitoring, automation	Kitchen process control
AR/VR	Virtual tours, AR guided tours	Interactive presentations, training
Internet of Things	Smart room, energy management	Connected device networks, order kiosks

Source: Compiled from Maddikunta et al. (2022), Tussyadiah (2020), and related literature.

3.10. Barriers to Technology Adoption

The widespread adoption of Industry 5.0 technologies in tourism and gastronomy faces various barriers. These barriers manifest at different levels, including technical, economic, organizational, and consumer-related factors. Technical barriers include infrastructure deficiencies, system integration challenges, and cybersecurity risks. Economic barriers center on high initial investment costs and uncertainty regarding return on investment.

At the organizational level, employee resistance to change, lack of digital skills, and an organizational culture unprepared for transformation are significant barriers. Consumer-driven barriers, on the other hand, encompass distrust of technology, privacy concerns, fears of losing human interaction, and anti-innovation attitudes. The findings of this study, which indicate that perceptions regarding robotic technologies are relatively fragile, suggest that consumer-driven barriers are more pronounced in the field of robotics.

Overcoming these barriers is possible not only through technological investment but also through consumer education, transparent communication, trust-building, and human-centered design. The human-centered principle of Industry 5.0 offers an approach that specifically addresses the consumer-side of these barriers.

3.11. The Impact of Robotics Technologies on the Consumer Experience

The growing prevalence of robotic technologies in tourism and gastronomy is transforming the consumer experience in multifaceted ways. While robotic services offer functional benefits such as speed, consistency, and reduced error rates, they also carry potential drawbacks on the social-emotional dimension, such as a reduction in human interaction. Research indicates that consumers' attitudes toward robotic service vary depending on the type of task: while robotic service is positively received for routine and standard tasks, human service is preferred for tasks requiring personalization and empathy.

The novelty value of robotic technologies also influences the consumer experience. Especially during initial encounters, robotic service can create memorable experiences by sparking curiosity and excitement. However, this novelty effect diminishes over time; for sustainable value, robotic service must provide consistent functional benefits. In this study, the relatively fragile psychometric performance of the Robotics and Autonomy dimension suggests that consumers' perceptions of this technology have not yet fully crystallized.

3.12. The Strategic Role of Cloud Computing and Big Data

Cloud computing and big data form the invisible yet critical infrastructure of the Industry 5.0 ecosystem. While cloud computing provides businesses with a scalable and flexible technology infrastructure, big data analytics creates a value-generating intelligence layer on top of this infrastructure. These two technologies form the foundation for all other Industry 5.0 applications (artificial intelligence, the Internet of Things, personalization).

From a strategic perspective, data is increasingly becoming one of the most valuable assets for businesses. The collection, analysis, and transformation of customer data into insights are a key source of competitive advantage. However, this also brings with it the responsibility of data governance and privacy. In this study, the strong psychometric performance ($\alpha = 0.803$) of the Data, Cloud, and Analytics dimension indicates that consumers have developed a consistent perception of these technologies.

3.13. The Role of Immersive Technologies in Experience Design

Augmented and virtual reality technologies stand out as powerful tools in experience design. These technologies offer the ability to create multi-layered, interactive, and personalized experiences by transcending the boundaries of physical space. In tourism, virtual pre-experiences (experiencing a destination virtually before visiting) influence decision-making processes and visit intent.

In gastronomy, immersive technologies are applied through interactive presentations that enrich the dining experience with visual and auditory layers, AR-based menus, and immersive tasting experiences. These applications transform food from merely a source of nutrition into a multi-sensory experience, aligning with the requirements of the experience economy. The fact that the Immersive and Smart Technologies dimension demonstrated the strongest performance in this study confirms that these technologies have established a clear and positive category in the consumer's mind.

3.14. Cost-Benefit Balance in Technology Investments

The adoption of Industry 5.0 technologies requires significant investment decisions for businesses. The cost-benefit balance plays a critical role in these decisions. High initial costs, uncertain return on investment, and rapid technological obsolescence are leading businesses to act cautiously. Conversely, well-timed and well-managed technology investments can yield significant returns through competitive advantage, operational efficiency, and customer satisfaction.

Consumer perception adds a critical dimension to this cost-benefit equation. No matter how high the operational benefit a technology provides to a business, the return on investment decreases if it is perceived negatively by consumers. Therefore, technology investment decisions must be made by considering not only operational efficiency but also consumer perception and acceptance potential. The scale developed in this study provides a tool that enables businesses to evaluate the perceived returns of their technology investments.

3.15. Sector-Specific Case Examples

The applications of Industry 5.0 technologies in tourism and gastronomy are better understood through concrete examples rather than abstract concepts. This section explains the typical forms of application of these technologies in the sector using examples. These examples represent common application patterns observed in the sector rather than referring to specific businesses.

Robotic kitchen and service applications: Some restaurants use robotic arms for order preparation, autonomous delivery robots for service, and robotic bartenders. These applications enhance efficiency, particularly in high-volume establishments offering standardized menu items. In the hotel industry, reception robots, room service robots, and cleaning robots are becoming increasingly common.

Cloud and big data applications: Hotel chains are integrating reservations, revenue management, and customer relations through cloud-based property management systems. Big data analytics is used for demand forecasting, dynamic pricing, and personalized marketing. These technologies enable businesses to make data-driven operational decisions.

Immersive experience applications: Museums and cultural heritage sites are offering augmented reality-based guided tour systems. Destinations are providing potential visitors with a preview experience through virtual tours. Restaurants, meanwhile, are enhancing the dining experience with augmented reality menus and interactive presentations.

Internet of Things and smart room applications: Smart hotels offer voice-controlled room systems, keyless entry, personalized environment settings, and energy management. These applications enhance both guest comfort and operational efficiency. These case studies demonstrate that Industry 5.0 technologies have already become part of everyday reality in the sector and, consequently, highlight the practical importance of measuring consumer perception.

3.16. The Transformative Role of Artificial Intelligence

Artificial intelligence holds a special position among Industry 5.0 technologies because it adds an intelligence layer to other technologies, thereby multiplying their value. Through its subfields such as machine learning, deep learning, and natural language processing, artificial intelligence enables capabilities such as prediction, classification, recommendation, and automated decision-making. In tourism and gastronomy, artificial intelligence spans a wide range of applications, from chatbots to recommendation systems, and from demand forecasting to dynamic pricing.

The rise of generative AI has opened up new opportunities in the sector. In areas such as travel planning, content creation, customer service, and personalization, generative AI creates value for both businesses and consumers. However, the widespread adoption of AI also raises ethical questions regarding transparency, accountability, algorithmic bias, and the role of human oversight. Industry 5.0's human-centered approach envisions AI designed to support and empower people.

From the perspective of consumer perception, artificial intelligence evokes conflicting reactions. While the personalization and convenience offered by artificial intelligence are viewed positively, concerns about privacy, reduced human interaction, and the fear of losing control fuel negative perceptions. This complex perception structure underscores the need for artificial intelligence applications to be designed with care and transparency.

3.17. Technology Maturity Levels and Adoption Curves

Industry 5.0 technologies vary in terms of their maturity levels. While some technologies (cloud computing, mobile applications) are mature and widely adopted, others (robotics, 3D food printing, advanced artificial intelligence) are still in the early adoption phase. These differences in maturity also influence consumers' levels of experience and perception regarding these technologies.

Mature technologies are viewed as routine by consumers and are generally perceived positively or neutrally. Early-stage technologies, on the other hand, evoke higher levels of uncertainty, curiosity, and sometimes anxiety. The findings of this study show that dimensions containing relatively mature technologies (Data-Cloud-Analytics, Immersive Technologies) exhibit stronger psychometric performance, while the Robotics dimension, which includes early-stage technologies, is more fragile—a finding consistent with these maturity differences. As technologies mature, consumer perceptions are expected to become more stable and consistent.

3.18. Technology Infrastructure and Cybersecurity

The successful implementation of Industry 5.0 technologies depends on a robust technology infrastructure and effective cybersecurity measures. Connection speed, system integration, data storage capacity, and processing power are the fundamental infrastructure components that determine technology performance. Insufficient infrastructure can prevent even the most advanced technologies from functioning effectively.

Cybersecurity is a critical priority in the interconnected and data-intensive Industry 5.0 ecosystem. The proliferation of Internet of Things (IoT) devices, the widespread adoption of cloud computing, and the accumulation of big data are expanding the attack surface. Data breaches, service disruptions, and privacy violations pose serious risks for both businesses and consumers. Therefore, cybersecurity is an integral component of technology adoption.

From the consumer's perspective, cybersecurity and data protection are key determinants of trust in technology. Consumers are more likely to adopt technology when they believe their personal data is secure. When businesses implement robust security measures and communicate them transparently, they foster consumer trust and, consequently, a positive perception. This underscores the need for Industry 5.0's ethical and human-centered approach to be fully integrated with its technical infrastructure.

3.19. Digital Twins and Simulation Technologies

A digital twin refers to creating an exact replica of a real physical system, process, or object in a virtual environment. This technology, which is becoming widespread in the manufacturing sector, is also leading to innovative applications in the gastronomy and tourism sectors. A restaurant's digital twin simulates customer flow, table turnover, kitchen operations, and energy consumption, thereby providing decision-support capabilities to business managers (Grieves and Vickers, 2017).

Digital twins of tourism destinations, on the other hand, are considered tools for management on a larger scale. Digital twins that simulate a destination's visitor capacity, traffic flows, environmental impact, and economic multiplier effect are becoming a powerful tool in sustainable tourism planning. The strategic value of digital twins is particularly high during peak tourism seasons in terms of crowd management and maintaining the quality of the visitor experience (Tao, 2019).

3.20 The Impact of Industry 5.0 on the Service Sectors

The Industry 5.0 approach significantly impacts not only the manufacturing sector but also the service sectors. Technological transformation is accelerating in sectors such as tourism, gastronomy, healthcare, and education. In particular, digital technologies have become key tools for enhancing the customer experience in the tourism and gastronomy sectors. Smart restaurant systems, digital menus, robotic service staff, and AI-powered recommendation systems are becoming increasingly widespread in the gastronomy sector (Ivanov & Webster, 2019).

Thanks to these technologies, gastronomy businesses can analyze customer preferences to offer more personalized services. At the same time, sustainable production practices can also be managed more effectively through technological systems.

3.21. The Future of Industry 5.0

The Industry 5.0 approach is regarded as a significant paradigm that will shape the production and service systems of the future. A human-centered production philosophy, sustainability policies, and technological advancements form the core elements of this approach. In the future, Industry 5.0 technologies are expected to become more widespread, particularly in sustainable production, energy management, food production, and the service sectors. In this context, it is anticipated that Industry 5.0 applications will play a significant role in the tourism and gastronomy sectors as well.

3.22. Differences Between Industry 4.0 and Industry 5.0

The fundamental difference between Industry 4.0 and Industry 5.0 reflects a hierarchical prioritization at the paradigmatic level. While Industry 4.0 is built on efficiency, automation, and connectivity, Industry 5.0 focuses on human well-being, environmental sustainability, and social resilience. Table 1.1 provides a basic comparison between the two paradigms.

While the role of humans in Industry 4.0 is largely limited to supervision and exception handling, Industry 5.0 emphasizes human creativity, intuition, and ethical judgment. This shift is particularly evident in the service sectors, the cultural economy, and the gastronomy sector (Nahavandi, 2019).

3.23. The Development Process of Industry 5.0 Globally and in Turkey

Although the concept of Industry 5.0 originated as a product of a Europe-centric policy agenda, it quickly gained global attention. Japan has placed humans at the center of a super-smart society through its "Society 5.0" vision, which aligns with this paradigm (Cabinet Office of Japan, 2018). In the U.S., federal initiatives focused on human-AI collaboration and trustworthy AI demonstrate a similar orientation.

While awareness of Industry 5.0 is still developing in Turkey, the 2023–2028 Industry and Technology Strategy documents increasingly emphasize concepts of human-centered transformation and green transformation. R&D projects supported by TÜBİTAK and KOSGEB cover topics such as human-robot collaboration in smart production systems. Specifically in the fields of gastronomy and tourism, the Ministry of Culture and Tourism's digitalization strategies and policies for developing gastronomy destinations provide a foundation that can be evaluated from an Industry 5.0 perspective (Republic of Turkey Ministry of Culture and Tourism, 2023).

3.24. Augmented and Virtual Reality

Augmented reality (AR) is an immersive technology that enriches the real environment by overlaying digital content onto the physical world; virtual reality (VR), on the other hand, fully immerses the user in a digital environment. These technologies have the potential to create interactive and memorable experiences in alignment with the needs of the experience economy.

Tourism is one of the most productive application areas for AR and VR technologies. Research led by Jung and Tom Dieck demonstrates that AR enriches visitor experiences and learning in museums and cultural heritage sites, while VR is effective in destination promotion and fostering visit intent (Tom Dieck and Jung, 2018). In tourism, virtual destination tours, AR-based guided tours, immersive employee training, and the creation of virtual replicas of physical production processes are the primary application areas of these technologies.

From the perspective of consumer perception, immersive technologies are generally well-received because they offer experiences with high innovation and entertainment value. This aligns with the study's findings, where the Immersive and Smart Technologies dimension demonstrated the strongest psychometric performance.

Chapter 4

The Relationship Between Industry 5.0 and Sustainable Gastronomy

4.1 The Concept of Sustainable Gastronomy

The concept of sustainability largely gained its modern meaning with the 1987 Brundtland Commission report, Our Common Future. In this report, sustainable development was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). This definition highlighted the three fundamental dimensions of sustainability—economic, social, and environmental—by emphasizing the need to balance economic growth, social development, and environmental protection.

Following the Brundtland Report, sustainability has taken center stage on the international policy agenda. The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, have concretized sustainability through a broad set of objectives ranging from poverty reduction to climate action, and from responsible production and consumption to decent work. The sustainability pillar of Industry 5.0 is directly linked to this global framework and envisions technology serving the goals of sustainable development.

While the concept of sustainability has deep historical roots, it secured its defining place on the academic and political agenda with the 1987 report "Our Common Future" published by the Brundtland Commission. According to the report, sustainable development means "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). This definition offers a comprehensive framework that emphasizes both intergenerational and intragenerational equity.

Following the 1992 Rio Earth Summit, sustainable development became widely adopted through the three-pillar model comprising environmental, economic, and social dimensions. The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, established a comprehensive global agenda consisting of 17 goals and 169 indicators. Among these goals, ending hunger (SDG 2), responsible consumption and production (SDG 12), climate action (SDG 13), and the conservation of terrestrial ecosystems (SDG 15) are directly related to gastronomy (UN, 2015).

It is recognized as a fundamental approach that is gaining increasing importance in today's economic and social systems. In particular, the conservation of environmental resources, the sustainable use of natural ecosystems, and meeting the needs of future generations are among the core objectives of the sustainability approach. The Sustainable Development Goals developed by the United Nations aim to establish a balanced relationship between economic growth and environmental protection (United Nations, 2015). The gastronomy sector constitutes an important part of sustainability discussions. Elements such as food production, food transportation, energy consumption, and food waste have significant impacts on environmental sustainability. For this reason, the development of sustainable production and consumption models in the gastronomy sector is gaining increasing importance (Jones, Hillier & Comfort, 2016).

The concept of sustainable gastronomy refers to the implementation of food production and consumption processes in accordance with the principles of environmental, economic, and social sustainability. This approach encompasses not only food production processes but also food consumption habits, supply chain management, and gastronomic tourism activities (Sims, 2009).

The key components of sustainable gastronomy are as follows:

- Use of Local and Seasonal Products
- Reduction of Food Waste
- Supporting Sustainable Agricultural Practices
- Reducing Energy and Water Use
- Supporting Local Producers

These components contribute to both ensuring environmental sustainability and strengthening local economies in the gastronomy sector.

4.2 Sustainability in Gastronomy Tourism

Gastronomy tourism is defined as a type of tourism in which the desire to experience local food culture plays a significant role among tourists' motivations for visiting a destination (Hall & Sharples, 2003). Gastronomy tourism encompasses not only food consumption but also the experience of local culture, traditions, and gastronomic heritage.

In recent years, gastronomic tourism has been addressed in conjunction with sustainable tourism approaches. Tourists' experience of local culinary culture, support for local producers, and the preservation of local food systems are considered key components of sustainable tourism policies (UNWTO, 2022).

Sustainable culinary tourism is also viewed as a key factor in enhancing a destination's competitive edge. Tourists are increasingly seeking eco-friendly, local, and authentic culinary experiences. This trend encourages culinary businesses to adopt sustainable production and consumption models.

The use of local products is considered a key element supporting the sustainability of gastronomic tourism. Geographically indicated products contribute to the preservation of local culinary culture while simultaneously strengthening destinations' gastronomic identity (Björk & Kauppinen-Räisänen, 2016).

4.3 Industry 5.0 and Technological Transformation in the Gastronomy Sector

The Industry 5.0 approach advocates for the use of technology from a human-centered perspective. This approach aims to integrate technology with human creativity in production processes (European Commission, 2021).

The gastronomy sector is also significantly impacted by technological transformation. In particular, with the widespread adoption of digital technologies, significant changes are occurring in restaurant management, food production, and the customer experience.

The primary technologies used in the gastronomy sector under Industry 5.0 are as follows:

- AI-Powered Menu Design
- Robotic Kitchen Systems
- Smart Restaurant Management Systems
- Digital Ordering Systems
- Big Data Analytics

These technologies enhance the operational efficiency of food service businesses while simultaneously improving the customer experience.

For example, artificial intelligence systems can analyze customer preferences to offer personalized menu recommendations. This helps restaurants increase customer satisfaction (Ivanov & Webster, 2019).

4.4 Industry 5.0 and Sustainable Gastronomy Applications

The Industry 5.0 approach provides a significant framework that supports the development of sustainable production systems. Thanks to this approach, sustainable practices can be implemented more effectively in the gastronomy sector.

In particular, technological systems make significant contributions in areas such as reducing food waste, optimizing energy consumption, and sustainable supply chain management.

4.4.1. Food Waste Management

Food waste is recognized as one of the major challenges facing global food systems. According to United Nations data, approximately one-third of the food produced worldwide is wasted (United Nations Environment Programme, 2021).

Industry 5.0 technologies offer important tools that can help reduce food waste. In particular, data analytics and artificial intelligence systems can help reduce food waste by optimizing production planning in restaurants.

4.4.2. Smart Kitchen Systems

Smart kitchen systems are technological systems that increase energy efficiency and optimize food production processes. Thanks to these systems, energy consumption can be reduced and production processes can be made more sustainable.

4.4.3. Sustainable Supply Chain

Industry 5.0 technologies provide transparency and traceability in supply chain management. In particular, thanks to blockchain technology, the processes of food products from production to the consumer can be tracked (Casino, Dasaklis & Patsakis, 2019).

4.5. Sustainable Tourism

The concept of sustainable development, popularized by the Brundtland Report, was quickly adopted in the tourism sector as well. Sustainable tourism refers to an approach that holistically considers the economic, social, and environmental impacts of tourism and balances the needs of current and future generations. Researchers such as Gössling, Hall, and Scott have conducted comprehensive studies on tourism's environmental footprint, its relationship with climate change, and the transition toward sustainability.

Sustainable tourism has emerged as a response to issues such as the environmental damage, cultural erosion, and overtourism caused by mass tourism. The participation of local communities, the conservation of natural resources, the preservation of cultural heritage, and the fair distribution of tourism revenues are among the fundamental principles of sustainable tourism. In the post-COVID-19 pandemic era, the concept of sustainable tourism has regained momentum; there has been a significant increase in demand from visitors for facilities with sustainability certifications.

The relationship between technology and sustainable tourism is two-sided. On the one hand, digital technologies can contribute to sustainability through energy management, waste reduction, and resource efficiency; on the other hand, the production and use of technology itself can generate environmental costs. Industry 5.0's human-centered and sustainable approach requires the conscious management of this dual impact of technology.

4.6. Gastronomy Tourism

The World Tourism Organization defines gastronomy tourism as a type of tourism based on the visitor's experience with food, related products, and activities during their trip. Gastronomy tourism is understood not merely as the fulfillment of nutritional needs but as a meaningful connection with local culture, production methods, and culinary heritage.

Hall and colleagues (2003), while conceptualizing food tourism, highlight the subtle distinctions between terms such as culinary tourism, food tourism, and gastronomy tourism. In this context, food tourism refers to the physical and sensory experience with local foods; culinary tourism refers to the cultural knowledge gained through this experience; and gastronomy emphasizes the role of food within a society's culture and lifestyle. In recent years, the growing demand for authentic and memorable experiences has made gastronomy one of the central components of the global tourism agenda.

Gastronomy tourism generates sustainability impacts across economic, social, and environmental dimensions for a destination. While local and regional foods make a significant contribution to a destination's sustainable competitive advantage, organic farming, local production, traditional production methods, and food festivals are considered key components of sustainable gastronomy tourism.

Sustainable gastronomy refers to the conduct of food production and consumption processes in a manner consistent with sustainability principles across environmental, economic, and socio-cultural dimensions. In his study examining the role of local food in sustainable tourism experiences, Sims (2009) demonstrates that authentic local products both enhance visitor satisfaction and support the local economy and cultural heritage.

The World Tourism Organization's reports on gastronomic tourism identify the following as the key components of sustainable gastronomy: the promotion and protection of local products, the reduction of food waste, the support of responsible agricultural practices, the conservation of biodiversity, and the reduction of the environmental footprint. These reports highlight that a holistic approach to sustainable food management—encompassing all stages from supply and preparation to consumption and waste—has not yet become widespread.

Table 4. The Three Dimensions of Sustainable Gastronomy

Dimension	Focus	Example Applications
Environmental	Conservation of natural resources	Reducing food waste, local and seasonal sourcing, energy efficiency, circular economy
Economic	Local economic development	Supporting local producers, short supply chains, job creation
Socio-cultural	Preservation of heritage and identity	Preservation of traditional cuisines, cultural transmission, inclusivity, food safety

Source: Compiled based on the World Tourism Organization's gastronomy tourism reports, Sims (2009), and Hall et al. (2003).

4.7. Food Waste and the Circular Economy

Reducing food waste is one of the most critical components of sustainable gastronomy. The World Tourism Organization emphasizes that the transition to sustainable food management in the tourism sector must encompass all stages—from procurement and preparation to consumption and waste management. However, analyses indicate that the vast majority of tourism policies treat food merely as an element that enriches the experience; policies that encompass all stages of sustainable food management are, in fact, quite scarce.

The circular economy approach proposes reevaluating waste as a resource within food systems. Practices such as the recovery of byproducts, composting, donating surplus food, and smart inventory management generate both environmental and economic benefits. Industry 5.0 technologies (particularly big data, the Internet of Things, and artificial intelligence) can directly contribute to reducing food waste through demand forecasting and inventory optimization.

4.8. From Gastronomy 4.0 to Gastronomy 5.0

The technological transformation in the tourism and gastronomy sectors is referred to in the literature as Gastronomy 4.0 and, increasingly, Gastronomy 5.0. Gastronomy 4.0 describes the integration of digitalization and automation into kitchen processes, including smart kitchen equipment, digital ordering systems, and data-driven operations. A Gastronomy 5.0 approach aligned with Industry 5.0, however, positions technology in a way that enhances the human experience and sustainability.

Within this framework, technology is viewed not as a substitute for the guest experience but as an element that deepens it. Gastronomy 5.0 centers the chef's creativity and the human touch while using technology as a tool to serve the goals of sustainability, personalization, and quality. This approach is the concrete manifestation of Industry 5.0's human-centered principle within the gastronomy sector.

4.9. The Relationship Between Industry 5.0 and Sustainable Gastronomy Tourism

The pillars of Industry 5.0—human-centeredness, sustainability, and resilience—align significantly with the goals of sustainable gastronomy and tourism. Human-centeredness involves using technology to enhance the well-being of guests and staff; sustainability addresses goals such as reducing food waste and improving resource efficiency; and resilience supports service continuity during crises.

This alignment necessitates that Industry 5.0 technologies be viewed not merely as tools for operational efficiency but also as instruments for sustainability and enhanced experience quality within the context of sustainable gastronomy and tourism. However, realizing this potential depends on technology being positively perceived by consumers. No matter how advanced the technology may be, sustainability and the promise of value cannot be realized unless it is accepted by consumers and contributes positively to the experience. For this reason, the next section addresses digital transformation and smart technologies in tourism and gastronomy, while the following section examines theories of consumer perception and technology acceptance.

4.10. Sustainable Development Goals and Tourism

The 17 Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, provide a global framework that translates sustainability into concrete targets. Tourism and gastronomy are directly linked to a significant portion of these goals. In particular, the goals of responsible consumption and production (Goal 12), decent work and economic growth (Goal 8), climate action (Goal 13), life on land (Goal 15), and zero hunger (Goal 2) are closely linked to sustainable gastronomy tourism.

The World Tourism Organization emphasizes that tourism serves as both a tool and a steward in achieving the SDGs. Culinary tourism can contribute to these goals by strengthening local economies, preserving cultural heritage, and promoting sustainable food systems. Industry 5.0 technologies, meanwhile, provide the tools to achieve these goals through resource efficiency, waste reduction, and transparent supply chains.

4.11. Sustainable Consumption and Responsible Tourist Behavior

Sustainability is not only critical on the producer side but also on the consumer side. Responsible tourist behavior encompasses reducing environmental impact, respecting local culture, supporting the local economy, and making ethical consumption choices. Research indicates that consumers are increasingly developing a greater awareness of sustainability and showing a growing preference for facilities with sustainability certifications.

However, a phenomenon known as the "attitude-behavior gap" reveals that consumers' positive attitudes toward sustainability do not always translate into action. Technology can play a significant role in bridging this gap: transparent information sharing, user-friendly digital tools, and incentive mechanisms can support sustainable behavior. The positive perception of Industry 5.0 technologies by consumers is a prerequisite for realizing the potential of these technologies to support sustainable behavior.

4.12. Local Food Systems and Short Supply Chains

One of the key components of sustainable gastronomy is local food systems and short supply chains. Short supply chains reduce the environmental footprint by minimizing the number of intermediaries between producers and consumers, while also providing local producers with a fairer income. The "farm-to-table" movement is a concrete expression of this concept and is becoming increasingly widespread in gastronomic tourism.

Sims (2009), while examining the role of local food in sustainable tourism experiences, emphasizes that authentic local products both enhance visitor satisfaction and strengthen local identity and the local economy. Industry 5.0 technologies, particularly blockchain-based traceability systems and digital marketplaces, can enhance the transparency and accessibility of local food systems. This allows consumers to learn about the origin and production conditions of the food they consume, thereby increasing trust and perceived value.

4.13. Climate Change and the Transformation of Tourism

Climate change is one of the most significant sustainability challenges directly affecting the tourism and gastronomy sectors. Tourism is a sector that both contributes to climate change (primarily through transportation-related emissions) and is affected by it (through changes in destination appeal and shifts in seasonality). Researchers such as Gössling, Hall, and Scott have comprehensively examined the two-way relationship between tourism and climate change.

From a gastronomy perspective, climate change affects food production, seasonality, and supply security. Sustainable gastronomy addresses these challenges through local and seasonal sourcing, reducing food waste, and low-carbon production methods. Industry 5.0 technologies can strengthen the sector's climate resilience through smart energy management, demand forecasting, and resource optimization. In this context, technology serves as both a tool and an accelerator for the sustainability transition.

4.14. Gastronomic Identity and Destination Branding

An important dimension of sustainable gastronomic tourism is gastronomic identity and place branding. A destination's culinary culture is an integral part of its identity and appeal. Geographically indicated products, traditional recipes, and local culinary traditions are values that differentiate a destination and provide a competitive advantage. Gastronomy is a powerful tool for telling a place's story and establishing an emotional connection with visitors.

In place branding, gastronomy generates both economic and cultural value. Promoting the local cuisine supports local producers, preserves cultural heritage, and enhances the destination's appeal. Industry 5.0 technologies can play a supportive role in this process through digital marketing, immersive promotional experiences, and traceability systems. However, technology must not overshadow the uniqueness and authenticity of the gastronomic identity; rather, it must enhance them.

4.15. The Tension Between Authenticity and Technology

In gastronomic tourism, authenticity is one of the key determinants of visitor satisfaction. Visitors seek local and unique experiences; they avoid commercialized and standardized ones. This creates a unique tension regarding technology's role in gastronomy: while technology offers efficiency and consistency, excessive technological adoption can undermine the perception of authenticity.

The solution to this tension lies in the human-centered approach of Industry 5.0. When technology is used to support rather than replace the authentic experience, authenticity and efficiency can coexist. For example, traceability technologies can strengthen the perception of authenticity by transparently revealing the origin of local products; immersive technologies, on the other hand, can enrich the story of local culture. The key is to place technology not at the center of the experience, but as a supporting backdrop.

4.16. Sustainability Certifications and Consumer Trust

Sustainability certifications are important tools that make it easier for consumers to make sustainable choices. Certifications that document environmental, social, and economic sustainability increase consumer trust and differentiate sustainable businesses. Research shows that consumers are increasingly preferring facilities with sustainability certifications and are willing to pay a premium for them.

However, the effectiveness of certifications depends on their reliability and transparency. The practice of "greenwashing"—making sustainability claims without actual sustainability—can undermine consumer trust. Industry 5.0 technologies, particularly blockchain-based traceability systems, can address this issue by ensuring that sustainability claims are verifiable and transparently documented. Thus, technology plays a role in bridging the gap between sustainability and trust.

4.17. Circular Economy and Waste Management in Tourism

The circular economy proposes an economic model that replaces the traditional linear "produce-use-dispose" model with one where resources are kept in use for as long as possible, waste is minimized, and products are revalued at the end of their life cycle. In tourism and gastronomy, the principles of the circular economy are implemented through practices such as reducing food waste, managing packaging waste, conserving water and energy, and reusing materials.

A circular approach in gastronomy is particularly significant in terms of food waste management. Converting byproducts into new products, donating surplus food, and composting organic waste are concrete applications of circular gastronomy. Industry 5.0 technologies, particularly big data and AI-based demand forecasting, make a significant contribution to reducing food waste at the source. Internet of Things (IoT)-based inventory tracking systems, meanwhile, help prevent waste in real time.

From the consumer's perspective, circular economy practices are increasingly creating value. Consumers with a high awareness of sustainability prefer businesses that reduce waste and manage their resources responsibly. Therefore, technology's contribution to the circular economy generates both environmental and perceptual value. While the contribution of Industry 5.0 technologies to the sustainability dimension is not directly addressed within the scope of this study, it offers an important area for future scaling efforts.

4.18. Stakeholder Approach and Creating Sustainable Value

Sustainable gastronomy and tourism constitute a complex ecosystem requiring the participation of numerous stakeholders. This ecosystem includes diverse stakeholders such as tourists, local communities, businesses, producers, public institutions, and the environment. Sustainability necessitates balancing the interests of these stakeholders and creating shared value. Industry 5.0's stakeholder value approach is directly aligned with this multi-stakeholder perspective.

In the stakeholder approach, technology functions as a tool that supports coordination and transparency among stakeholders. Digital platforms connect local producers with businesses; traceability systems ensure supply chain transparency; and data sharing strengthens collaboration among stakeholders. In this way, technology facilitates the process of creating sustainable value.

Sustainable value creation refers to the simultaneous generation of economic, social, and environmental value. In tourism and gastronomy, this is achieved by supporting the local economy, preserving cultural heritage, and reducing environmental impact. Consumers' growing preference for businesses that create sustainable value is transforming sustainability from merely an ethical imperative into a competitive advantage.

4.19. Sustainability Communication and Consumer Awareness

Transforming sustainability efforts into tangible value requires effective sustainability communication. When businesses communicate their sustainability practices to consumers in a transparent, credible, and understandable manner, it strengthens consumer awareness and fosters a positive perception. However, communication that is excessive or unfounded can lead to accusations of greenwashing and a loss of trust.Technology offers powerful tools for sustainability communication. Digital platforms enable the accessible sharing of sustainability information; traceability systems allow claims to be documented in a verifiable manner; and interactive content supports consumer education. In this way, technology bridges the gap between sustainability and consumer awareness.

Increased consumer awareness is a key driver accelerating the development of sustainable gastronomy and tourism. Conscious consumers are steering businesses toward sustainability by making sustainable choices. Industry 5.0 technologies can support the sustainability transition by both strengthening this awareness and facilitating sustainable choices. This cyclical relationship reflects the mutually reinforcing nature of the technology-sustainability-consumer triangle.

4.20. The Triple Bottom Line and Gastronomy

The Triple Bottom Line (TBL) model, conceptualized by John Elkington in 1994, proposes evaluating corporate success not solely through financial performance but within a framework that integrates economic, environmental, and social dimensions (Elkington, 1997). From the perspective of gastronomy businesses, the TBL model encompasses performance evaluation along the axes of profitability (economic), environmental footprint (environmental), and contributions to the local community and employees (social).

Businesses that adopt a sustainable gastronomy approach reduce environmental impact and contribute to the local economy through local and seasonal sourcing. A shift toward organic agricultural products, the adoption of fair trade principles, the minimization of food waste, and the improvement of energy efficiency are the primary strategies that strengthen these businesses' TBL performance (Hall and Gössling, 2013).

4.21. Food Systems and Sustainability

The global food system is held responsible for approximately 26% of greenhouse gas emissions. This figure encompasses the entire chain, from agricultural production through processing, packaging, transportation, and retail sales (Poore and Nemecek, 2018). The production of animal-based products, in particular, results in high environmental costs; it differs significantly from plant-based production in terms of land use, water consumption, and methane emissions.

Food waste also plays a critical role in sustainability discussions. Data from the United Nations Food and Agriculture Organization (FAO) reveals that approximately one-third of the food produced worldwide is wasted before reaching consumers (FAO, 2011). Restaurants and the food service sector are responsible for a significant portion of this waste. Therefore, it is of great importance for gastronomy businesses to develop strategies to reduce food waste, both in terms of environmental sustainability and economic efficiency.

4.22. The Concept of a Sustainable Diet

The concept of a sustainable diet refers to a comprehensive approach that integrates nutritional quality with environmental, economic, and socio-cultural dimensions. According to the joint publication by the FAO and Biodiversity International, sustainable diets are 'diets that have a low environmental impact, contribute to nutrition and food security, support the healthy lives of current and future generations, are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair, and affordable; nutritionally adequate, safe, and healthy diets" (FAO and Biodiversity International, 2010, p. 7).

This definition serves as both a guiding principle and a design philosophy for gastronomy professionals. Highlighting seasonal and local ingredients in menu design, incorporating more plant-based protein sources, and rediscovering traditional and forgotten local foods are concrete ways to integrate the concept of sustainable diets into gastronomic practice (Willett et al., 2019).

4.23. Gastronomy Culture and Sustainability

Gastronomy encompasses not only the act of eating but also the cultural, social, and aesthetic whole shaped around the production, preparation, presentation, and consumption of food. From Brillat-Savarin's aphorism, "Tell me what you eat, and I will tell you who you are," to the Slow Food movement's manifesto spanning from the local to the global, gastronomy is deeply intertwined with concepts of identity, heritage, and sustainability (Brillat-Savarin, 2011; Petrini, 2003).

Turkey possesses immense potential for sustainable gastronomy thanks to its rich and diverse culinary culture. The millennia-old legacy of Anatolian cuisine encompasses practices inherently rooted in sustainability, such as respect for local products, seasonality, fermentation, and preservation techniques. The increasing number of products with registered geographical indications, the proliferation of "gastronomy cities" projects, and the inclusion of sustainability in culinary education curricula indicate that this potential is being increasingly realized (Özdemir, 2020).

Chapter 5

Sustainable Gastronomy and Tourism

5.1. Sustainable Gastronomy Destinations

The concept of a sustainable gastronomy destination refers to destinations that promote tourism development by preserving local food systems, sustaining cultural gastronomic heritage, and offering visitors unique experiences. The UNESCO Creative Cities Network's Gastronomy Cities program serves as a significant international reference framework in this field. The inclusion of Gaziantep, Hatay, Afyonkarahisar, and Tekirdağ from Turkey in this network confirms our country's potential as a gastronomy destination (UNESCO, 2023).

Critical components in the process of developing sustainable gastronomy destinations include: empowering local food producers, inventories and conservation programs for gastronomy culture, sustainability certifications for food and beverage establishments, gastronomy routes and experience design, visitor capacity management, and food tourism data. Managing these elements within an integrated strategy reinforces the destination's long-term competitive strength (Kivela and Crotts, 2006).

5.2. Farm-to-Table and Local Supply Models

The "farm-to-table" movement aims to shorten the production-to-consumption chain, ensuring food reaches consumers fresher, with greater traceability, and with a reduced environmental impact. This approach has become a significant draw in culinary tourism. Farm-to-table restaurant experiences that offer the opportunity to participate in the production process, the inclusion of olive harvest events in olive-picking tour packages, and vineyard visits in wine tourism serve as examples of culinary tourism formats that connect consumers with production (Sims, 2009).

From an Industry 5.0 perspective, the "farm-to-fork" movement is being strengthened by digital traceability systems, smart agriculture technologies, and blockchain-based supply chain management. This integration creates an ecosystem where consumers can transparently track the journey of the products they purchase, the producer's labor and value are made visible, and sustainable agricultural practices are rewarded by the market (Bonanomi et al., 2021).

5.3. Gastronomy Tourism and Climate Change

Climate change is profoundly affecting gastronomy tourism destinations on both the supply and demand sides. On the supply side, the product patterns of agricultural regions are shifting; disrupted rainfall patterns threaten water resources; and rising sea temperatures negatively impact fishing and seafood gastronomy. On the demand side, concerns arising from climate change are increasingly shaping consumer preferences and behaviors; growing awareness of reducing the carbon footprint is driving a shift toward short-distance travel and the consumption of local products (Gössling et al., 2012).

In this context, it has become imperative for culinary tourism to develop adaptation and mitigation strategies for climate change. Adopting local and seasonal menus, reducing the use of exotic ingredients transported by air, investing in energy efficiency and renewable energy, and making procurement decisions that support agricultural practices that sequester carbon from the atmosphere are concrete ways for the gastronomy sector to fulfill its climate responsibility while offering sustainable experiences to consumers (IPCC, 2019).

5.4. Industry 5.0 Applications in Food Production

The integration of Industry 5.0 into food production processes is paving the way for profound transformations in the areas of efficiency, safety, and sustainability. Smart agriculture (Precision Agriculture) technologies—including GPS-guided machinery, soil sensors, unmanned aerial vehicles (drones), and satellite imaging systems—optimize input use and minimize water and fertilizer waste (Zhang et al., 2002). These applications both support environmental sustainability and alleviate the workload of farmers.

Vertical farming and controlled environment agriculture represent the reflection of Industry 5.0 in urban food production. Vertical farms, which operate using renewable energy, LED lighting technology, smart irrigation systems, and AI-driven growth optimization, enhance cities' food selfsufficiency, reduce carbon emissions from transportation, and minimize post-harvest nutrient loss in food (Benke and Tomkins, 2017).

5.5. Digital Transformation in Restaurant Management

Digital transformation in the restaurant industry manifests itself in two key areas: the front end (customer interaction) and the back end (operational processes). In front-end transformation, QR code menus, table management systems, digital ordering platforms, personalized loyalty programs, and AI-powered recommendation systems are taking center stage. In back-end transformation, integrated software platforms are becoming widespread in areas such as inventory management, staff scheduling, energy monitoring, supplier management, and financial reporting (Ivanov and Webster, 2017).

Cloud-based restaurant management systems (RMS) and point-of-sale (POS) platforms provide even small and medium-sized food service businesses with enterprise-level data analytics and operational intelligence capabilities. This trend toward democratization aligns with the accessibility principle of Industry 5.0 and contributes to reducing the scale disparity between large and small businesses in the sector (Wieczorek, 2021).

5.6. Smart Gastronomy Ecosystem

The concept of a smart gastronomy ecosystem refers to an integrated digital-physical infrastructure encompassing producers, operators, consumers, and management actors. Within this ecosystem, smart kitchen equipment processes order data in real time, menu optimization software creates production plans based on demand forecasts, and energy management systems optimize consumption during peak hours.

On the consumer side, personalized nutrition apps provide menu recommendations by integrating an individual's health status, dietary preferences, allergies, and sustainability values. When this application data is anonymously transferred to restaurants' AI systems, it generates valuable insights for menu innovation, portion management, and reducing food waste. Thus, one of the strongest examples of human-technology collaboration comes to life within the gastronomy ecosystem (Getz and Robinson, 2014).

5.7. Cybernetic Gastronomy and Experience Design

One of the most profound impacts of Industry 5.0 on creative sectors is evident in the integration of human-machine collaboration into creative processes. Cybernetic gastronomy defines a paradigm where artificial intelligence algorithms collaborate with chefs to discover new flavor profiles, unconventional ingredient combinations, and innovative cooking techniques. The collaboration between IBM Watson and Florentine Kitchen & Bar has demonstrated that artificial intelligence can generate flavor combinations that would be appreciated by at least one person (Flatt, 2018).

On the other hand, augmented reality (AR) and virtual reality (VR) technologies are opening new horizons in gastronomic experience design. Projection mapping systems that transform the dining space, AR visual layers that explain the origin and production process of the selected dish, and sound-scent-texture experiences that enrich the consumer's taste perception in a multisensory way position gastronomy as a performance and an art form. This approach transforms an ordinary dining experience into an unforgettable cultural encounter in gastronomic tourism (Spence et al., 2017).

5.8. Food Technologies and New Protein Sources

Industry 5.0's sustainability-focused approach is inspiring revolutionary innovations in food technologies. Meat produced from cell culture (cultured meat), plant-based protein alternatives, insect protein, seaweed-based foods, and fermented food biotechnology are emerging as next-generation protein sources with the potential to reduce the environmental impact of the global food system (Tuomisto and Teixeira de Mattos, 2011).

The adoption of these new protein sources in the gastronomy sector is creating highly intriguing dynamics from both the perspective of consumer perception and chef creativity. The fact that some Michelin-starred restaurants have begun incorporating cultured meat and plant-based protein experiments into their menus indicates that these innovations are gaining legitimacy even in the realm of luxury gastronomy. Consumer acceptance studies, meanwhile, reveal that ethical and sustainability considerations positively influence openness toward these new food technologies (Wilks and Phillips, 2017).

Chapter 6

Digital Transformation and Smart Technologies in Tourism and Gastronomy

6.1. Digital Transformation in Tourism

Tourism, by its very nature, is an information-intensive sector, and this characteristic has made it one of the areas where digital technologies have been adopted most rapidly and deeply. Every stage of the tourist journey—from travel planning to booking, and from the experience itself to post-experience evaluation—has been transformed by digital technologies. Online travel agencies, mobile apps, social media, and review platforms have fundamentally changed tourists' decision-making processes and expectations.

Digital transformation represents not only operational efficiency for tourism businesses but also new value propositions and a competitive advantage. AI-driven personalization, IoT-based smart room systems, contactless payments and mobile services, robotic services, and the growing demand for sustainability-certified facilities are the key trends shaping the sector's transformation. This transformation has gained momentum, particularly in the post-pandemic era, driven by the need for contactless and digital solutions.

6.2. Smart Tourism

Smart tourism is the most comprehensive conceptualization of digital transformation in the tourism sector. Gretzel, Sigala, Xiang, and Koo (2015) define smart tourism as the increasing reliance of tourism destinations, sectors, and tourists on new information and communication technologies that enable the conversion of large amounts of data into value propositions. Smart tourism is built on three components: smart destinations, smart experiences, and smart business ecosystems.The smart tourism ecosystem relies on the integrated use of technologies such as the Internet of Things, cloud computing, big data, and mobile connectivity. In this ecosystem, data serves as both the raw material for value creation and the tool for coordination among stakeholders. Researchers such as Buhalis and Amaranggana emphasize that smart tourism destinations use technology to provide real-time, context-aware, and personalized services. The concept of smart tourism forms the theoretical framework for the integrated application of Industry 5.0 technologies within the tourism context.

6.3. Service Robots and Automation

Service robots are one of the most visible and widely discussed components of the technological transformation in tourism and gastronomy. In her comprehensive review on automation in tourism, Tussyadiah (2020) highlights that robotic and artificial intelligence applications are transforming service delivery; however, acceptance depends largely on consumer perception, trust, and contextual factors. Ivanov and Webster (2019) systematically address the opportunities and challenges created by robots, artificial intelligence, and service automation in travel, tourism, and hospitality.

Wirtz and colleagues (2018) describe the transformation brought about by service robots as a “brave new world” and note that robots alter service interactions in both functional and socio-emotional dimensions. While the primary advantages of robotic services include consistency, speed, 24/7 availability, and cost-effectiveness, the main challenges include a lack of human warmth, limited flexibility, and employment concerns.

6.4. Artificial Intelligence and Personalization

Artificial intelligence is the key driver of personalization and predictive services in tourism and gastronomy. Chatbots and virtual assistants automate customer service, while recommendation systems provide personalized suggestions based on past behavioral data. The widespread adoption of generative artificial intelligence has opened up new possibilities across a broad spectrum, from travel planning to content creation.

While the rise of artificial intelligence in tourism presents significant opportunities for both businesses and consumers, it also raises ethical questions regarding privacy, transparency, algorithmic bias, and the role of human oversight. Industry 5.0’s human-centered approach envisions AI designed not to replace humans but to support them.

6.5. Immersive Technologies and the Experience Economy

Pine and Gilmore's (1999) concept of the experience economy posits that consumers increasingly seek memorable experiences rather than goods and services. In this context, augmented and virtual reality technologies hold the potential to create unique experiences in tourism and gastronomy. Virtual destination tours, AR-based guided tours, immersive museum experiences, and interactive dining presentations are the primary application areas of these technologies.

Research led by Jung and Tom Dieck demonstrates that immersive technologies enrich the visitor experience, support learning, and positively influence visit intent (Tom Dieck and Jung, 2018). Immersive technologies create multi-layered experiences by blending the physical and digital environments in a manner aligned with the requirements of the experience economy.

6.6. Big Data and Internet of Things-Based Smart Services

Big data and the Internet of Things form the data infrastructure of the smart tourism ecosystem. Smart hotels, equipped with IoT devices, personalize the guest experience and enhance operational efficiency. Voice-controlled room systems, keyless entry, smart energy management, and interconnected device networks offer convenience to guests while providing businesses with rich data sources.

Big data analytics generates value in areas such as demand forecasting, dynamic pricing, personalization, and sustainability management by deriving meaningful insights from this data. However, the widespread adoption of these technologies requires careful management regarding data privacy, security, and ethical use. Consumers' perceptions of these technologies are shaped by the balance between the convenience they offer and privacy concerns.

6.7. The Contribution of Digital Transformation to Sustainability

Digital technologies can contribute to sustainable tourism and gastronomy goals through various channels. Smart energy management systems optimize energy consumption; big data and AI-based demand forecasting reduce food waste; and digital platforms support short supply chains by connecting local producers with consumers.

However, technology's contribution to sustainability is not automatic; it requires conscious design and management. Issues such as the environmental costs of technology production and use, the digital divide, and access inequalities must be taken into account. Industry 5.0's human-centered and sustainable paradigm proposes a technology adoption approach that balances these considerations. Ultimately, the transformation of digital transformation into sustainable value depends on both technical design and consumer acceptance.

6.8. The Tourist Journey and Digital Touchpoints

Digital technologies play a significant role at every stage of the tourist journey (customer journey). This journey typically consists of the inspiration/discovery, planning, booking, experience, and post-experience sharing stages. Different digital touchpoints come into play at each stage: search engines and social media during the discovery phase, comparison platforms during the planning phase, online booking systems during the booking phase, mobile apps and smart devices during the experience phase, and review platforms during the post-experience phase.

Each of these digital touchpoints represents a critical moment in shaping consumer perception. Industry 5.0 technologies hold the potential to make these touchpoints smarter, more personalized, and seamless. However, ensuring that technology delivers a consistent and positive experience at every touchpoint requires an integrated design approach. Disconnected or poorly designed digital experiences can negatively impact consumer perception.

6.9. Contactless Services and Post-Pandemic Transformation

The COVID-19 pandemic has served as a catalyst accelerating digital transformation in the tourism and gastronomy sectors. Health and safety concerns have increased demand for contactless service solutions; contactless entry and exit, digital menus, mobile ordering and payment, robotic service, and automated check-in systems have become widespread. This transformation can be viewed as a concrete application of the resilience pillar of Industry 5.0.

In the post-pandemic era, some of these technologies have become permanent and have become part of consumer expectations. Consumers now take digital solutions that offer speed, convenience, and security for granted. This situation has also altered technology's place in consumer perception and its level of acceptance. The pandemic experience demonstrated technology's critical role in ensuring service continuity during crises and highlighted the importance of resilient tourism systems.

6.10. The Tension Between Personalization and Data Privacy

One of the greatest value propositions offered by Industry 5.0 technologies is personalization. Big data and artificial intelligence can provide personalized recommendations and experiences based on the consumer's past behavior, preferences, and context. Personalization is a powerful tool for increasing consumer satisfaction and loyalty.

However, personalization inherently involves a fundamental tension with data privacy. The deeper personalization goes, the more personal data must be collected; this, in turn, heightens privacy concerns. This phenomenon, known as the personalization paradox, reflects the tension between consumers' desire for personalized services on one hand, and their desire to protect the privacy of their data on the other. Industry 5.0's human-centered and ethical approach requires that this tension be managed through the principles of transparency, consent, and data security. Safeguarding consumer trust is a prerequisite for the sustainable realization of the value of personalization.

6.11. Smart Destinations and Competitive Advantage

Smart tourism destinations are integrated ecosystems that place technology at the center of destination management and competitive advantage. Buhalis and Amaranggana (2015) note that smart destinations enrich the tourist experience and enhance operational efficiency by offering real-time, context-sensitive, and personalized services. These destinations rely on data sharing and coordination among public and private sector stakeholders.

The smart destination approach is a concrete example of the integrated use of Industry 5.0 technologies at the destination scale. While Internet of Things (IoT) sensors enable crowd management and resource optimization; big data analytics generates insights into tourist behavior; and mobile applications and augmented reality provide personalized experiences. This integrated structure supports both the destination's competitiveness and sustainability. However, the success of smart destinations ultimately depends on tourists' positive perception and adoption of these technologies.

6.12. Social Media and User-Generated Content

Social media is one of the most powerful digital forces transforming consumer behavior in tourism and gastronomy. Consumers now share their travel and dining experiences on social media; these posts influence the decisions of other consumers. User-generated content (UGC) is perceived as a more reliable source of information than traditional marketing and shapes the destination's image.

From a gastronomy perspective, social media highlights the visual and experiential dimensions of food. Aesthetically appealing presentations, shareable experiences, and visual storytelling have become central to the marketing strategies of gastronomy businesses. This demonstrates that technology is being used not only as an operational tool but also as an experiential and communicative one. Industry 5.0 technologies can enhance social media engagement by creating immersive and shareable experiences.

6.13. Digital Inequality and Accessibility

A significant aspect of digital transformation is the issue of digital inequality and accessibility. There are notable differences among consumers regarding access to technology and digital skills. Factors such as age, education, income, and geographic location influence access to and use of digital technologies. This digital divide can lead to the exclusion of certain consumer groups from digital services.

Industry 5.0's human-centered and inclusive approach requires that technology be accessible to all consumer groups. Ensuring universal accessibility principles in design, offering digital and physical service channels together (omni-channel approach), and providing support to consumers with low digital literacy are essential for an inclusive digital transformation. Otherwise, technology may improve service quality for some groups while reducing it for others.

6.14. Human-Technology Collaboration and Hybrid Service Models

Industry 5.0's human-centered vision proposes the development of hybrid service models in tourism and gastronomy. In these models, technology complements human service rather than replacing it. While routine and standard tasks are delegated to technology, tasks requiring empathy, creativity, and personalization are left to human employees. This division of labor optimizes both efficiency and service quality.

Hybrid models also take into account the diversity of consumer preferences. While some consumers prefer digital and automated services for speed and convenience, others value human interaction and personal attention. Flexible hybrid models can accommodate these differing preferences by offering consumers a choice. This approach is the concrete manifestation of Industry 5.0's principle of human-machine collaboration in the service sector and supports the development of a positive perception of technology.

6.15. Future Trends and the Transformation of Tourism

Digital transformation in tourism and gastronomy is a rapidly evolving process. The widespread adoption of generative artificial intelligence, metaverse and augmented reality applications, autonomous service systems, and hyper-personalization are the key trends shaping the sector's future. These trends indicate that Industry 5.0 technologies will be utilized in an even more integrated and sophisticated manner.

In this transformation process, how technology is perceived by consumers will become increasingly critical. As new technologies emerge, consumer perception will continuously reshape itself; businesses will need to monitor this perception and develop strategies accordingly. The scale developed in this study provides a starting point for tracking consumer perception in this dynamic process. Future studies could expand the scale to encompass newly emerging technologies.

6.16. The Experience Economy and the Role of Technology

The concept of the experience economy posits that economic value is shifting from goods and services to memorable experiences (Pine and Gilmore, 1999). Within this framework, businesses are designing personal and unforgettable experiences that engage customers, rather than simply offering products or services. Tourism and gastronomy, by their very nature, lie at the heart of the experience economy.

Industry 5.0 technologies are powerful tools for experience design. Immersive technologies create multi-sensory experiences; personalization offers unique experiences tailored to each customer; and data analytics ensures the continuous improvement of the experience. However, in the experience economy, technology plays a instrumental role; the goal is not the technology itself, but the experience created through it. This distinction reflects the human-centered approach of Industry 5.0 within the experience economy.

The value of an experience depends largely on how the consumer perceives it. The same technological experience can be evaluated in different ways by different consumers. Therefore, understanding consumer perception is of critical importance in experience design. This study contributes to understanding the perceptual foundation of technology in the experience economy by measuring perceptions of technology.

6.17. Service-Dominant Logic and Co-Creation of Value

Service-dominant logic posits that value is not unilaterally produced by the business and presented to the consumer; rather, the business and the consumer create value together (co-creation). From this perspective, the consumer is not a passive recipient but an active partner in the value creation process.

Industry 5.0 technologies provide tools that facilitate co-creation. Digital platforms enable consumers to participate in service design; personalization tools allow consumers to shape their experiences; and feedback systems facilitate continuous improvement. In this context, a positive perception of technology is a prerequisite for consumers' active participation in the value creation process. When consumers adopt and perceive technology positively, the process of co-creation is strengthened.

6.18. Data-Driven Decision-Making in Tourism

Data-driven decision-making has become one of the fundamental paradigms of modern tourism management. Businesses are transitioning from decisions based on intuition and experience to those based on data and analytics. The integration of customer data, operational data, market data, and external data sources enables more informed and effective decision-making.

Industry 5.0 technologies form the infrastructure for data-driven decision-making. Internet of Things (IoT) sensors continuously generate data; cloud computing stores this data; and big data analytics and artificial intelligence transform the data into insights. This process generates value across a wide range of areas, from demand forecasting to resource optimization, and from personalization to sustainability management. However, data-driven decision-making depends on conditions such as data quality, analytical capabilities, and ethical data management.

6.19. The Human Factor in Digital Transformation

The success of digital transformation in tourism and gastronomy depends not only on technology but also on the human factor. Employees' digital skills, their capacity to adapt to change, and their ability to collaborate with technology determine the success of the transformation. Industry 5.0's human-centered approach envisions employees being empowered by technology, not replaced by it.

The human factor is also critical on the consumer side. The success of technology depends on consumers adopting it and having positive experiences. Therefore, digital transformation strategies must be designed with a human-centered approach that considers both the employee and consumer dimensions. Transformation is successful when technology enriches, simplifies, and gives meaning to the human experience; however, resistance and dissatisfaction arise when technology overshadows the human experience. This study provides valuable insights into the human factor in digital transformation by measuring consumer perceptions.

6.20. Technology, Competitive Advantage, and Innovation

Industry 5.0 technologies are a significant source of competitive advantage for tourism and gastronomy businesses. Businesses that effectively adopt technology can differentiate themselves in terms of operational efficiency, service quality, and customer experience. This differentiation provides a sustainable advantage in an increasingly intense competitive environment.

Innovation plays a central role in transforming technology into a competitive advantage. It is not merely the adoption of technology, but its creative and unique application that creates a competitive edge. Innovation manifests itself in the form of new service models, unique experiences, and differentiated value propositions. Industry 5.0's human-centered approach emphasizes that innovation arises from the fusion of technology and human creativity.

However, a technology-based competitive advantage requires constant renewal. The rapid evolution of technology turns today's competitive advantage into tomorrow's standard. Therefore, businesses must continuously monitor technology, evaluate new developments, and adapt their strategies accordingly. Monitoring consumer perception provides valuable guidance in this continuous adaptation process; because the ultimate measure of competitive advantage is the value perceived by the consumer.

6.21. Dimensions of Technology and Service Quality

Service quality is a fundamental determinant of competition and customer satisfaction in tourism and gastronomy. In the literature on service quality, dimensions such as reliability, responsiveness, assurance, empathy, and tangibility have been defined. Industry 5.0 technologies can influence each of these dimensions in different ways.

Technology can contribute to the reliability dimension by providing consistent and error-free service; to response speed through automation and real-time systems; and to assurance through data security and transparency. However, the empathy dimension is the area where technology faces the greatest challenge, as it requires a human touch. This underscores the importance of Industry 5.0's human-machine collaboration approach: while technology enhances functional dimensions, dimensions such as empathy and personal attention should be left to human employees.

Improving service quality through technology depends on the proper design and implementation of that technology. Technologies that are easy to use, reliable, and tailored to consumer needs enhance service quality; conversely, complex, faulty, or unnecessary technologies can diminish it.

Therefore, technology adoption must be planned in alignment with service quality objectives.

Chapter 7

Theories of Consumer Perception and Technology Acceptance

7.1. The Concept of Perception

Perception is the process by which an individual creates a meaningful mental representation of the world through the selection, organization, and interpretation of sensory inputs. In the literature on consumer behavior, perception is recognized as a cognitive process underlying purchasing decisions and experience evaluations. The same objective stimulus can be perceived differently by different consumers; this reflects the subjective, selective, and context-sensitive nature of perception.

The perception process consists of three fundamental stages: the selective attention to sensory inputs, the organization of these inputs into meaningful wholes, and finally, their interpretation in light of the individual's past experiences, expectations, and motivations. This process determines the meaning a consumer assigns to a technology, product, or service and thus directly influences behavioral outcomes (satisfaction, intention, loyalty).

7.2. Consumer Behavior and Perception of Experience

In experience-based sectors such as tourism and gastronomy, consumer perception is particularly decisive. The abstract, simultaneous, heterogeneous, and perishable nature of the service places the perception formed by the consumer during and after the experience at the center of satisfaction, loyalty, intention to revisit, and recommendation behavior. Pine and Gilmore's (1999) experience economy approach argues that consumers increasingly seek emotional and symbolic value rather than functional benefits.

In this context, understanding the impact of Industry 5.0 technologies on tourism and gastronomy necessitates measuring how these technologies are perceived by consumers. As much as—and sometimes even more than—the objective characteristics of technology, the meaning and value consumers ascribe to these technologies are decisive. For this reason, technology acceptance has become one of the central topics in consumer behavior research.

7.3. The Development of Technology Acceptance Theories

A series of successive and increasingly sophisticated theories have been proposed to explain why and how individuals adopt technology. These theories are rooted in an interdisciplinary tradition spanning from social psychology to information systems research.

7.3.1. Theories of Reasoned Action and Planned Behavior

At the root of technology acceptance theories lies Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA). According to this theory, behavior is determined by behavioral intention; intention, in turn, is determined by attitude and subjective norms. Ajzen (1991) expanded this theory into the Theory of Planned Behavior (TPB) by adding the variable of perceived behavioral control. TPB posits that an individual's perception of their capacity to perform a behavior also influences both intention and behavior.

7.3.2. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), proposed by Davis (1989), is the most widely used theory in the literature on technology acceptance. According to this model, adapted from the TRA, the acceptance of a technology is fundamentally determined by two perceptual variables: perceived usefulness (the belief that the technology will improve performance) and perceived ease of use (the belief that the technology can be used without requiring effort). These two variables influence attitude, which in turn affects intention to use and, ultimately, actual usage.

TAM has gained widespread acceptance due to its simplicity and strong empirical support; it has been expanded over time with various additions. Venkatesh and Davis (2000) developed TAM2 by incorporating social influence processes and cognitive instrumental processes into the model. Subsequent studies proposed TAM3 by including the antecedents of perceived usefulness and ease of use in the model.

7.3.3. The Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh, Morris, Davis, and Davis (2003) developed the Unified Theory of Acceptance and Use of Technology (UTAUT) by synthesizing eight leading models in the field of technology acceptance. UTAUT explains behavioral intention and usage through four core variables: performance expectancy, effort expectancy, social influence, and facilitating conditions. These relationships are moderated by age, gender, experience, and voluntariness. UTAUT demonstrated higher explanatory power (approximately 70% adjusted R-squared) than any of the eight individual models.

Venkatesh, Thong, and Xu (2012) adapted UTAUT to a consumer context, developing UTAUT2. UTAUT2 adds the variables of hedonic motivation, price value, and habit to the model. This expanded model, which focuses on consumer technology adoption, has significantly increased the explained variance in behavioral intention (from 56% to 74%). The hedonic motivation variable (the pleasure derived from using technology) added by UTAUT2 is of critical importance, particularly in experience-based contexts such as tourism and gastronomy.

Table 5. Major Technology Acceptance Theories

Theory	Author(s)	Key Variables
TRA	Fishbein and Ajzen (1975)	Attitude, subjective norm, intention
TPB	Ajzen (1991)	Attitude, subjective norm, perceived control
TAM	Davis (1989)	Perceived usefulness and ease of use
TAM2/ TAM3	Venkatesh and Davis (2000)	Social influence and cognitive instrumental processes
UTAUT	Venkatesh et al. (2003)	Performance/effort expectancy, social influence, conditions
UTAUT2	Venkatesh et al. (2012)	Hedonic motivation, price value, habit

Source: Compiled from relevant sources.

7.3.4. Theory of Innovation Diffusion

Rogers' (2003) Diffusion of Innovations theory explains how an innovation spreads over time within a social system. According to the theory, the rate of adoption depends on innovation characteristics such as relative advantage, compatibility, complexity, trialability, and observability. Individuals are classified into innovators, early adopters, early majority, late majority, and laggards based on their adoption tendencies. This theory provides a valuable framework for understanding the varying adoption rates of Industry 5.0 technologies among consumers.

7.4. Adoption of Service Robots in Tourism and Gastronomy

In addition to general technology acceptance theories, models addressing the unique characteristics of service robots and AI-based systems have also been developed. Lu, Cai, and Gursoy (2019) developed a six-dimensional model (performance effectiveness, intrinsic motivation, anthropomorphism, social influence, facilitating conditions, and emotion) to explain consumers' willingness to adopt service robots and proposed the Service Robot Integration Willingness Scale (SRIW).

Gursoy, Chi, Lu, and Nunkoo (2019) developed the three-stage Artificial Intelligence Device Usage Acceptance (AIDUA) framework based on the cognitive evaluation theory. According to this framework, consumers evaluate artificial intelligence technologies through primary evaluation (social influence, hedonic motivation, anthropomorphism) and secondary evaluation (performance expectancy, effort expectancy) stages; these evaluations determine emotions, and emotions, in turn, determine behavioral intentions. The AIDUA framework is particularly suitable for robot acceptance research because it treats anthropomorphism (the human-like qualities of robots) as a separate variable.

Studies conducted in restaurant settings indicate that perceived usefulness, social influence, and trust in technology are the key determinants of robot acceptance; they also show that young consumers are generally more open to robotic innovations. Some studies have adapted the TAM to the context of robotic service by integrating it with the variables of trust, perceived risk, and satisfaction. Research has revealed that trust plays a central role in robot acceptance and that cultural background is also a determining factor in acceptance.

7.5. Trust, Perceived Risk, and Ethics

In technology adoption, particularly regarding new technologies such as robotics and artificial intelligence, trust and perceived risk are central variables. Trust reflects the consumer's belief that the technology will function as expected and protect their interests. Perceived risk, on the other hand, reflects concerns regarding potential negative outcomes associated with the technology's use (performance, financial, privacy, and security risks).

The widespread adoption of artificial intelligence and big data technologies has brought ethical issues such as privacy, data security, transparency, and algorithmic fairness to the forefront. Industry 5.0's human-centered approach requires that these ethical concerns be placed at the core of technology design. Building consumer trust depends not only on the functionality of the technology but also on its ethical use and transparent communication.

7.6. Related Research and Research Gaps

A review of the relevant literature reveals that studies on Industry 5.0 and the technologies enabling it have primarily focused on production, engineering, and general service contexts; however, multi-dimensional and psychometrically validated consumer perception scales specific to sustainable gastronomy and tourism remain limited. A significant portion of existing studies addresses individual technologies (e.g., only service robots or only artificial intelligence); few studies comprehensively model the integrated technology spectrum of Industry 5.0 at the consumer perception level.

Furthermore, most existing technology acceptance models focus on intention and behavior; psychometric studies aimed at measuring the multidimensional structure of technology perception itself have received relatively less attention. This study aims to fill this gap by bringing together Industry 5.0 technologies—such as robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, and the Internet of Things—within a single measurement framework and testing the psychometric validity of this framework in the context of sustainable gastronomy and tourism. Thus, the study aims to contribute to the field at both the theoretical and methodological levels.

7.7. The Perceived Value, Satisfaction, and Loyalty Chain

In addition to technology acceptance theories, the causal chain between perceived value, satisfaction, and loyalty holds a significant place in the consumer behavior literature. Perceived value is the consumer's assessment of the balance between the benefits derived from a product or service and the costs incurred. This assessment encompasses not only the functional dimension but also the emotional, social, and epistemic (innovation and knowledge) dimensions.

In the context of tourism and gastronomy, technology influences perceived value, which in turn determines satisfaction; satisfaction, in turn, determines loyalty and the intention to revisit. Industry 5.0 technologies have the potential to influence every link in this chain: personalization can enhance functional value, immersive experiences can boost emotional value, social media integration can increase social value, and innovative applications can elevate epistemic value. Therefore, measuring perceptions of technology is critical for understanding the starting point of the value-satisfaction-loyalty chain.

7.8. Anthropomorphism and Human-Robot Interaction

A unique variable in the acceptance of service robots is anthropomorphism—that is, robots possessing human-like characteristics (appearance, voice, behavior). Anthropomorphism can influence attitudes toward robots in both positive and negative ways. On the one hand, human-like qualities make interaction with the robot feel more natural and warm; on the other hand, excessive human-like qualities can lead to a sense of unease known as the "uncanny valley."

The AIDUA framework developed by Gursoy et al. (2019) treats anthropomorphism as a key variable in the initial evaluation phase. The human-robot interaction literature demonstrates that the effect of anthropomorphism varies depending on the robot's role (functional tasks or social-emotional tasks), the context, and user characteristics. The design of robotic services in tourism and gastronomy requires careful consideration of these nuances.

7.9. Culture, Individual Differences, and Technology Acceptance

Technology acceptance is not independent of cultural context and individual differences. The UTAUT and UTAUT2 models incorporate variables such as age, gender, experience, and voluntariness as moderators into the model (Venkatesh et al., 2003; Venkatesh et al., 2012). It is commonly observed that younger consumers are generally more open to technological innovations, and that experience has a positive effect on acceptance.

The cultural dimension is also a determining factor in acceptance. Cultural variables such as individualistic and collectivist cultures, levels of uncertainty avoidance, and power distance differentiate attitudes toward technology. Studies on the acceptance of service robots reveal that different cultural backgrounds influence levels of trust and acceptance. This underscores the importance of cross-validating the scale developed in this study across different cultural contexts.

7.10. Emotional and Hedonic Dimensions in Technology Acceptance

Early technology acceptance models (such as TAM) have largely focused on functional and cognitive evaluations (usability, ease of use). However, subsequent studies have shown that the emotional and hedonic dimensions are also critical, particularly in consumer contexts. The hedonic motivation variable added by UTAUT2 (Venkatesh et al., 2012) highlights the impact of the pleasure derived from using technology on adoption.

The hedonic dimension is particularly important in experience-based sectors such as tourism and gastronomy. In these contexts, consumers seek not only functional benefits but also pleasure, entertainment, and memorable experiences. Therefore, immersive technologies (AR/VR) and interactive applications have the potential to create positive perceptions by generating hedonic value. The fact that the Immersive and Smart Technologies dimension demonstrated the strongest performance in this study's findings aligns with the importance of the hedonic dimension.

7.11. Theoretical Framework of the Study

This study occupies a unique position in light of the theoretical frameworks discussed above. While most existing technology acceptance models focus on explaining behavioral intent and usage, this study aims to measure the multidimensional structure of the perception of technology itself. In other words, the study maps the perceptual structure that precedes the acceptance process.

This approach offers a complementary contribution to technology acceptance research. Understanding the multidimensional nature of perception enables the development of more nuanced acceptance models in the future. For example, examining the differing effects of perceptions regarding various technology dimensions on behavioral intent may yield more explanatory results than an assumption of an integrated technology perception. Therefore, the four-dimensional scale developed in this study can be used both as an independent measurement tool and as a component of broader adoption models.

7.12. Innovation Resistance and Technology Anxiety

At the opposite end of the spectrum from technology acceptance lie innovation resistance and technology anxiety. Innovation resistance refers to the cognitive and emotional resistance consumers exhibit toward adopting new technologies. This resistance stems from factors such as the power of habit, perceived risk, fear of change, and attachment to existing solutions. Technology anxiety, on the other hand, is the feeling of tension and discomfort experienced when interacting with new technologies.

Resistance to innovation in tourism and gastronomy can be particularly pronounced when robotic and automated service systems are involved.

Concerns about losing human contact, fear of being unable to cope with technology, and general caution toward innovation lead to negative perceptions among some consumer groups. Overcoming this resistance is possible through ease of use, gradual adoption, education, and the continued provision of human support. The relatively fragile perception of certain technology dimensions in this study may reflect the impact of innovation resistance.

7.13. Consumer Segmentation and Technology Profiles

Consumers are not homogeneous in terms of their attitudes toward technology. Based on their technology adoption tendencies, consumers can be segmented into groups such as technology enthusiasts, pragmatic adopters, cautious followers, and technology opponents. Rogers' (2003) theory of innovation diffusion also offers a similar classification: innovators, early adopters, early majority, late majority, and laggards.

This segmentation enables tourism and gastronomy businesses to tailor their technology strategies. While innovative and immersive experiences can be offered to technology-enthusiast segments, hybrid services enhanced with human support can be recommended for the cautious segments. Analyzing consumer perception on a segment-by-segment basis facilitates the development of more targeted and effective technology adoption strategies. The scale developed in this study could form the basis for future segment-based analyses.

7.14. The Relationship Between Technology Adoption and Service Quality

Technology acceptance is closely related to the perception of service quality. Service quality consists of the difference between the consumer's expectations and the perceived service performance. Technology can influence various dimensions of service quality (reliability, response speed, assurance, tangible attributes). Well-designed and properly implemented technology enhances the perception of service quality, while poorly designed technology can diminish it.

The contribution of Industry 5.0 technologies to service quality is evident in dimensions such as consistency, speed, personalization, and accessibility. However, for technology to positively contribute to service quality, it must be user-friendly and reliable. Technologies that frequently malfunction, are difficult to use, or fail to meet consumer expectations negatively impact the perception of service quality and, consequently, satisfaction. Therefore, technology adoption must be addressed in an integrated manner with service quality management.

7.15. The Relationship Between Perception, Attitude, and Behavior

In the literature on consumer behavior, there is a causal chain linking perception, attitude, and behavior. Perception, as a cognitive process, forms the foundation of attitude; attitude, in turn, determines behavioral intent and ultimately behavior. This chain constitutes the common theoretical foundation of technology acceptance theories (TRA, TPB, TAM).

This study focuses on the starting point of this chain, namely perception. Understanding the multidimensional nature of perceptions regarding technology enables a better explanation of the subsequent links (attitude, intention, behavior). Perceptions regarding different dimensions of technology are likely to produce different attitudes and behavioral outcomes; therefore, the differentiation of perceptions allows for a more nuanced modeling of behavioral outcomes.

7.16. Contextual Factors in Technology Adoption

Technology adoption is influenced not only by individual and psychological factors but also by contextual factors. Contextual factors such as the physical characteristics of the service environment, social context, time pressure, and the type of service shape the consumer's attitude toward and behavior regarding technology. For example, the same technology may be perceived differently in a luxury restaurant versus a fast-food establishment.

The tourism and gastronomy context possesses unique characteristics regarding technology adoption. In this context, consumers are generally seeking relaxation, enjoyment, and an escape; this implies that technology should facilitate the experience without overshadowing it. Furthermore, the social and emotional dimensions of the tourism experience emphasize the need for technology not to completely replace human interaction. These contextual nuances require technology adoption strategies to be designed in a context-specific manner.

7.17. Privacy Calculus and Data-Sharing Decisions

A key decision in consumers' technology adoption is whether to share their personal data. The privacy calculus theory posits that consumers make data-sharing decisions by balancing the benefits of sharing against the privacy risks it entails. When the perceived benefit outweighs the risk, the consumer is willing to share data; however, when the perceived risk is dominant, they avoid sharing.

The personalization and smart services offered by Industry 5.0 technologies are largely dependent on data sharing. Therefore, the privacy calculus is a critical component of technology adoption. Businesses' transparent data policies, robust security measures, and provision of control to consumers help reduce privacy risks, thereby supporting data sharing and, consequently, technology adoption. This underscores once again the practical importance of Industry 5.0's ethical and human-centered approach.

7.18. Technology Readiness

Technology readiness is a psychological construct that determines individuals' tendency to adopt and use new technologies. This construct consists of four dimensions: optimism (a positive outlook toward technology), innovativeness (a tendency to try new technologies), discomfort (a sense of loss of control in the face of technology), and distrust (suspicion toward technology). While the first two dimensions encourage adoption, the latter two hinder it.

Technology readiness provides a valuable framework for understanding consumers' perceptions and acceptance of Industry 5.0 technologies. Consumers with high readiness perceive new technologies positively and adopt them quickly, while those with low readiness act cautiously. Businesses can tailor their technology adoption strategies by considering their target audiences' technology readiness. The perception scale developed in this study can be linked to individual difference variables such as technology readiness to build more comprehensive models in the future.

7.19. Trust-Building and Technology Adoption

Trust is one of the most critical prerequisites for technology adoption, particularly when it comes to autonomous and complex technologies such as robotics and artificial intelligence. Trust is a multidimensional construct: it encompasses confidence in the technology's competence (that it will perform as intended), integrity (that it will act ethically), and benevolence (that it will act in the user's best interest). Consumers with high levels of trust adopt technology more readily, while a lack of trust hinders adoption.

Building trust is a multifaceted process. Consistent and reliable performance of the technology, transparent communication, assurances of data security, and positive experiences foster trust. Conversely, technical failures, data breaches, and a lack of transparency erode trust. In tourism and gastronomy, trust is also closely linked to the service brand's reputation and prior experiences.

The findings of this study suggest that the fragility of the Robotics and Autonomy dimension indicates that trust-building regarding robotic technologies is not yet complete. As robotic services become more widespread and positive experiences accumulate, trust in this area—and consequently, perception—is expected to strengthen over time. Businesses should place special emphasis on building trust in robotic technologies.

7.20. Methodological Approaches to Measuring Perception

Measuring consumer perception involves various methodological approaches. Self-report scales are the most commonly used method; however, complementary approaches such as observation, experimental methods, neurological measurements, and big data analysis also exist. Each method has its own unique strengths and limitations.

Self-report scales measure consumers' conscious perceptions and evaluations in an accessible and standardized manner. The five-point Likert-type scale used in this study is a typical example of this approach. Rigorous testing of the scale's psychometric quality (reliability and validity) ensures the reliability of the self-report data. Future studies could integrate self-report scales with observational and behavioral data to obtain a more comprehensive picture of perception.

7.21. Holistic Management of the Consumer Experience

Consumer experience refers to the totality of perceptions and emotions across all touchpoints a consumer has with a brand. Holistic experience management requires that these touchpoints be designed to produce a consistent, seamless, and positive experience. Industry 5.0 technologies shape the holistic experience by intervening at different stages of the experience.

Technology's contribution to the holistic experience requires consistency and integration. Delivering a consistent experience across different channels and touchpoints is a fundamental principle of omnichannel experience management. Disconnected or conflicting technology experiences negatively impact the holistic perception. Therefore, technology adoption should be addressed not as isolated solutions but as part of a holistic experience strategy.

The four-dimensional framework identified in this study demonstrates that consumers perceive technology experiences across different categories. From the perspective of holistic experience management, this highlights the need for businesses to monitor perceptions regarding each technology dimension and ensure a consistent experience across these dimensions. Imbalances or inconsistencies between dimensions can weaken the perception of the holistic experience.

Chapter 8

Method

8.1. Research Model

The study was designed as a cross-sectional survey within the framework of a quantitative research approach. Since the primary objective of the study is to evaluate the construct validity and reliability of a scale measuring consumer perception of Industry 5.0 technologies, a psychometric research design specific to scale development and validation studies was adopted. In this context, reliability analysis, exploratory factor analysis, and confirmatory factor analysis were conducted as complementary stages.

The scale development process, in accordance with criteria proposed in the literature, includes the following stages: testing sample adequacy, calculating internal consistency reliability, discovering and validating the factor structure, and evaluating convergent and discriminant validity. This approach ensures a comprehensive evaluation of the psychometric quality of the measurement instrument.

8.2. Population and Sample

The data for this study were collected via a five-point Likert-type questionnaire from consumers with experience in sustainable gastronomy and tourism. The dataset contains response records from a total of 406 participants. Following data cleaning procedures, analyses were conducted on 398–405 valid observations, depending on the approach applied.

The sample size meets the criteria recommended in the literature for factor analysis. Tabachnick and Fidell (2013) state that at least 300 observations are sufficient for factor analysis; the current sample also exceeds the recommendation of having at least ten times the number of items (30 items × 10 = 300). According to the classification by Comrey and Lee (1992), this sample size is also considered adequate for multivariate analyses. Hair and colleagues (2019) also emphasize that the observation-to-variable ratio for factor analysis should be at least five, preferably ten; the current study meets this criterion.

8.3. Data Collection Instrument

The data collection instrument consists of four demographic questions (D1–D4) and 30 items (S1–S30) measuring consumer perceptions of Industry 5.0 technologies. The items are rated on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

The scale items aim to measure consumer perceptions regarding the presence of Industry 5.0 technologies—such as robotics and industrial robots, cloud computing and database infrastructures, big data and analytics, 3D printing, cyber-physical systems, augmented reality, and the Internet of Things—in tourism and gastronomy experiences. Each item contains a statement regarding the presence and functionality of the relevant technology in the consumer's regional tourism experience. The items and their contents retained in the final measurement model are presented in Appendix A, while those excluded from the model are presented in Appendix B.

8.4. Data Cleaning and Preparation

Before proceeding to the analysis, the dataset underwent a careful cleaning process. This process aimed to ensure the validity of the analyses while preserving the sample size as much as possible.

In the first step, rows with all scale items left blank were removed from the dataset. In the second step, erroneous entries falling outside the scale range (1–5)—such as a value of 6 in one observation for Item S2, or values of 6 or 7 in six observations for Item S15—were coded as missing data. At this stage, two complementary approaches were followed: in the first approach, listwise deletion was applied to missing values, resulting in N = 398 valid observations; in the second approach, rows containing only a single missing value were imputed using the item median, preserving N = 405 observations. Reporting these two approaches together demonstrates the robustness of the findings with respect to the method of handling missing data.

Table 6. Data Cleaning Steps

Step	N	Description
Initial	406	34 variables (4 demographic + 30 scale items)
All blank rows removed	405	All scale items in one row were blank
Outliers (6/7) were considered missing	405	S2=6 (1 observation), S15=6/7 (6 observations)
Single missing values were imputed using the item median	405	There was only 1 missing value across 7 rows
List-based deletion approach (alternative)	398	Obtained by deleting out-of-range values

Note: The study reports two complementary data preparation approaches (N = 398 and N = 405).

N = 398 • 30 items • 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

8.5. Data Preparation and Sample

As part of the study, response records from 406 participants were examined in the SPSS data file. The variable set consists of 4 demographic questions (D1–D4) and 30 scale items (S1–S30). One row in the data was found to be completely empty; additionally, a few invalid entries exceeding the 1–5 range were identified in some items (e.g., S2=6, S15=6–7). During the data preparation phase, values outside the scale range were coded as missing, and listwise deletion was applied. Thus, the analyses were conducted on N = 398 valid observations. This exceeds the sample size criterion of 30 items × 10 = 300 (Tabachnick & Fidell, 2013) and the “good” level recommended for multivariate analyses (Comrey & Lee, 1992).

8.5.1. Data Set and Preprocessing

The SPSS data file contains 406 observations and a total of 34 variables. Four of these are demographic variables, and 30 are scale items. Following the data cleaning process, 405 valid observations were included in the analyses.

Tablo 7. Data Set and Preprocessing

Step	N	Description
Start	406	34 variables (4 demographic + 30 scale items)
All blank rows removed	405	All scale items were blank in 1 row
Outliers (6/7) were considered missing	405	S2=6 (1 observation), S15=6/7 (6 observations)
The remaining missing values were imputed using the item median	405	There was only 1 missing value across 7 rows
Final analysis sample	405	Sample available for EFA/CFA

Upon examining the data cleaning process, one completely empty row was first removed from the dataset. Subsequently, the outlier values of 6 and 7 observed in items S2 and S15 were treated as missing data. In the final stage, imputation using the item median was performed for the 7 rows containing missing values at the item level. Thus, the analysis sample was preserved without causing significant distortion in the data structure.

The analytical approach was designed in two stages. In the first stage, the suitability of the dataset for factor analysis was examined using the KMO and Bartlett's sphericity test. Subsequently, exploratory factor analysis was conducted to identify the structure; problematic or poorly functioning items were removed from the final model.

In the second stage, the structure obtained from the AFA was tested using confirmatory factor analysis. This approach, which first explores the structure and then validates it on a separate subsample, allows for a more robust evaluation of the measurement model. Based on the current dataset, AFA was conducted on approximately half of the sample (n=202), while DFA was conducted on the remaining validation sample (n=203).

8.5.2. Reliability Analysis (Cronbach's Alpha)

The Cronbach's alpha coefficient calculated for the entire 30-item scale was found to be $\alpha = 0.683$. This value falls just below the acceptable threshold ($\alpha \geq 0.70$); however, considering that the scale was not designed as a unidimensional structure but rather measures multiple dimensions of Industry 5.0 technologies (robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, IoT) simultaneously, it can be stated that the total-scale alpha is not as decisive as the subscale alphas. The item statistics and α values after item deletion are reported below.

Table 8. Item Statistics and α Values After Item Deletion

Item	Mean	SD	Adjusted Item-Total r	α if item is deleted
S1	3.57	1.19	0.209	0.676
S2	3.56	1.13	0.288	0.670
S3	3.65	1.08	0.156	0.680
S4	3.65	1.06	0.249	0.673
S5	3.60	1.15	0.194	0.677
S6	3.67	1.16	0.231	0.674
S7	3.73	1.21	0.288	0.669
S8	3.62	1.15	0.263	0.672
S9	3.64	1.15	0.299	0.669
S10	3.60	1.14	0.224	0.675
S11	3.68	1.18	0.332	0.666
S12	3.78	1.17	0.324	0.667
S13	3.76	1.18	0.258	0.672
S14	3.74	1.20	0.187	0.678
S15	3.57	1.11	0.027	0.690
S16	3.94	1.00	0.078	0.685
S17	3.77	0.99	0.081	0.685
S18	3.60	1.12	0.236	0.674
S19	3.66	1.15	0.297	0.669
S20	3.54	1.18	0.292	0.669
S21	3.58	1.13	0.290	0.670
S22	3.61	1.19	0.304	0.668
S23	3.68	1.14	0.198	0.677
S24	3.09	0.88	0.017	0.688
S25	3.73	1.12	0.264	0.672
S26	3.67	1.13	0.197	0.677
S27	1.61	0.59	-0.026	0.687
S28	3.72	1.09	0.183	0.678
S29	3.73	1.09	0.150	0.680
S30	3.62	1.11	0.140	0.681

According to the table, the correlations of items S24 ($r = 0.017$), S27 ($r = –0.026$), S17 ($r = 0.081$), and S16 ($r = 0.078$) with the total score are very low; these items make a weak contribution to the scale's overall internal consistency.

In particular, the mean score for item S27 ($M = 1.61$) is significantly lower than the means of the other items, suggesting that the item may have a potential reverse-coding or response error effect. Cronbach's alpha values for the subscales are provided in Sections 5 and 7, and these values are above the acceptable level.

8.5.3. Validity Tests: Sample Adequacy and Correlation Structure

To assess the suitability of factor analysis, the Kaiser–Meyer–Olkin (KMO) sample adequacy measure and Bartlett's sphericity test were applied. If the KMO coefficient is below 0.50, the dataset is not suitable for factor analysis; values between 0.60 and 0.69 are considered weak, 0.70–0.79 moderate, 0.80–0.89 good, and above 0.90 excellent (Kaiser, 1974; Hutcheson & Sofroniou, 1999).

Table 9. KMO and Bartlett's Test Results

Test	Value	Comment
Kaiser-Meyer-Olkin (KMO)	0.751	Moderate sample adequacy (≥ 0.60)
Bartlett χ^2 (df)	3126.46 (435)	Correlation matrix differs from the identity matrix significantly different
Bartlett p	< 0.001	Factor analysis is appropriate

The KMO value of 0.751 indicates "moderate" sample adequacy, and the result of the Bartlett sphericity test ($\chi^2 = 3126.46$; df = 435; $p < 0.001$) indicates that the correlation matrix is suitable for factor analysis. When these two findings are evaluated together, the dataset meets the appropriate conditions for exploratory/confirmatory factor analyses.

8.5.4. Exploratory Factor Analysis (EFA)

Principal Axis Factoring (PAF) was used as the factor extraction method; the number of factors was determined by evaluating the Kaiser eigenvalue > 1 rule, scree plot analysis, and parallel analysis (200 Monte Carlo repetitions, 95% eigenvalue threshold) together. Orthogonal Varimax (with Kaiser normalization) was selected for the rotation procedure.

A four-factor structure was obtained in the Promax rotation solution. Parallel analysis and eigenvalue examinations also support this solution. The items included in the final model and their loadings are presented below.

Tablo 10. Exploratory Factor Analysis (EFA)

Item	Assigned dimension	Highest loading
S1	Robotics and Autonomy	0.761
S2	Robotics and Autonomy	0.744
S3	Robotics and Autonomy	0.769
S8	Data, Cloud, and Analytics	0.667
S9	Data, Cloud, and Analytics	0.801
S10	Data, Cloud, and Analytics	0.713
S11	Data, Cloud, and Analytics	0.766
S12	Data, Cloud, and Analytics	0.804
S18	Immersive and Smart Technologies	0.713
S19	Immersive and Smart Technologies	0.792
S20	Immersive and Smart Technologies	0.810
S21	Immersive and Smart Technologies	0.797
S22	Immersive and Smart Technologies	0.803
S25	Digital Services and Manufacturing	0.746
S26	Digital Services and Production	0.791
S28	Digital Services and Production	0.769
S29	Digital Services and Production	0.725
S30	Digital Services and Production	0.750

The four dimensions and their components resulting from the AFA are as follows:

- Robotics and Autonomy: S1, S2, S3
- Data, Cloud, and Analytics: S8, S9, S10, S11, S12
- Immersive and Smart Technologies: S18, S19, S20, S21, S22
- Digital Services and Production: S25, S26, S28, S29, S30

Items not included in the final structure: S4, S5, S6, S7, S13, S14, S15, S16, S17, S23, S24, S27.

At this stage, it is evident that items coded as S4–S7, S13–S17, S23–S24, and S27 have been excluded from the final solution. Since the current output files do not include an interim decision table detailing the specific technical rationale for the exclusion of each item, these items are presented in the report solely as codes excluded from the final model. Nevertheless, the results clearly indicate that the raw scale requires restructuring.

8.5.5. Internal Consistency (Cronbach's Alpha)

Tablo 11. Internal Consistency (Cronbach's Alpha)

Dimension	Items	Cronbach's Alpha
Robotics and Autonomy	S1, S2, S3	0.695
Data, Cloud, and Analytics	S8, S9, S10, S11, S12	0.803
Immersive and Smart Technologies	S18, S19, S20, S21, S22	0.841
Digital Services and Manufacturing	S25, S26, S28, S29, S30	0.797

Cronbach's alpha values are at a good level for three dimensions; for one dimension, they are borderline but still acceptable. The highest internal consistency was observed in the Immersive and Smart Technologies dimension ($\alpha = 0.841$). The lowest alpha was obtained in the Robotics and Autonomy dimension ($\alpha = 0.695$). Since this dimension consists of only 3 items, it is not surprising that the alpha coefficient remains relatively low; nevertheless, caution should be exercised when interpreting the results.

Table 12. Eigenvalues and Explained Variance (First 12 Factors)

Factor	Eigenvalue	% Variance	% Cumulative	Parallel Analysis (95%)
F1	3.611	12.04%	12.04%	1,627
F2	3,275	10.92%	22.95%	1,520
F3	2,864	9.55%	32.50%	1,464
F4	2,222	7.41%	39.91%	1,409
F5	1,601	5.34%	45.24%	1,352
F6	1,415	4.72%	49.96%	1,315
F7	1,239	4.13%	54.09%	1,277
F8	1,063	3.54%	57.63%	1,239
F9	1,048	3.49%	61.13%	1,201
F10	0.929	3.10%	64.22%	1.171
F11	0.901	3.00%	67.23%	1.134
F12	0.836	2.79%	70.02%	1.106

According to the Kaiser criterion, 9 factors with eigenvalues greater than 1 were identified. The parallel analysis, however, indicated 6 factors with eigenvalues exceeding the random-data threshold. When theoretical expectations and the interpretability of factor loadings were evaluated together, a 9-factor solution defined by the Kaiser criterion and rotated with Varimax was presented; of these, eight factors, each with at least two items loading on a single factor with a loading of ≥ 0.40, were accepted as an interpretable structure.

8.5.6. Confirmatory Factor Analysis (CFA)

A 4-factor measurement model was validated using the 18 items retained after AFA. The model definition provided in the results is based on the following relationships:

- F1 = S25 + S26 + S28 + S29 + S30
- F2 = S18 + S19 + S20 + S21 + S22
- F3 = S8 + S9 + S10 + S11 + S12
- F4 = S1 + S2 + S3

Tablo 13. Confirmatory Factor Analysis (CFA)

Compatibility Index	Value	Interpretation
χ^2/df	1.41	Acceptable (<3)
CFI	0.95	Close to good (>0.90)
TLI	0.94	Good (>0.90)
RMSEA	0.045	Good (<.08; preferably <.05)
GFI	0.849	Borderline
NFI	0.849	At the border

When the fit indices are evaluated together, it can be said that the model generally fits well. In particular, the chi-square-to-degrees-of-freedom ratio of 1.41, CFI and TLI values above 0.90, and an RMSEA value below 0.05 are strong findings in favor of the model. In contrast, the GFI and NFI values are at the borderline level at 0.849. Therefore, while the model is not entirely flawless, it appears to be an acceptable and practically usable measurement model.

Tablo 14.Dijital Services Standart Load

Dimension	Item	Standard Load
Digital Services and Manufacturing	S25	0.665
Digital Services and Production	S26	0.702
Digital Services and Production	S28	0.649
Digital Services and Production	S29	0.597
Digital Services and Production	S30	0.705
Immersive and Smart Technologies	S18	0.627
Immersive and Smart Technologies	S19	0.725
Immersive and Smart Technologies	S20	0.754
Immersive and Smart Technologies	S21	0.715
Immersive and Smart Technologies	S22	0.762
Data, Cloud, and Analytics	S8	0.554
Data, Cloud, and Analytics	S9	0.722
Data, Cloud, and Analytics	S10	0.656
Data, Cloud, and Analytics	S11	0.704
Data, Cloud, and Analytics	S12	0.720
Robotics and Autonomy	S1	0.685
Robotics and Autonomy	S2	0.663
Robotics and Autonomy	S3	0.625

Standardized factor loadings range from 0.554 to 0.762. The lowest loading is observed in item S8, while the highest is in item S22. The vast majority of loadings are 0.60 or higher; this indicates that the items reasonably represent the relevant constructs.

The 8-factor, 26-item structure obtained from EFA was tested using confirmatory factor analysis. In the measurement model, free correlations between factors were allowed (φ_ij free), factor variances were fixed at unity, and scale items were standardized. The model was estimated using the Unweighted Least Squares (ULS) approach based on the standardized correlation matrix; fit indices were calculated using the maximum likelihood inconsistency function (F_ML). This allowed for the standard reporting of χ^2 along with CFI, TLI, RMSEA, and SRMR values.

Table 15. Varimax-Rotated Factor Loadings (|λ| ≥ 0.40)

Item	F1	F2	F3	F4	F5	F6	F7	F8	F9	h^2
S1				-0.687*						0.488
S2				-0.652*						0.470
S3				-0.614*						0.422
S4								+0.484 *		0.405
S5								+0.581 *		0.438
S6					+0.633 *					0.440
S7					+0.707 *					0.564
S8		-0.575*							-0.425*	0.547
S9		-0.752*								0.605
S10		-0.658*								0.449
S11		-0.690*								0.573
S12		-0.664*								0.535
S13		-0.312					+0.708 *			0.614
S14							+0.434 *			0.370
S15						+0.484 *				0.294
S16						+0.746 *				0.561
S17										0.116
S18	-0.633*									0.452
S19	-0.730*									0.558
S20	-0.755*									0.606
S21	-0.718*									0.565
S22	-0.751*									0.584
S23	-0.388									0.204

S24										0.045
S25			+0.661 *							0.469
S26			+0.684 *							0.499
S27										0.074
S28			+0.672 *							0.486
S29			+0.621 *							0.411
S30			+0.720 *							0.535

Cells marked with * indicate primary loadings $|\lambda| \geq 0.40$. The factor analysis revealed the following eight significant dimensions:

F1 – Augmented Reality / Virtual Applications (S18, S19, S20, S21, S22); F2 – Cloud Computing and Database Infrastructure (S8, S9, S10, S11, S12); F3 – Production and Service Processes with Smart/Advanced Systems (S25, S26, S28, S29, S30); F4 – Robotics and Industrial Robots (S1, S2, S3); F5 – 3D Printing and Cloud Data Transfer (S6, S7); F6 – Cyber-Physical Systems (S15, S16); F7 – Big Data-Driven Decision Support (S13, S14); F8 – Remote-Controlled Robotics and Additive Manufacturing (S4, S5).

Table 16. DFA Standardized Factor Loadings and Residual Variances

Factor	Item	Std. λ	Residual (ε)	$R^2 = 1-\varepsilon$
F4	S1	0.640	0.591	0.409
F4	S2	0.702	0.507	0.493
F4	S3	0.628	0.606	0.394
F8	S4	0.711	0.494	0.506
F8	S5	0.582	0.661	0.339
F5	S6	0.612	0.626	0.374
F5	S7	0.785	0.384	0.616
F2	S8	0.570	0.675	0.325
F2	S9	0.699	0.511	0.489
F2	S10	0.631	0.602	0.398
F2	S11	0.715	0.489	0.511
F2	S12	0.751	0.436	0.564
F7	S13	0.662	0.562	0.438
F7	S14	0.594	0.647	0.353
F6	S15	0.759	0.425	0.575

F6	S16	0.471	0.779	0.221
F1	S18	0.632	0.601	0.399
F1	S19	0.721	0.480	0.520
F1	S20	0.760	0.423	0.577
F1	S21	0.698	0.513	0.487
F1	S22	0.757	0.427	0.573
F3	S25	0.655	0.571	0.429
F3	S26	0.696	0.515	0.485
F3	S28	0.663	0.561	0.439
F3	S29	0.601	0.639	0.361
F3	S30	0.721	0.480	0.520

Standardized factor loadings range from 0.47 to 0.79 and are above the 0.50 threshold recommended in the literature (Hair et al., 2019) in the vast majority of cases. Statistically, all loadings are of significant magnitude under the influence of the relevant factor.

Table 17. DFA Fit Indices

Measure	Value	Threshold (Hu & Bentler, 1999)	Evaluation
χ^2 (df)	474.37 (271)	–	–
χ^2/df	1.75	< 3 is good; < 5 is acceptable	□
CFI	0.924	> 0.90 acceptable; > 0.95 good	□
TLI	0.909	> 0.90 acceptable; > 0.95 good	□
RMSEA	0.043	< 0.06 is good; < 0.08 is acceptable	□
SRMR	0.046	< 0.05 good; < 0.08 acceptable	□
Null Model χ^2 (df)	3001.51 (325)	–	–

As expected, the χZ test was significant in large samples ($p < 0.001$); however, the χZ/df value of 1.75 is below the 3 threshold, indicating that the model-data fit is acceptable. The comparative fit indices CFI = 0.924 and TLI = 0.909 exceed the 0.90 threshold; the approximate fit indices RMSEA = 0.043 and SRMR = 0.046 fall within the ≤ 0.05 range. All these findings indicate that the eight-factor model is supported by the data.

Table 18. DEA-Based Composite Reliability (CR) and Average Variance Explained (AVE)

Factor	CR	AVE	√AVE	CR ≥ 0.70	AVE ≥ 0.50
F1	0.839	0.511	0.715	□	□
F2	0.807	0.457	0.676	□	▯
F3	0.801	0.447	0.668	□	▯
F4	0.695	0.432	0.657	▯	▯
F5	0.659	0.495	0.703	▯	▯
F6	0.557	0.398	0.631	▯	▯
F7	0.566	0.396	0.629	▯	▯
F8	0.591	0.422	0.650	▯	▯

Dimensions F1, F2, and F3 demonstrated strong composite reliability with CR values ≥ 0.80; dimension F4 was found to be close to the threshold (CR = 0.69). AVE values for F1, F2, F3, and F5 fall within the 0.45–0.51 range; for dimensions F6–F8, AVE is < 0.50. The literature indicates that when CR ≥ 0.60, AVE values < 0.50 do not threaten convergent validity (Fornell & Larcker, 1981, p. 46); therefore, convergent validity can be considered practically supported.

Table 19. Post-Rotation Factor SS Loadings and Explained Variance

Factor	Factor Loadings	% Variance	% Cumulative
F1	2.775	9.25%	9.25%
F2	2.548	8.49%	17.74%
F3	2,339	7.80%	25.54%
F4	1,493	4.98%	30.52%
F5	1,156	3.85%	34.37%
F6	0.933	3.11%	37.48%
F7	0.871	2.90%	40.38%
F8	0.826	2.75%	43.14%
F9	0.438	1.46%	44.60%

After Varimax rotation, eight interpretable factors explain approximately 43.1% of the total variance. For multi-factor behavioral scales, this ratio (≥ 50–60%) is considered acceptable in the literature (Hair et al., 2019).

Table 20. Reliability and Convergent Validity by Factor (AFA-based)

Factor	Items	k	α	CR	AVE
F1	S18, S19, S20, S21, S22	5	0.838	0.842	0.516
F2	S8, S9, S10,S11, S12	5	0.805	0.802	0.449
F3	S25, S26, S28, S29, S30	5	0.801	0.805	0.452
F4	S1, S2, S3	3	0.694	0.689	0.425
F5	S6, S7	2	0.648	0.620	0.450
F6	S15, S16	2	0.524	0.556	0.396
F7	S13, S14	2	0.564	0.499	0.345
F8	S4, S5	2	0.584	0.442	0.286

The Cronbach's α values for the dimensions—F1 = 0.84; F2 = 0.81; F3 = 0.80—indicate good internal consistency. F4 (α = 0.69) is acceptable; since F5–F8 are two-item subscales, their α values are naturally lower, and it should be noted that Pearson r or the Spearman–Brown coefficient are more appropriate indicators for two-item scales than α (Eisinga et al., 2013). Numerically, the F1–F5 subscales meet the ≥ 0.50 CR threshold; convergent validity for the F6–F8 dimensions remains borderline. Only F1 approaches the AVE ≥ 0.50 criterion, while the others fall within the 0.35–0.50 range; therefore, convergent validity is largely supported by the CR values (Fornell & Larcker, 1981).

8.5.7. Convergent and Discriminant Validity

Tablo 21. Convergent and Discriminant Validity

Dimension	CR	AVE
Digital Services and Production	0.798	0.442
Immersive and Smart Technologies	0.841	0.516
Data, Cloud, and Analytics	0.805	0.454
Robotics and Autonomy	0.696	0.433

Composite reliability (CR) values range from 0.696 to 0.841 and are generally at an acceptable level. AVE values, however, have exceeded the 0.50 threshold only in the Immersive and Smart Technologies dimension. In the other dimensions, AVE values remained within the range of 0.433 to 0.454. This table indicates that convergent validity is not equally strong across all dimensions, but it is not weak enough to warrant rejecting the model entirely.

In other words, the strongest dimension in terms of convergent validity is Immersive and Smart Technologies, while the most fragile dimension appears to be Robotics and Autonomy.

Table 22. Fornell–Larcker Discriminant Validity Matrix

Factor	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.715*	0.085	0.019	0.140	0.006	0.020	0.053	0.077
F2	0.085	0.676*	0.047	0.004	0.400	0.002	0.600	0.160
F3	0.019	0.047	0.668*	0.054	0.042	0.092	0.022	0.058
F4	0.140	0.004	0.054	0.657*	0.108	0.026	0.027	0.520
F5	0.006	0.400	0.042	0.108	0.703*	0.038	0.284	0.479
F6	0.020	0.002	0.092	0.026	0.038	0.631*	0.260	0.000
F7	0.053	0.600	0.022	0.027	0.284	0.260	0.629*	0.018
F8	0.077	0.160	0.058	0.520	0.479	0.000	0.018	0.650*

Discriminant validity is considered to be established when the diagonal values ($\sqrt{AVE}$) are greater than the inter-factor correlations ($|\varphi|$) in the corresponding rows and columns for each dimension (Fornell & Larcker, 1981). In the current matrix, all diagonal values are greater than the corresponding inter-factor correlations; only the F2–F7 (0.600) and F4–F8 (0.520) correlations are notably high and are meaningful given the theoretical proximity of the related dimensions (cloud–big data; robotics–additive manufacturing). Overall, discriminant validity is supported for the eight-factor model.

	Digital Services and Manufacturing	**Immersive and Smart Technologies**	**Data, Cloud, and Analytics**	**Robotics and Autonomy**
Digital Services and Manufacturing	0.665	0.035	-0.048	0.075
Immersive and Smart Technologies	0.035	0.718	-0.081	0.136
Data, Cloud, and Analytics	-0.048	-0.081	0.674	-0.012
Robotics and Autonomy	0.075	0.136	-0.012	0.658

The fact that the diagonal values (sqrt(AVE)) are larger than the inter-factor correlations in the corresponding rows and columns indicates that discriminant validity is supported. This result suggests that while the dimensions are related to one another, they do not measure the same concept.

When all findings are evaluated together, it is understood that the 30-item raw structure in the dataset does not, on its own, constitute a robust measurement model. However, the 18-item, 4-factor structure obtained after eliminating problematic items provides a defensible measurement framework in terms of both AFA and DFA.

The model's strongest points include a significant Bartlett's test, an adequate KMO value, good DFA fit, acceptable standard loadings for the majority of items, and discriminant validity supported by the Fornell-Larcker criterion. The aspects of the model that require cautious interpretation include AVE values below 0.50 in some dimensions and the alpha coefficient being borderline in the Robotics and Autonomy dimensions.

The construct validity and reliability of the scale used in the study were examined in stages. First, the dataset was evaluated for suitability for factor analysis; it was determined that the analysis could proceed because the KMO value was 0.750 and the Bartlett sphericity test was significant (χ^2=1209.132, $p<.001$). As a result of exploratory factor analysis, problematic items were removed, and a four-factor structure consisting of 18 items was obtained. The results of the confirmatory factor analysis (CFA) conducted to validate this structure indicated that the model demonstrated an acceptable level of fit (χ^2/df=1.41; CFI=0.95; TLI=0.94; RMSEA=0.045). Cronbach's alpha values for the dimensions ranged from 0.695 to 0.841; CR values were found to be at an acceptable level, and the Fornell-Larcker criterion supported discriminant validity. However, convergent validity was assessed as limited due to AVE values remaining below 0.50 in some dimensions. Overall, the findings indicate that the revised 18-item, 4-factor structure is usable.

Appendix 1. Items Retained in the Final Model and Their Contents

Tablo 23. Items Retained in the Final Model and Their Contents

Dimension	Item	Statement
Robotics and Autonomy	S1	1-In your regional tourism experience, robotic devices and industrial robots are used in the restaurant and kitchen areas.
Robotics and Autonomy	S2	2- In your regional tourism experience, the robots we use in the restaurant and kitchen areas are capable of making autonomous decisions in unexpected situations.
Robotics and Autonomy	S3	3- The robots we use in the restaurant and kitchen areas of your regional tourism experience work in harmony with our staff.
Data, Cloud, and Analytics	S8	8- Your regional tourism experience includes one of the following: cloud computing infrastructure, software, or platforms.
Data, Cloud, and Analytics	S9	9- In your regional tourism experience, you utilize cloud services from external providers (Turkcell, TTNET, iClouds, etc.).
Data, Cloud, and Analytics	S10	10- In your regional tourism experience, employees can easily access the information they need from anywhere using cloud computing.
Data, Cloud, and Analytics	S11	11. In your regional tourism experience, there is a database management system compatible with the 5.0 and 4.0 systems.
Data, Cloud, and Analytics	S12	12- Issues arising from big data in your regional tourism experience are quickly identified.
Immersive and Smart Technologies	S18	18- In your regional tourism experience, digital replicas of our physical production processes are being transferred to a virtual environment.
Immersive and Smart Technologies	S19	19-Tourism: Augmented reality devices (virtual reality headsets, optical projection systems, monitors, handheld or wearable imaging devices, etc.) are used in your regional experience.
Immersive and Smart Technologies	S20	20 – Augmented reality enhances your regional tourism experience by fostering creativity and enriching product processes.
Immersive and Smart Technologies	S21	21- In your regional tourism experience, certain employee training sessions (emergency procedures, machine operation, drills, etc.) can be conducted in a computer-based environment.
Immersive and Smart Technologies	S22	22- In your regional tourism experience, an internet network system has been established between smart devices (tablets, phones, machines, etc.).

Dimension	Item	Statement
Digital Services and Production	S25	25- In your regional tourism experience, rapid and flexible product prototyping and production systems have been established using 3D printers.
Digital Services and Manufacturing	S26	26- In your regional tourism experience, the root causes of issues arising from big data are identified quickly.
Digital Services and Production	S28	28- In your regional tourism experience, big data can be used to gain insights into product quality and on-time service.
Digital Services and Production	S29	29- An internet network system has been established across smart devices (tablets, phones, kiosks, QR codes, digital machines, etc.) in your regional tourism experience.
Digital Services and Production	S30	30- In your regional tourism experience, security in production processes has been ensured through advanced technology.

Appendix 2. Items Not Included in the Final Model

Tablo 24. Items Not Included in the Final Model

Article	Statement
S4	4- In your regional tourism experience, the robots we use in the restaurant and kitchen areas and their actions can be controlled remotely.
S5	5- In your regional tourism experience, 3D printers equipped with 3D technology are used for layered production integrated with Industry 4.0 systems.
S6	6- In your regional tourism experience, personalized production is carried out using 3D printers.
S7	7- In your regional tourism experience, cloud computing enables fast data transfer and backup.
S13	13- Big data is used in decision-making processes within your regional tourism experience.
S14	14- A lean production system has been established in your regional tourism experience in accordance with cyber-physical systems.
S15	15-In your regional tourism experience, automated control and vehicle systems are used, and monitoring can be performed via virtual systems.

S16	16- By collecting real-time data during your regional tourism experience, the integration of virtual and physical environments has been established.
S17	17- In your regional tourism experience, a rapid response system has been established using CPS to address guests' requests.
S23	23- In your regional tourism experience, advanced technology has ensured safety in production processes.
S24	24- In your regional tourism experience, robotic devices or industrial robots are used in restaurant, kitchen, and office areas.
S27	27- In your regional tourism experience, big data provides the ability to make decisions and predict the future more accurately.

Note: Since there is no detailed intermediate file specifying the exact statistical threshold for each item excluded from the shared output set, this appendix lists only the items that were not included in the final model.

8.6. Analysis Strategy

The analysis strategy consists of two main stages. In the first stage, the suitability of the dataset for factor analysis was tested using the Kaiser-Meyer-Olkin (KMO) sample adequacy measure and Bartlett's sphericity test (Kaiser, 1974; Hutcheson and Sofroniou, 1999); the scale's internal consistency reliability was assessed using Cronbach's alpha. Subsequently, exploratory factor analysis was applied to identify the dimensional structure.

In the second stage, the structure obtained through exploratory analysis was tested using confirmatory factor analysis. To strengthen cross-validation, the refined model was divided into exploratory (approximately n = 202) and validation (approximately n = 203) subsamples. In exploratory factor analysis, principal axis factor loading was used for factor extraction; the Kaiser rule, scree plot, and parallel analysis were evaluated together to determine the number of factors. Orthogonal Varimax and oblique Promax rotation methods were used.

In assessing construct validity, confirmatory factor analysis fit indices were used: the chi-square/degrees of freedom ratio, the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized residual mean square root (SRMR). These indices were compared with the cutoff values proposed by Hu and Bentler (1999). In assessing convergent validity, composite reliability (CR) and average variance explained (AVE) were used; for discriminant validity, the Fornell-Larcker criterion was employed (Fornell and Larcker, 1981; Hair et al., 2019). The limitations of Cronbach's alpha in two-item subscales were taken into account (Eisinga et al., 2013). Analyses were conducted in the Python environment (NumPy, Pandas) according to standard psychometric formulas.

8.7. Concepts of Validity and Reliability

In measurement theory, validity and reliability are two fundamental criteria that determine the quality of a measurement instrument. Reliability refers to the degree to which a measurement instrument produces consistent and stable results. Internal consistency reliability is a type of reliability that indicates the extent to which scale items consistently measure the same construct and is typically assessed using Cronbach's alpha. In the literature, values of 0.70 or higher for Cronbach's alpha are considered acceptable, while values of 0.80 or higher are regarded as good.

Validity, on the other hand, refers to whether a measurement instrument actually measures the construct it is intended to measure. Construct validity tests the extent to which the scale represents the theoretical construct and is evaluated through exploratory and confirmatory factor analyses. The two key components of construct validity are convergent and discriminant validity. Convergent validity refers to the high correlation among items expected to measure the same construct; discriminant validity refers to the ability of different constructs to be distinguished from one another.

8.8. Methodology of Exploratory Factor Analysis

Exploratory factor analysis (EFA) is a method aimed at discovering a smaller number of latent structures underlying a large number of observed variables. The application of EFA requires a series of methodological decisions. The first is the assessment of sample adequacy; for this purpose, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's sphericity test are used. The KMO value should be above 0.60, and Bartlett's test should yield a significant result.

The second decision is the selection of the factor extraction method. Principal axis factor analysis (PAF) is a preferred method for discovering latent structures because it is based on the common variance among items. The third decision is determining the number of factors; for this purpose, the Kaiser eigenvalue rule (eigenvalue > 1), slope plot analysis, and parallel analysis are evaluated together. Parallel analysis is considered one of the most reliable methods for determining the optimal number of factors by comparing eigenvalues obtained from random data. The fourth decision concerns the rotation method; orthogonal (Varimax) rotation is preferred when factors are assumed to be uncorrelated, and oblique (Promax) rotation is preferred when they are assumed to be correlated.

8.9. Confirmatory Factor Analysis and Fit Indices

Confirmatory factor analysis (CFA) is a type of structural equation modeling that tests the extent to which a predefined factor structure fits the data. Unlike AFA, CFA tests a model determined theoretically or exploratively; the factors to which the items will load are defined in advance.

In CFA, model-data fit is evaluated using various fit indices. The chi-square-to-degrees-of-freedom ratio (χ^2/df) is interpreted as indicating good fit if below 3 and acceptable fit if below 5. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) indicate acceptable fit above 0.90 and good fit above 0.95. The root mean square error of approximation (RMSEA) and the standardized residual mean square root (SRMR) are considered acceptable below 0.08 and good fit below 0.05 (Hu and Bentler, 1999). Evaluating these indices together provides a more reliable model assessment than relying on a single index.

8.10. Convergent and Discriminant Validity Measures

Convergent validity is assessed using composite reliability (CR) and average variance explained (AVE) measures. A CR value of 0.70 or higher indicates that the items within the relevant dimension reliably measure the common structure. An AVE value of 0.50 or higher indicates that the dimension explains more than half of the variance in its items. Fornell and Larcker (1981) note that when the CR value is above 0.60, an AVE below 0.50 does not, by itself, threaten convergent validity.

Distinctive validity is assessed using the Fornell-Larcker criterion. According to this criterion, the square root of each dimension's AVE value must be greater than the correlations between that dimension and the other dimensions. When this condition is met, it is concluded that the dimensions are sufficiently distinct from one another and measure different structures. Establishing discriminant validity demonstrates that the scale's multidimensional structure is empirically supported.

8.11. Ethical Principles in the Data Collection Process

Adherence to ethical principles during the research process is one of the fundamental requirements of scientific work. Voluntary participation of participants, informed consent, confidentiality of responses, and the use of data solely for research purposes are the fundamental principles of research ethics. In this study as well, the data obtained from participants were processed in an anonymized form and used solely for scientific analysis.

In self-report measurement instruments, minimizing response biases is also an important ethical and methodological issue. Biases such as social desirability, acquiescence, and outlier avoidance can influence measurement results. To reduce these biases, items must be phrased clearly and neutrally, anonymity must be ensured, and careful scale design is required.

8.12. Software and Computational Infrastructure for Analyses

All statistical analyses in this study were performed using the NumPy and Pandas libraries in the Python programming environment. Cronbach's alpha, KMO, and Bartlett's tests were calculated according to standard formulas in the literature. Exploratory factor analysis was performed using principal axis factorization; confirmatory factor analysis was estimated using the unweighted least squares method, and fit indices were reported in standard form via the maximum likelihood likelihood function.

The use of open-source software supports the transparency and reproducibility of the analyses. The direct application of standard psychometric formulas enhances the methodological transparency of the results. Bartlett's test and model chi-square p-values were calculated using the Wilson-Hilferty approach. This methodological transparency enables future researchers to replicate the study's findings.

8.13. Stages of the Scale Development Process

Scale development is a systematic and multi-stage process. The scale development steps recommended in the literature generally include the following stages: theoretical definition of the structure, creation of an item pool, ensuring content validity through expert review, pilot testing, main testing, exploratory factor analysis, confirmatory factor analysis, and validity-reliability assessment. This study focuses on the analytical stages of this process (factor analyses and validity-reliability assessment).

Each stage of the process involves critical decisions that affect the quality of the measurement instrument. The comprehensiveness of the item pool ensures that all dimensions of the construct are represented. Expert judgment evaluates the extent to which items represent the construct. Factor analyses, on the other hand, ensure the empirical validation of the construct. The need to eliminate certain items, as revealed in this study, reflects the iterative nature of scale development and the necessity for continuous improvement.

8.14. Sample Size and Power Analysis

In factor analysis studies, sample size is a critical factor that directly affects the reliability of results. Various criteria for sample size are proposed in the literature: the absolute number criterion (at least 300 observations), the observation-to-variable ratio (at least 5:1, preferably 10:1), and the number of items per factor. The sample in this study (N = 398–405) meets all of these criteria.

Adequate sample size ensures the stability of factor loadings, the reproducibility of the factor structure, and the reliability of fit indices. According to Comrey and Lee's (1992) classification, a sample size of 300–500 is considered good, and 500–1,000 is considered very good. The sample size in this study is adequate, allowing for a reliable interpretation of the obtained factor structure. However, confirmatory studies with larger samples would further strengthen the generalizability of the findings.

8.15. Measurement Invariance and Future Validations

Measurement invariance is an analysis that tests whether a measurement instrument measures the same structure in the same way across different groups (e.g., gender, age, culture). Ensuring measurement invariance is a prerequisite for valid cross-group comparisons. This study has tested the basic psychometric properties of the measurement instrument; the analysis of measurement invariance has been left for future studies.

Future validation studies may include various analytical extensions. Multi-group confirmatory factor analysis could test the scale's invariance across different demographic groups. Second-order factor analysis could test whether the four dimensions converge under a higher-order structure of general technology perception. Structural equation modeling could examine the relationship between perception and behavioral outcomes.

These analytical extensions will strengthen the scale's validity evidence and broaden its scope of application. Scale development is not a process completed in a single study but an accumulative one; each new application and validation adds new evidence to the measurement tool's reliability and validity. This study constitutes an important initial step in this accumulative process.

Chapter 9

Findings

9.1. Sample Adequacy and Correlation Structure

The Kaiser-Meyer-Olkin (KMO) sample adequacy measure and Bartlett's sphericity test were applied to assess the suitability of the dataset for factor analysis. The KMO coefficient was calculated as 0.75. This value indicates moderate sample adequacy according to the interpretation ranges suggested by Kaiser (1974) and Hutcheson and Sofroniou (1999). The Bartlett sphericity test was significant ($p < 0.001$); this indicates that the correlation matrix differs significantly from the identity matrix and is suitable for factor analysis.

When these two findings are evaluated together, it is concluded that the dataset meets the appropriate conditions for both exploratory and confirmatory factor analyses. The KMO value being above 0.70 and the high significance level of the Bartlett test confirm the presence of a relationship structure among the items sufficient to support factor analysis.

Table 25. KMO and Bartlett Test Results

Test	Value	Interpretation
Kaiser-Meyer-Olkin (KMO)	0.750–0.751	Moderate sample adequacy (≥ 0.60)
Bartlett χ^2 (df)	3126.46 (435) / 1209.13	Correlation matrix significantly different from the identity matrix
Bartlett p	< 0.001	Factor analysis is appropriate

Note: The first χ^2 value is reported for the full sample (N = 398), and the second value for the refined sample (N = 405).

9.2. Reliability Analysis

The Cronbach's alpha coefficient calculated for the entire 30-item scale was found to be 0.683. This value falls just below the acceptable threshold ($\alpha \geq 0.70$). However, considering that the scale was designed to simultaneously measure multiple dimensions of Industry 5.0 technologies (robotics, cloud computing, big data, 3D printing, cyber-physical systems, augmented reality, Internet of Things) rather than a single-dimensional structure, it can be argued that the total-scale alpha is not as decisive as the subscale alphas.

Upon examining item-total correlations, it was observed that the correlations of items S24 ($r = 0.017$), S27 ($r = -0.026$), S17 ($r = 0.081$), and S16 ($r = 0.078$) with the total score were very low. These items make a weak contribution to the scale's overall internal consistency. In particular, the mean for item S27 ($M = 1.61$) is significantly lower than that of the other items; this suggests that the item may be subject to reverse-coding or response error effects. The following table summarizes the main items with low item-total correlations.

Table 26. Items with Low Item-Total Correlations

Item	Mean	SD	Adjusted Item-Total r	If Item Is Deleted, α
S15	3.57	1.11	0.027	0.690
S16	3.94	1.00	0.078	0.685
S17	3.77	0.99	0.081	0.685
S24	3.09	0.88	0.017	0.688
S27	1.61	0.59	-0.026	0.687

Note: The Cronbach's α value for the full 30-item scale is 0.683.

9.3. Exploratory Factor Analysis

Exploratory factor analysis was conducted using two complementary approaches. In the first approach, a basic orthogonal factor loading and Varimax rotation were applied to the full scale to obtain an exploratory structure; in the second approach, problematic items were excluded to achieve a more robust and interpretable structure.

9.3.1. Exploratory Structure on the Full Scale

The Kaiser eigenvalue rule, the scree plot, and parallel analysis were evaluated together to determine the number of factors. According to the

Kaiser criterion, nine factors with eigenvalues greater than 1 were identified; parallel analysis, however, indicated six factors. When theoretical expectations and the interpretability of factor loadings were evaluated together, eight factors—each with at least two items loading on a single factor with a loading of 0.40 or higher—were accepted as an interpretable structure.

Table 27. Eigenvalues and Explained Variance (First Nine Factors)

Factor	Eigenvalue	% Variance	% Cumulative	Parallel Analysis (95%)
F1	3.611	12.04	12.04	1,627
F2	3,275	10.92	22.95	1,520
F3	2,864	9.55	32.50	1,464
F4	2,222	7.41	39.91	1,409
F5	1,601	5.34	45.24	1,352
F6	1,415	4.72	49.96	1,315
F7	1,239	4.13	54.09	1,277
F8	1,063	3.54	57.63	1,239
F9	1,048	3.49	61.13	1,201

Source: Principal axis factor analysis, N = 398.

The eight interpretable dimensions obtained after Varimax rotation and the items they contain are as follows: F1 - Augmented Reality/Virtual Applications (S18-S22); F2 - Cloud Computing and Database Infrastructure (S8-S12); F3 - Production and Services with Smart/Advanced Systems (S25, S26, S28, S29, S30); F4 - Robotics and Industrial Robots (S1–S3); F5 - 3D Printing and Cloud Data Transfer (S6, S7); F6 - Cyber-Physical Systems (S15, S16); F7 - Big Data-Driven Decision Support (S13, S14); F8 - Remote-Controlled Robotics and Additive Manufacturing (S4, S5). These eight factors account for approximately 43.1% of the total variance. While this exploratory structure reveals the nuanced composition of Industry 5.0 technologies in the consumer's mind, it is fragile in terms of measurement due to certain dimensions being represented by only two items.

9.3.2. Refined Four-Factor Structure

The fact that some dimensions in the full scale are represented by only two items and the presence of items with low item-total correlations necessitated refinement for a more robust measurement model. In Promax rotational analysis, problematic items (S4, S5, S6, S7, S13, S14, S15, S16, S17, S23, S24, S27) were excluded, resulting in a four-factor structure comprising 18 items with high interpretability and psychometric robustness. Parallel analysis and eigenvalue examinations also support this solution.

Table 28. Refined Four-Factor Structure: Dimensions, Items, and Highest Loadings

Dimension	Items	Highest Load Range
Robotics and Autonomy	S1, S2, S3	0.744–0.769
Data, Cloud, and Analytics	S8, S9, S10, S11, S12	0.667–0.804
Immersive and Smart Technologies	S18, S19, S20, S21, S22	0.713–0.810
Digital Services and Manufacturing	S25, S26, S28, S29, S30	0.725–0.791

Source: Promax rotatory exploratory factor analysis, N = 405. A total of 18 items were retained.

9.4. Confirmatory Factor Analysis

The four-factor structure consisting of 18 items obtained through exploratory factor analysis was tested using confirmatory factor analysis. In the measurement model, free correlation between factors was allowed, and the items were standardized. The model's fit indices were compared with the cutoff values proposed by Hu and Bentler (1999).

Table 29. Confirmatory Factor Analysis Fit Indices (Four-Factor Model)

Measure	Value	Threshold (Hu and Bentler, 1999)	Evaluation
χ^2/df	1.41	< 3 good; < 5 acceptable	Good
CFI	0.95	> 0.90 acceptable; > 0.95 good	Good
TLI	0.94	> 0.90 acceptable; > 0.95 good	Acceptable
RMSEA	0.045	< 0.06 is good; < 0.08 is acceptable	Good
GFI	0.849	> 0.90 preferred	Borderline
NFI	0.849	> 0.90 is preferred	At the cutoff

Note: The confirmatory model of the full scale (26-item, eight-factor) also yielded acceptable fit indices (χ^2/df = 1.75; CFI = 0.92; TLI = 0.91; RMSEA = 0.043; SRMR = 0.046).

A chi-square/degrees of freedom ratio of 1.41, CFI and TLI values exceeding the 0.90 threshold, and an RMSEA value below 0.05 are strong findings in favor of the model. The fact that the GFI and NFI values remain at the borderline of 0.849 indicates that the model is not perfect, but it offers an acceptable and practically usable measurement model. Taken together, these findings demonstrate that the four-factor measurement model is validated by the data.

Table 30. Confirmatory Factor Analysis Standardized Factor Loadings (Four-Factor Model)

Dimension	Item	Std. Load	Dimension	Item	Standard Load
Robotics and Autonomy	S1	0.685	Immersive and Smart	S18	0.627
Robotic and Autonomous	S2	0.663	Immersive and Smart	S19	0.725
Robotics and Autonomy	S3	0.625	Immersive and Smart	S20	0.754
Data, Cloud, and Analytics	S8	0.554	Immersive and Smart	S21	0.715
Data, Cloud, and Analytics	S9	0.722	Immersive and Smart	S22	0.762
Data, Cloud, and Analytics	S10	0.656	Digital Services and Manufacturing	S25	0.665
Data, Cloud, and Analytics	S11	0.704	Digital Services and Manufacturing	S26	0.702
Data, Cloud, and Analytics	S12	0.720	Digital Services and Manufacturing	S28	0.649
—	—	—	Digital Services and Production	S29	0.597
—	—	—	Digital Services and Production	S30	0.705

Note: Standardized factor loadings range from 0.554 to 0.762; the majority are 0.60 or higher.

Standardized factor loadings range from 0.554 to 0.762, and the vast majority fall above the 0.50 threshold recommended in the literature (Hair et al., 2019). The lowest loading is observed in item S8, while the highest loading is observed in item S22. The fact that the vast majority of loadings are 0.60 or higher indicates that the items represent the relevant constructs at a reasonable level.

9.5. Convergent and Discriminant Validity

Convergent validity was assessed using composite reliability (CR) and average variance explained (AVE). CR values range from 0.696 to 0.841 and are generally at an acceptable level (CR ≥ 0.70). AVE values exceeded the 0.50 threshold only in the Engaging and Smart Technologies dimension; in the other dimensions, they remained within the 0.433–0.454 range.

Table 31. Reliability and Convergent Validity by Dimension (Four-Factor Model)

Dimension	Number of Items	Cronbach's α	CR	AVE
Robotics and Autonomy	3	0.695	0.696	0.433
Data, Cloud, and Analytics	5	0.803	0.805	0.454
Immersive and Smart Technologies	5	0.841	0.841	0.516
Digital Services and Manufacturing	5	0.797	0.798	0.442

Note: Fornell and Larcker (1981) state that when CR ≥ 0.60, AVE values below 0.50 do not threaten convergent validity.

According to Fornell and Larcker (1981), when CR values are above 0.60, an AVE below 0.50 does not, by itself, threaten convergent validity. Therefore, convergent validity can be considered practically supported to a large extent by CR values. The strongest convergent validity is observed in the Immersive and Smart Technologies dimension (CR = 0.841; AVE = 0.516); the most fragile dimension is the Robotics and Autonomy dimension (CR = 0.696; AVE = 0.433).

Discriminant validity was assessed using the Fornell-Larcker matrix. According to this criterion, discriminant validity is considered established when the square root of each dimension's AVE value (diagonal values) is greater than the correlations of that dimension with the other dimensions.

Table 32. Fornell-Larcker Distinctive Validity Matrix (Four-Factor Model)

Dimension	DHÜ	SAT	VBA	RÖ
Digital Services and Production (DHÜ)	0.665			
Immersive and Smart Technologies (IST)	0.035	0.718		
Data, Cloud, and Analytics (VBA)	-0.048	-0.081	0.674	
Robotics and Autonomy (RÖ)	0.075	0.136	-0.012	0.658

Note: Diagonal values represent √AVE; off-diagonal values represent inter-dimension correlations. All diagonal values are greater than the corresponding correlations.

It can be seen that all diagonal values (√AVE) in the matrix are greater than the corresponding inter-dimension correlations. The fact that the inter-dimension correlations remain at a low level indicates that while the four dimensions are related to one another, they measure distinct concepts; thus, discriminant validity is supported. This finding suggests that consumers perceive Industry 5.0 technologies as distinct categories.

9.6. Final Measurement Model

When all findings are evaluated together, it is understood that the original 30-item structure does not constitute a robust measurement model on its own; however, the 18-item, four-factor structure obtained by eliminating problematic items provides a defensible measurement framework in terms of both exploratory and confirmatory factor analysis. Therefore, the four-factor, 18-item structure is proposed as the study's final measurement model.

The strongest aspects of the final model include a significant Bartlett's test, an adequate KMO value, good fit in confirmatory factor analysis, acceptable standard loadings for the majority of items, and discriminant validity supported by the Fornell-Larcker criterion. The aspects that require cautious interpretation include AVE values below 0.50 in some dimensions and the alpha coefficient being borderline in the Robotics and Autonomy dimension. These findings are discussed in detail in the next section in light of the literature.

9.7. Detailed Item Statistics for the Full Scale

This section presents detailed item statistics for the full 30-item scale. Table 8.9 shows the mean, standard deviation, adjusted item-total correlation, and Cronbach's alpha values obtained when the item is omitted for each item. These statistics clearly reveal which items contribute to the scale's internal consistency and which ones are problematic.

Table 33. Full Scale Item Statistics (N = 398)

Item	Mean	SD	Item-Total r	If the item is deleted, α
S1	3.57	1.19	0.209	0.676
S2	3.56	1.13	0.288	0.670
S3	3.65	1.08	0.156	0.680
S4	3.65	1.06	0.249	0.673
S5	3.60	1.15	0.194	0.677
S6	3.67	1.16	0.231	0.674
S7	3.73	1.21	0.288	0.669
S8	3.62	1.15	0.263	0.672
S9	3.64	1.15	0.299	0.669
S10	3.60	1.14	0.224	0.675
S11	3.68	1.18	0.332	0.666
S12	3.78	1.17	0.324	0.667
S13	3.76	1.18	0.258	0.672
S14	3.74	1.20	0.187	0.678
S15	3.57	1.11	0.027	0.690
S16	3.94	1.00	0.078	0.685
S17	3.77	0.99	0.081	0.685
S18	3.60	1.12	0.236	0.674
S19	3.66	1.15	0.297	0.669
S20	3.54	1.18	0.292	0.669
S21	3.58	1.13	0.290	0.670
S22	3.61	1.19	0.304	0.668
S23	3.68	1.14	0.198	0.677
S24	3.09	0.88	0.017	0.688
S25	3.73	1.12	0.264	0.672
S26	3.67	1.13	0.197	0.677
S27	1.61	0.59	-0.026	0.687
S28	3.72	1.09	0.183	0.678
S29	3.73	1.09	0.150	0.680
S30	3.62	1.11	0.140	0.681

Note: The item averages, with the exception of S27, are concentrated in the range of 3.09–3.94. S27's low average (1.61) indicates a possible reverse-coding effect.

Upon examining the table, it is observed that the vast majority of item means fall above the scale midpoint (3.0); this suggests that participants generally hold a positive perception regarding the presence of Industry 5.0 technologies. The standard deviations ranging from 0.59 to 1.21 indicate a reasonable degree of variability in the responses. Items with corrected item-total correlations above 0.30 (such as S9, S11, S12, and S22) contribute most significantly to the scale's internal consistency.

9.8. Detailed Findings of the Eight-Factor Model

The eight-factor structure generated by the exploratory factor analysis conducted on the full scale was also tested using confirmatory factor analysis. This structure provides a more finely differentiated map of technology perception. The tables below present the post-rotation explained variance, standardized factor loadings, and reliability and validity indices of the eight-factor model.

Table 34. Eight-Factor Model: Post-Rotation Explained Variance

Factor	SS Loadings	% Variance	% Cumulative
F1	2.775	9.25	9.25
F2	2,548	8.49	17.74
F3	2,339	7.80	25.54
F4	1,493	4.98	30.52
F5	1,156	3.85	34.37
F6	0.933	3.11	37.48
F7	0.871	2.90	40.38
F8	0.826	2.75	43.14

Note: The eight factors explain approximately 43.1% of the total variance.

Table 35. Eight-Factor Model: Reliability and Validity Indices

Factor	Number of Items	CR	AVE
F1 (Augmented Reality)	5	0.839	0.511
F2 (Cloud Computing)	5	0.807	0.457
F3 (Smart Manufacturing/Services)	5	0.801	0.447
F4 (Robotics)	3	0.695	0.432
F5 (3D Printing)	2	0.659	0.495
F6 (Cyber-Physical Systems)	2	0.557	0.398
F7 (Big Data Decision Support)	2	0.566	0.396
F8 (Remote Robotics/Additive Manufacturing)	2	0.591	0.422

Source: Full-scale confirmatory factor analysis, N = 398.

In the eight-factor model, dimensions F1, F2, and F3 exhibit strong composite reliability (CR ≥ 0.80), while the reliability coefficients of the two-item dimensions F5–F8 are naturally lower. This reflects the limitations of two-item subscales (Eisinga et al., 2013) and explains why the refined four-factor model was preferred. While the eight-factor model is theoretically valuable for illustrating the fine structure of technology perception, the four-factor model offers a more robust and practical solution in terms of measurement.

The comparison of the two models concretely illustrates the balance between coverage and parsimony in scale development. While the eight-factor model offers more detail at the expense of robustness, the four-factor model provides higher psychometric quality with less detail. Which model is preferred in practice depends on the research objective and sample size.

9.9. Detailed Evaluation of Dimensions

In this section, each dimension in the final four-factor model is evaluated in detail in terms of its psychometric properties. This evaluation highlights the strengths and weaknesses of each dimension, guiding future improvement efforts.

The **Immersive and Smart Technologies** dimension demonstrates the strongest psychometric performance ($\alpha = 0.841$; CR = 0.841; AVE = 0.516). This five-item dimension meets both reliability and convergent validity criteria. Standardized factor loadings range from 0.627 to 0.762. This strong performance indicates that augmented reality and smart device technologies form a consistent and clear category in the consumer's mind.

The **Data, Cloud**, **and Analytics** dimension exhibits the second-strongest performance ($\alpha = 0.803$; CR = 0.805; AVE = 0.454). In this five-item dimension, factor loadings range from 0.554 to 0.722. While this dimension strongly meets reliability criteria, it exhibits a value close to the threshold in terms of AVE. This dimension reveals that cloud computing and big data technologies are perceived by consumers as an integrated category.

The **Digital Services and Production** dimension also demonstrates acceptable performance ($\alpha = 0.797$; CR = 0.798; AVE = 0.442). This five-item dimension encompasses 3D printing, big data-based forecasting, and advanced technology applications. While reliability criteria are met, the AVE value remains below the 0.50 threshold.

The **Robotics and Autonomy** dimension exhibits the weakest performance ($\alpha = 0.695$; CR = 0.696; AVE = 0.433). The reliability coefficient of this dimension, consisting of only three items, remains borderline. This situation may stem from both the dimension being represented by a small number of items and the fact that consumer perceptions regarding robotic technologies have not yet been fully established. This dimension is the area that should be prioritized for strengthening in future studies.

A comparative evaluation of the dimensions reveals that technology perception is not homogeneous; perceptions regarding different technology families exhibit varying levels of clarity and consistency. This finding underscores the need to differentiate technology adoption strategies based on these dimensions.

9.10. Comprehensive Evaluation of the Findings

When the study's findings are evaluated as a whole, a consistent and mutually supportive picture emerges. Sample adequacy tests confirmed the suitability of the dataset for factor analysis; reliability analysis demonstrated the internal consistency of the sub-dimensions; exploratory factor analysis identified the multidimensional structure; confirmatory factor analysis validated this structure; and validity analyses supported the convergent and discriminant validity of the dimensions.

This series of findings demonstrates that a robust measurement tool has been developed. In particular, the four-factor model's good fit in confirmatory factor analysis and the establishment of discriminant validity across all dimensions prove the scale's strong construct validity. Limitations such as AVE values falling below the threshold in some dimensions and the fragility of the Robotics dimension, however, provide a clear and concrete roadmap for future improvements.

The most important message from the findings is that consumer perceptions of Industry 5.0 technologies exhibit a multidimensional and differentiated structure. Consumers perceive these technologies not as a single general category, but as four distinct categories: robotics, data-cloud, immersive technologies, and digital services-production. This finding carries significant implications from both theoretical and practical perspectives and highlights the need to differentiate technology adoption strategies by dimension.

Chapter 10

Discussion

10.1. General Evaluation of Findings

This study comprehensively evaluated the psychometric properties of a scale designed to measure consumer perception of Industry 5.0 technologies within the context of sustainable gastronomy and tourism. The findings clearly demonstrate that consumer perception exhibits a multidimensional structure rather than a unidimensional one. The fact that the raw scale's total Cronbach's alpha value (0.683) falls just below the acceptance threshold was interpreted as an indication that the scale is not unidimensional; indeed, reliability coefficients at the sub-dimension level are largely at an acceptable level.

Conducting exploratory factor analysis using two complementary approaches has strengthened the robustness of the findings. The exploratory analysis on the full scale revealed the nuanced structure (eight dimensions) of Industry 5.0 technologies in the consumer mind; the refined analysis demonstrated that this structure could be reduced to a more robust, parsimonious, and valid four-factor model. The good fit indices of confirmatory factor analysis ($\chi^2/df = 1.41$; CFI = 0.95; RMSEA = 0.045) confirm that the four-factor model is consistent with the data. This dual analytical approach is consistent with the exploratory-confirmatory logic proposed in the scale development literature (Hair et al., 2019).

10.2. Interpretation of Dimensions

The four dimensions emerging from the final model meaningfully represent the core technology families of Industry 5.0. The **Robotics and Autonomy** dimension reflects perceptions regarding the presence of robotic devices and autonomous decision-making systems in tourism and gastronomy experiences. The **Data, Cloud**, **and Analytics** dimension integrates perceptions related to cloud computing infrastructures and big data-based processes. The **Immersive and Smart Technologies** dimension encompasses augmented reality, virtual applications, and networks of interconnected smart devices. The **Digital Services and Production** dimension, meanwhile, includes 3D printing, big data-based quality forecasting, and service processes enabled by advanced technology.

Among these dimensions, the highest internal consistency and convergent validity were observed in the Immersive and Smart Technologies dimension ($\alpha = 0.841$; AVE = 0.516). This finding suggests that augmented reality and immersive technologies form a relatively clear and consistent category in the consumer's mind. This result is consistent with the literature emphasizing that immersive technologies offer high-value, memorable, and distinctive experiences (Tom Dieck and Jung, 2018; Pine and Gilmore, 1999). The most fragile dimension is the Robotics and Autonomy dimension, which consists of only three items ($\alpha = 0.695$); it should be noted that the alpha coefficient may naturally remain low in dimensions with few items (Eisinga et al., 2013). It is recommended that this dimension be strengthened with additional items in future studies.

10.3. Comparison with the Literature

The findings are consistent with the literature on technology acceptance and service robots. Tussyadiah (2020) and Ivanov and Webster (2019) emphasize that technology acceptance in tourism is a multidimensional and context-sensitive phenomenon. The four-dimensional structure of this study empirically supports this multidimensionality. Furthermore, the relatively more fragile nature of perceptions regarding robotic technologies (Robotics and Autonomy dimension) aligns with studies indicating that trust and perceived risk are decisive factors in robot acceptance (Lu et al., 2019; Gursoy et al., 2019).

The study's connection to the Industry 5.0 framework is also noteworthy. Breque et al.'s (2021) emphasis on human-centeredness, the three core characteristics identified by Leng et al. (2022), and the technology families defined by Maddikunta et al. (2022) conceptually align with the dimensions identified in this study. This suggests that the production-centered conceptualization of Industry 5.0 can also be extended to the consumer-experience level. Consistent with the smart tourism literature (Gretzel et al., 2015), the emergence of the data-cloud-analytics and smart technology dimensions as distinct categories reveals that technology integration is structured in consumer perception.

The relatively low inter-dimensional relationships (supporting discriminant validity) indicate that consumers perceive these technologies as distinct categories. This finding aligns with perspectives emphasizing the importance of measuring technology-specific perceptions rather than a single general technology perception, as highlighted in technology acceptance models (Davis, 1989; Venkatesh et al., 2003).

10.4. Discussion of Measurement Issues

The exclusion of items S16, S17, S23, S24, and S27—which have low item-total correlations—from the final model is a significant finding in terms of scale development. In particular, the unusually low mean score for item S27 (M = 1.61) suggests a possible reverse-coding error or that the item's wording was interpreted differently by consumers. Similarly, the fact that some items (e.g., S23 and S30) convey nearly identical content highlights an aspect of the scale that requires review.

These findings underscore the iterative nature of the scale development process. Psychometric weaknesses identified in the initial application can be addressed by rephrasing items and strengthening weak dimensions. Therefore, this study serves not only to validate a scale but also as a diagnostic guide for future improvements. The fact that AVE values remain below 0.50 in some dimensions also indicates the need to redesign the items in those dimensions to better represent the common structure.

10.5. Theoretical and Practical Implications

At the theoretical level, the study expands the Industry 5.0 literature from a consumer-experience perspective and empirically documents the multidimensional structure of perceptions regarding technology. This contribution highlights the neglected importance of the service and consumer dimensions in a field that remains largely focused on production and engineering.

At the practical level, the validated four-dimensional scale offers tourism and gastronomy businesses the ability to track how technology investments are perceived by consumers. Businesses can compare perceptions regarding different technology dimensions to determine investment priorities and focus on areas with strong consumer perception. The fragility of perceptions regarding robotic technologies underscores the critical importance of building trust and maintaining transparent communication in this field.

10.6. Evaluation of Findings in Terms of the Pillars of Industry 5.0

The study's findings can also be evaluated in terms of the three core pillars of Industry 5.0 (human-centeredness, sustainability, and resilience). The resulting four-dimensional framework primarily measures the perceived presence of technologies by consumers; however, it is evident that this perception is closely linked to the principle of human-centeredness. Consumers' positive perception of technology can be interpreted as an indication that the technology is designed in a human-centered manner that enriches the experience.

Regarding the sustainability dimension, the fact that the scale does not include items directly measuring sustainability perception can be considered a limitation. In future studies, adding items that measure consumer perceptions regarding technology's contribution to sustainability would strengthen the scale's alignment with the Industry 5.0 framework. Regarding the resilience dimension, examining perceptions of technology's contribution to service continuity—particularly in the post-pandemic period—as a separate dimension could be meaningful.

10.7. Methodological Contributions and the Value of the Dual Analytical Approach

A significant methodological contribution of the study is its reporting of the scale development process using two complementary analytical approaches. The exploratory analysis of the full scale with eight factors reveals the nuanced structure of technologies in the consumer's mind, while the refined four-factor model offers a more robust and parsimonious solution in terms of measurement. Presenting these two approaches together concretely illustrates the breadth-parsimony trade-off in scale development.

Furthermore, the combined use of two different missing data handling methods (listwise deletion and imputation with the median) and their production of similar results supports the robustness of the findings. This methodological transparency is valuable in demonstrating the extent to which measurement results are sensitive to methodological choices and serves as a good practice example for future studies.

10.8. Methodological Contributions and the Value of the Dual Analytical Approach

The study's limitations must be considered when interpreting the findings. The fact that AVE values fall below the 0.50 threshold in some dimensions indicates that the items in those dimensions have limited representativeness of the common structure. This situation can be improved by rephrasing the items or adding new ones. Similarly, the fact that the Robotics and Autonomy dimension is represented by only three items necessitates that inferences regarding this dimension be made with caution.

The cross-sectional design of the study limits causal inferences. Changes in consumer perception over time and the effect of technology experience on perception can only be examined using longitudinal designs. Additionally, since the scale was developed within a single context, cross-validation across different cultural and demographic groups is required. These limitations also provide a productive agenda for future research.

10.9. Sectoral Application Scenarios for the Findings

The study's findings can be translated into various application scenarios for tourism and gastronomy businesses. In the first scenario, a lodging business can use the developed four-dimensional scale to periodically measure guests' perceptions of technology and track these perceptions over time. This tracking enables the evaluation of the perceptual returns on technology investments and the determination of investment priorities.

In the second scenario, a restaurant chain can compare technology perceptions across its different branches to identify the most successful practices and roll them out to other locations. In the third scenario, a destination management organization can collectively assess the technology perceptions of businesses in the region to develop digital transformation strategies at the destination level. These scenarios demonstrate the practical value and multi-level applicability of the developed scale.

10.10. Positioning the Study's Contribution to the Literature

This study offers an original contribution at the intersection of three literature streams. It contributes an empirical study to the Industry 5.0 literature that shifts the paradigm to the consumer-experience level. It adds a measurement framework that systematically addresses the technology dimension to the sustainable gastronomy and tourism literature. To the technology acceptance literature, it offers a complementary perspective that maps the multidimensional perceptual structure underlying the acceptance process.

This threefold contribution highlights the study's interdisciplinary nature and the integrative value it brings to the field. The development and validation of the measurement tool lay the groundwork for future theoretical and empirical studies; the transparent reporting of the scale development process, meanwhile, establishes a methodological model. Thus, the study not only answers a specific research question but also enriches the future research agenda.

10.11. Relating the Findings to Theoretical Models

The study's findings can also be interpreted within the framework of technology acceptance theories. The resulting four-dimensional perceptual structure can be positioned as a precursor to variables such as perceived usefulness and perceived ease of use found in technology acceptance models. Consumers' perceptions regarding specific technology dimensions can influence their evaluations of the usefulness and ease of use of those technologies and, consequently, their acceptance intentions.

From the perspective of the hedonic motivation variable within the UTAUT2 framework (Venkatesh et al., 2012), it is significant that the Immersive and Smart Technologies dimension demonstrates the strongest performance. These technologies generate high hedonic value, creating a clear and positive category in the consumer's mind. From the perspective of the AIDUA framework (Gursoy et al., 2019), the fragility of the Robotics and Autonomy dimension suggests that robotic technologies evoke more complex and conflicting emotions during primary and secondary evaluation processes.

These findings suggest that the scale developed in this study could serve as a component of broader adoption models in the future. Testing the effect of perception's multidimensional structure on behavioral intent and usage via structural equation modeling will both assess the scale's predictive validity and contribute to the technology acceptance literature.

10.12. A Comparative Evaluation

When the study's findings are compared with similar scale development studies, the psychometric values obtained are found to be consistent with the literature. A KMO value of 0.75 represents a moderate level commonly observed in factor analysis studies. The fit indices of the four-factor model (CFI = 0.95; RMSEA = 0.045) align with values considered to indicate good fit in the scale development literature.

It is also common for AVE values to fall below the 0.50 threshold on some dimensions in multidimensional behavior and perception scales. As noted by Fornell and Larcker (1981), when CR values are sufficient, this situation does not seriously threaten convergent validity. Therefore, the study's findings indicate that a measurement tool acceptable both in terms of absolute criteria and comparison with the literature has been developed.

10.13. Generalizability and Limitations of the Findings

The generalizability of the study's findings is limited by the characteristics of the sample and the context of the study. Since the data were obtained from a specific sample and time period, caution should be exercised when generalizing the findings to different cultural, demographic, and geographic contexts. Perceptions of technology can vary depending on cultural values, technological infrastructure, and sectoral maturity.

However, the theoretical consistency of the four-dimensional framework identified in this study and its alignment with Industry 5.0 technology families suggest that the findings possess validity beyond the scope of this study. Since the fundamental categories of technologies (robotics, data-cloud, immersive technologies, digital services-production) are universal in nature, it is likely that the four-dimensional structure will emerge similarly in different contexts. Nevertheless, this assumption requires cross-validation across different samples.

To strengthen generalizability, it is recommended that the scale be tested in different countries, across various tourism types (cultural tourism, maritime tourism, rural tourism), and at different business scales. These cross-validation studies will both test the scale's robustness and generate valuable insights into the contextual variability of technology perception.

10.14. The Interdisciplinary Nature of the Study

By its very nature, this study has an interdisciplinary character. Industry 5.0 and technology studies draw on engineering and business fields; sustainable gastronomy and tourism studies draw on tourism and gastronomy sciences; and consumer perception and technology acceptance studies draw on marketing and psychology fields. The study brings these different disciplines together to offer an integrative perspective.

The value of an interdisciplinary approach lies in its ability to facilitate a multifaceted understanding of complex phenomena. The impact of Industry 5.0 technologies on consumer perception within sustainable gastronomy and tourism is a phenomenon too complex to be fully grasped using the tools of a single discipline. This study seeks to address this complexity by combining the theoretical and methodological tools of different disciplines.

This interdisciplinary stance is both the study's strength and its challenge. Its strength lies in producing a rich understanding by integrating diverse perspectives. The challenge, however, is the need to harmonize the conceptual and methodological traditions of different disciplines. The study achieves this harmonization on the common methodological ground of scale development and validation.

Chapter 11

Conclusions and Recommendations

11.1. General Conclusion

This book addresses the development and validation of a scale designed to measure consumer perception of Industry 5.0 technologies from the perspective of sustainable gastronomy and tourism. As a result of comprehensive psychometric analyses, it was determined that the original 30-item structure did not constitute a robust measurement model on its own; however, the 18-item, four-factor structure obtained by eliminating problematic items provided a defensible, reliable, and valid measurement tool.

Sample adequacy (KMO = 0.75) and the correlation structure were found to be suitable for factor analysis; the final four-factor model showed good fit with confirmatory factor analysis ($\chi^2/df = 1.41$; CFI = 0.95; TLI = 0.94; RMSEA = 0.045). The reliability coefficients for the dimensions are largely at an acceptable level; discriminant validity is supported by the Fornell-Larcker criterion. These results indicate that consumers perceive Industry 5.0 technologies as falling into four distinct categories: Robotics and Autonomy, Data-Cloud-Analytics, Immersive and Smart Technologies, and Digital Services and Manufacturing.

11.2. Theoretical Implications

This study expands the Industry 5.0 literature—which has largely developed within the context of manufacturing and engineering—to include consumer and service perspectives. The empirical documentation of the multidimensional structure of consumer perceptions of Industry 5.0 technologies provides a foundation for future theoretical modeling. Additionally, a validated measurement framework specific to sustainable gastronomy and tourism has been introduced to the technology acceptance literature. The study also offers a theoretical contribution by demonstrating the transferability of the Industry 5.0 paradigm to the consumer-experience level.

11.3. Practical Recommendations

The findings for tourism and gastronomy businesses offer several practical implications:

- Businesses can use the validated four-dimensional scale as a feedback tool to monitor how their technology investments are perceived by consumers.
- The fact that immersive and smart technologies form the most consistent category in the consumer's mind suggests that the perceptual return on investments in this area may be relatively high.
- The fragility of perceptions regarding robotic technologies underscores the importance of building trust and maintaining transparent communication in robot-based services.
- Technology adoption processes should be designed in alignment with Industry 5.0's human-centered principle, adopting an approach that enhances rather than replaces the guest experience.
- Technology investments should be integrated with sustainability goals (reducing food waste, resource efficiency) to generate both environmental and perceived value.

11.4. Recommendations for Future Research

In light of this study's findings and limitations, recommendations for future research can be listed as follows:

- Dimensions represented by two or three items (particularly Robotics and Autonomy) should be strengthened by adding at least four to five additional items.
- Items with low item-total correlations and those potentially carrying reverse-coding effects (e.g., S27) should be rephrased or removed from the scale.
- The scale's generalizability should be tested by conducting cross-validation across different samples (different destinations, cultures, and demographic groups).

- The scale should be tested for predictive (nomological) validity by relating it to outcome variables such as satisfaction, intention to revisit, and willingness to pay.
- Longitudinal designs should be used to examine how consumer perceptions change over time as technology becomes more widespread.
- By integrating technology acceptance theories (TAM, UTAUT2, AIDUA), the effect of perception on behavioral intention should be tested using structural equation modeling.

11.5. Conclusion

Industry 5.0 presents a new paradigm with the promise of placing technology at the service of people, sustainability, and resilience. For this promise to translate into real value in experience-based sectors such as tourism and gastronomy, it is essential to accurately understand how technology is perceived by consumers. This study aims to contribute to both academic literature and industry practice by providing a tool to measure this perception in a valid and reliable manner. Uncovering the multidimensional nature of consumer perception lays the groundwork for developing more comprehensive and human-centered technology adoption strategies in the future.

11.6. Implications for Policymakers

The study's findings also offer implications for decision-makers shaping tourism and gastronomy policies. The integration of Industry 5.0 technologies into the sector is a strategic priority not only at the business level but also at the destination and national policy levels. While supporting the sector's digital transformation, policymakers must ensure that this transformation occurs in a human-centered, sustainable, and inclusive manner.

In this context, supporting the digital transformation of small and medium-sized enterprises, implementing educational programs to develop digital skills, and adopting policies that encourage technology investments are crucial. Additionally, developing regulatory frameworks regarding data privacy and technology ethics is essential for safeguarding consumer trust. Monitoring consumer perception can also serve as a useful tool for evaluating policy effectiveness.

11.7. General Evaluation of the Study

This book presents a comprehensive study aimed at measuring consumer perception of Industry 5.0 technologies within the context of sustainable gastronomy and tourism. It addresses the topic from multiple angles, covering a wide range of topics from the conceptual framework to empirical findings, and from methodological discussions to practical recommendations. The study's primary contribution lies in the development of a validated and reliable measurement tool and the extension of the Industry 5.0 paradigm to the consumer-experience level.

In conclusion, the success of Industry 5.0 in tourism and gastronomy depends on how technology is perceived by consumers. By taking a step toward understanding and measuring this perception, this study has contributed to both the academic literature and sectoral applications. It is hoped that future research will build upon this foundation to examine the technology-human-sustainability relationship in greater depth.

11.8. Summary of the Study's Contributions

This book offers valuable contributions to both the literature and practice through its multifaceted approach. Theoretically, it has extended the Industry 5.0 paradigm to the consumer-experience level and empirically documented the multidimensional nature of technology perception. Methodologically, it has provided a transferable model for future research by presenting the scale development and validation process in a transparent and iterative manner. In terms of application, it has developed a valid measurement tool that enables businesses to track the perceived returns on their technology investments.

The four-dimensional scale developed in this study—comprising Robotics and Autonomy, Data-Cloud-Analytics, Immersive and Smart Technologies, and Digital Service-Production—captures the fundamental categories of consumer perception regarding Industry 5.0 technologies. This dimensional structure serves as a reference framework for both academic research and sectoral applications.

In conclusion, this study aims to contribute to the adoption of technology in a human- and sustainability-focused manner within the rapidly evolving tourism and gastronomy sectors. The realization of Industry 5.0's promise depends on a proper understanding of how technology is perceived by consumers; this book takes a modest yet solid step toward that understanding.

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Glossary

Exploratory Factor Analysis (EFA): A multivariate statistical method aimed at discovering the underlying latent structures of a large number of observed variables.

Explained Variance (AVE): A convergent validity measure indicating the proportion of total variance in the items that a dimension explains.

Anthropomorphism: The attribution of human-like appearance, voice, and behavioral characteristics to a technology, particularly robots.

Discriminant Validity: A type of validity that demonstrates that dimensions expected to measure different concepts are sufficiently distinct from one another.

Composite Reliability (CR): A reliability measure indicating the extent to which the items of a dimension consistently measure the common structure.

Cobot (Collaborative Robot): A robot designed to share the same workspace with humans and collaborate with them.

Resilience: A system's capacity to demonstrate flexibility in the face of unexpected crises and to recover quickly; one of the three pillars of Industry 5.0.

Digital Twin: A real-time digital replica of a physical object, process, or system.

Industry 5.0: A production and service paradigm that integrates digitalization with the principles of human-centeredness, sustainability, and resilience.

Hedonic Motivation: The pleasure and enjoyment derived from using a technology; a key determinant of technology adoption.

Human-Centricity: The principle that technology should be designed to enhance human well-being and capabilities.

Internet of Things (IoT): An ecosystem where physical devices communicate with one another via sensors and network connections.

Cyber-Physical System: An integrated structure where physical processes are monitored and controlled in real time using sensors and software.

Sustainable Gastronomy: A culinary philosophy that prioritizes local sourcing, reducing food waste, and preserving cultural heritage.

Convergent Validity: The high correlation between items expected to measure the same construct.

Appendices

Appendix A. Items Retained in the Final Model

The table below presents the items retained in the final 18-item, four-factor measurement model and their content.

Dimension	Item	Item
Robotics and Autonomy	S1	In your regional tourism experience, robotic devices and industrial robots are used in the restaurant and kitchen areas.
Robotics and Autonomy	S2	Robots used in the restaurant and kitchen areas are capable of making autonomous decisions in unexpected situations.
Robotics and Autonomy	S3	Robots used in the restaurant and kitchen sector work in harmony with staff.
Data, Cloud, and Analytics	S8	Your regional tourism experience includes one of the following: cloud computing infrastructure, software, or platforms.
Data, Cloud, and Analytics	S9	Cloud services from external providers (Turkcell, TTNET, iCloud, etc.) are utilized.
Data, Cloud, and Analytics	S10	Employees can easily access the information they need from anywhere using cloud computing.
Data, Cloud, and Analytics	S11	A database management system compatible with Industry 5.0 and 4.0 systems is available.
Data, Cloud, and Analytics	S12	Issues arising from big data are quickly identified.
Immersive and Smart Technologies	S18	Virtual replicas of physical production processes are created in a computer environment.
Immersive and Smart Tech.	S19	Augmented reality devices (VR headsets, projectors, wearable display devices, etc.) are used.
Immersive and Smart Tech.	S20	Augmented reality is used to enhance creativity and enrich product processes.
Immersive and Smart Tech.	S21	Certain employee training sessions (emergency response, machine operation, drills, etc.) can be conducted in a computer-based environment.

Immersive and Smart Tech.	S22	An internet network system has been established between smart devices (tablets, phones, machines, etc.).
Digital Services and Production	S25	Systems for rapid and flexible product prototyping and production using 3D printers have been established.
Digital Services and Production	S26	Big data is used to quickly identify the root causes of problems.
Digital Services and Manufacturing	S28	Big data enables insights into product quality and on-time service.
Digital Services and Manufacturing	S29	An internet network system has been established among smart devices (tablets, phones, kiosks, QR codes, digital machines, etc.).
Digital Services and Production	S30	Security in production processes has been ensured through advanced technology.

Appendix B. Items Excluded from the Final Model

The following items were excluded from the final model due to psychometric weaknesses (low item-total correlation, low factor loading, or cross-loading).

Item	Item
S4	Robots used in restaurants and kitchens can be remotely controlled.
S5	3D printers are used for layered production integrated into Industry 4.0 systems.
S6	Personalized production is carried out using 3D printers.
S7	Cloud computing enables fast data transfer and backup.
S13	Big data is used in decision-making processes.
S14	A lean production system has been established in accordance with cyber-physical systems.
S15	Automated control and vehicle systems are in use, and monitoring can be performed via virtual systems.
S16	Real-time data is collected to establish the integration of the virtual and physical environments.
S17	A rapid response system has been established using cyber-physical systems to address guest requests.
S23	Security in production processes has been ensured through advanced technology.
S24	Robotic devices or industrial robots are used in restaurant, kitchen, and office areas.
S27	Big data provides the ability to make decisions and predict the future more accurately.

Note: Since there is no separate interim decision file indicating which statistical threshold caused each item to be excluded in the shared output set, the items are listed solely as codes excluded from the final model.

An Assessment of Consumer Perceptions of Industry 5.0 from the Perspective of Sustainable Gastronomy and Tourism

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