Tourism 4.0 in Portuguese tourism businesses

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Abstract: The future of tourism must take into consideration not only the new technologies associated with the environment provided by Tourism 4.0, but also concerns regarding sustainable development objectives. In this context, it is important to analyse the extent to which Portuguese tourism companies are adopting technologies associated with Tourism 4.0 through the identification and diagnosis of opportunities, the perception of their benefits, as well as the obstacles involved. A nationwide questionnaire survey was administered, and a sample of 412 responses was produced. The results of this study showed that many Portuguese tourism companies are not aware of the concept of Tourism 4.0, and that it is not being applied successfully due to perceived obstacles to adoption, although many companies recognise that Tourism 4.0 has advantages for their business and for sustainability practices.

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1   Introduction

Tourism 4.0 is a newly emerging paradigm (Peceny et al., 2019) that can enhance the tourist's experience through the use of modern high-tech information and communication technologies. It is vital that tourism enterprises should be informed about and encouraged to use the technology associated with this new concept.

The term Tourism 4.0 originated from a new business paradigm known as Industry 4.0 (Türke et al., 2019). Several countries, including Portugal, have launched programs and initiatives that aim to support this paradigm, which include a project entitled "Development of the Institutional Capacity of the Ministry of Economy, SIPOCA code: 7" in Romania (Türke et al., 2019), the work carried out by Araújo et al. (2021), who presented a technological proposal focused on the niche of nature tourism, and a project entitled 'Wine Tourism 4.0' that aims to promote ecotourism in the Alentejo region of Portugal (Korže, 2019).

The concept of Industry 4.0 has given rise to strategies for the development of markets, internationalisation and growth in competitiveness, and represents a progression towards maturity in the use of information and communication technologies (Grabowska and Saniuk, 2022). These technological trends are expected to cause disruptive changes in both the physical and digital environments of any company with the ability to

customise products and services, which is very important in the tourist industry (Korže, 2019).

The emergence of Industry 4.0 has also prompted the creation of Tourism 4.0, a new paradigm in the tourism activity, and can also contribute to achieving the UN's sustainable development goals (SDGs), as noted by Peceny et al. (2019). The technology associated with Tourism 4.0 can play a role in terms of changing attitudes (e.g., towards water and power consumption), mobility (e.g., the use of public transport and renting bicycles) and the flow of people (e.g., through weather prediction and traffic density estimates) to support the management of visitors to tourist destinations (Peceny et al., 2019).

The term 'Tourism 4.0' seems to have been used for the first time in Portugal in association with a wine tourism project which received an UNWTO award (UNWTO Awards, 2016). However, this usage referred primarily to technological transformations, despite the potential of the paradigm associated with this concept, and this term has been more commonly adopted in the tourism industry than among the scientific community, where the term 'smart tourism' has more often been adopted (Korže, 2019).

In contrast to the better-known concept of smart tourism, there has been relatively little research into the extent to which tourism businesses are aware of, and have already adopted, the technology associated with the concept of Tourism 4.0 (Korže, 2019). This study therefore investigates the awareness and adoption of the concept of Tourism 4.0 in Portugal, and its perceived benefits, including its relationship with the concept of sustainability.

To meet the objectives of this research, and based on a literature review, the following questions were drawn up:

1   Are tourism companies aware of the concept of Tourism 4.0?

2   To what extent is this concept being successfully applied by companies?

3   Is it perceived as beneficial for tourism businesses?

4   Can Tourism 4.0 contribute to increasing the sustainability of companies?

This paper is divided into five sections. The following section presents a literature review, which highlights the origins of Tourism 4.0 and explores whether this interaction with companies is beneficial to sustainability. Section 3 describes the methodology used in this study, which is associated with exploratory research. Section 4 presents the results of the survey, and Section 5 provides a discussion of the results. Finally, some conclusions and implications that can be drawn from the study are presented in Section 6.

2   Tourism 4.0 and sustainability

Nowadays, tourism businesses have a range of technological means and tools at their disposal, from artificial intelligence to big data and analytics; these techniques, which are associated with the fourth industrial revolution, can enhance the business environment and add value to the quality of service (Loureiro, 2018). The technological drivers of the fourth industrial revolution mainly originated in the field of software, and include autonomous robots, simulation, horizontal and vertical system integration, the industrial Internet of Things, cyber security, the cloud, additive manufacturing, augmented reality

and big data analytics (Korže, 2019). These technologies have found their way into the tourism industry; in the area of transportation services, for example, driverless vehicles form part of the concept of smart travel (Dewi, 2020). Immersive tourist experiences that are provided via virtual and augmented reality are taking on an important role in marketing destinations, as they offer tourists the opportunity to explore tourism destinations, activities, and even accommodations prior to visiting (Huang et al., 2016).

In the accommodation sector, we note the example of the Japanese Henn-na Hotel, which was designed by the Kawazor Lab (Reis et al., 2020) of the Institute of Industrial Science at the University of Tokyo and Kajima Corporation. It operates for the most part based on robotic employees (Osawa et al., 2017), including multi-lingual robots for checking in and out, thus eliminating any language barriers, and by using face recognition instead of traditional room keys (or even a mobile device version of keys) to access rooms (Zhong et al., 2022). Other technological features are used to enhance the hotel's environmentally friendly policies; for example, the lights and air conditioning are controlled automatically, according to the presence or absence of human beings in the room, which is monitored through motion sensors (Reis et al., 2020).

The environment provided by the fourth industrial revolution, also known as Industry 4.0, has had a disruptive effect on various economic sectors, including tourism, and has given rise to evolution due to technological innovations. This is described by the new term Tourism 4.0 (Korže, 2019). There is a strong assumption that the technological innovations of Tourism 4.0 will be beneficial to tourists (Stankov and Gretzel, 2020).

The key enabling digital technologies (including big data analytics, artificial intelligence, and the Internet of Things) are described as supporting the co-creation of a new, sustainable business model which contributes to the development of collaborative tourism (Pencarelli, 2020). This implies that the concept of Tourism 4.0 is more or less the same as that commonly referred to as 'smart tourism', although some authors have distinguished between the two. Pencarelli (2020, p.460) suggests that Tourism 4.0 is primarily focused on the hardware and software of the technologies, whilst the concept of smart tourism involves 'a more sustainability-oriented use' of technologies, with the aim of improving people's quality of life and the environmental quality of destinations, as well as enriching the customer's tourism experience (Dalkiran, 2022). Other authors, however, have conceptualised Tourism 4.0 as an integrative 'ecosystem' in which all stakeholders are involved in active, participatory processes (Peceny et al., 2019).

The technological innovations associated with Tourism 4.0 may enhance the development of a more competitive and sustainable destination: for example, mobile devices make it possible to connect the consumer with the product, through marketplaces and social networks (Dalkiran, 2022; Gretzel, 2016). Big data analytics offers an opportunity for hotel chains to manage their entire business with the implementation of revenue management systems (Pan and Yang, 2017).

In addition, responsive websites that are suitable for a range of mobile devices can be created (Tao et al., 2018). Smart hotels, which use sensors, big data and the Internet of Things, can enhance the products and services on offer, taking into account the context of the tourist's environment (Gretzel, 2016), and robots can be used to help with services and facilitate communication with the customer (Tussyadiah and Park, 2018).

Tourism destinations can take advantage of smart technologies to provide technology-enhanced tourism experiences, in order to achieve competitiveness and sustainability (Dalkiran, 2022; Gretzel and Scarpino-Johns, 2018). The development of smart tourism as a mindset and an approach to achieving efficiency and sustainability goals includes

many aspects that have been identified as critical for resilience management (Gretzel and Scarpino-Johns, 2018).

The concept of smart or intelligent hotel rooms, or smart hotels, has already been adopted in the hospitality industry (Leung, 2019; Zhong et al., 2022). These enable guests to control and personalise aspects such as their in-room preferences, check-in and check-out times, services, payment procedures, and so on, using a mobile device and/or apps that integrate a range of features, from the Internet of Things to payment applications. These elements add value to the guest's experience (Buhalis et al., 2023; Sari, 2018; Stylos et al., 2021).

All of these tools, together with efficient customer relationship management, can enable a hotel chain to nurture customer loyalty and tourist engagement within its hotels by providing an enhanced experience for its guests (Lam and Law, 2019). Tourism 4.0 may be a new form of travel design science, in which big data and artificial intelligence are combined to create benefits and personalised experiences that increase the satisfaction of guests.

In addition to creating fascinating and personalised experiences for tourists, future designs for tourism must consider the consequences of tourism, since according to Peceny et al. (2019), there are areas that need a great deal of attention in order to reduce the negative effects of such activity, specifically in terms of the environmental, economic and social sustainability dimensions (Leung, 2022). Although tourism is a pillar of modern economies and societies, it is necessary to ensure sustainable development to avoid deleterious effects on both the social and natural environments (Urbančič et al., 2020). Tourism generates economic profits based on intangible values such as the nature and cultures of a region, and thus reduces damage to nature and safeguards cultural sources. In addition, the value produced by tourism also contributes to the local community (Choe and Lugosi, 2022), thereby offering the potential to attain sustainable growth while minimising the negative economic, environmental and social consequences (Choo and Halim, 2022), and promoting diversity through communication during the process of value creation (Yoo et al., 2017).

However, the tourism industry can be a major enemy to sustainability, since the mass movements of people induced by tourism pose a direct threat to natural ecosystems. It also has adverse effects on local communities, causing pollution and cultural hostility, and it reduces diversity through globalisation (İştin, 2022). The convergence of technological innovation and tourism may decrease the negative effects of tourism and increase the positive effects from a sustainability point of view, when used as a strategic tool for sustainable development (Yoo et al., 2017). In 2015, the global community agreed on the 2030 Agenda for Sustainable Development (UN, 2015), which includes 17 universal SDGs. The cross-cutting nature of tourism means that it could contribute towards the elimination of poverty, the promotion of gender equality and social inclusion, and the fight against climate change (Rifai, 2017).

Technologies in general, and in particular those associated with Tourism 4.0, can be implemented by tourist destinations as part of active measures aimed at achieving the SDGs. Companies and destinations can develop platforms that allow the attitudes of tourists and residents to be monitored, through the management of water consumption, electricity consumption, and recycling, which have important effects on the environment (Buhalis et al., 2023; Peceny et al., 2020). In addition, platforms can be used to monitor and manage people's mobility, for example by public transport, bicycle rental, and the use of electric cars, in addition to helping to investigate the effects on the environment,

economy and society. Through the use of sensors, it should be possible to control mobility to avoid congestion; this should be complemented with an analysis of the flow of people, including the hours and days when there are peaks, weather forecasts, and the number of tourists at a given point of interest (Leung, 2022; Peceny et al., 2020).

An appropriate technological architecture that combines the technologies associated with Tourism 4.0 can improve the well-being of tourists, residents, and stakeholders, and the governance of destinations. This can contribute to job creation, economic growth, protection of the environment, consumption and sustainable production, as well as the well-being of the resident population (Dewi, 2020). All of these factors combined can provide a healthier and more harmonious environment in which to receive visitors, and can enable the development of a destination from a human-centred perspective (Stankov and Gretzel, 2020). In view of the high level of concern over environmental effects and the well-being of the population (Dwyer, 2022), we expect higher levels of awareness and implementation of the SDGs in the near future.

3   Methodology

3.1   Context and research questions

Before the era of innovations associated with Tourism 4.0, Portuguese entrepreneurship was marked by an economic downturn, rising unemployment, increasing competition from similar destinations such as Spain, Greece, Turkey, and Malta, and the concurrent need to add value to tourism experiences (Guerreiro, 2017). In this context, as explained by the national tourism organisation, Turismo de Portugal (2017), Portugal, as a tourism destination, needed to innovate in order to position itself as a global innovation hub for tourism, and to promote an ecosystem of technological and business cooperation. Turismo de Portugal therefore followed the international trend and created the Tourism 4.0 Program, which aims to foster entrepreneurship through innovation and the creation of new businesses, to promote the sharing of knowledge with companies, to anticipate and develop responses to future tourism changes, and to create and train companies on the various areas of innovation (Turismo de Portugal, 2018).

The main objective of the not-for-profit Tourism 4.0 Program is to potentiate Portugal as a global innovation and digital development hub in the tourism sector by launching new products and business ideas, adopting new technologies, and promoting tourism innovation and sustainability internationally (Araújo et al., 2021; Korže, 2019; Turismo de Portugal, 2018).

Although there are barriers to investment and a strong dependence on large external collaborative platforms, even with these initiatives, there have been some encouraging results. Examples of these are presented in Table 1, which shows some of the Portuguese start-ups created under the Tourism 4.0 Program (Guerreiro, 2017). The many initiatives related to Tourism 4.0 undertaken within the Turismo de Portugal Program also led to Portugal achieving its first runner-up position in the UNWTO Awards for Innovation in Research and Technology in 2017, and winning the UNWTO Award for Excellence and Innovation for Public Policy and Governance in 2018 (UNWTO, 2018, 2017).

Table 1 Portuguese start-ups created within the Tourism 4.0 Program

Start-ups	Description
doinn.co	Accommodation Marketplace
iclio	Historic and cultural city guides
tourmarker	Mobile pocket concierge and guided tours
guestU	Mobile Concierge
UniPlaces	Marketplace for student accommodation
Mygon	Self-advertising platform
Bguest	Mobile pocket concierge
Poshpacker	Booking site and community network for Millenials

Source: Adapted from Guerreiro (2017)

Research into the technological environment that surrounds the Portuguese tourism businesses gave rise to the following research questions, with a focus on Portuguese tourism companies:

1 Are tourism companies aware of the concept of Tourism 4.0 (adapted from Costa et al., 2018; Korže, 2019; Urbančič et al., 2020)?

2 To what extent is this concept being successfully applied by companies (adapted from Costa et al., 2018; Korže, 2019)?

3 Is it perceived as beneficial for tourism businesses (adapted from Costa et al., 2018; Korže, 2019)?

4 Can Tourism 4.0 contribute to increasing the sustainability of companies (adapted from Peceny et al., 2019; UN, 2015)?

3.2 Instruments

In order to answer the research questions outlined above, an online survey was created to collect data from Portuguese tourism companies. The survey was divided into two parts: the first part comprised the research questions, while the second contained questions related to the respondent's profile data, such as their company, address, sector of activity, and company size.

3.3 Data collection and sample

A link to the online survey was sent by email to the 15,100 tourism companies registered in the official Portuguese tourism database (Registo Nacional de Turismo, 2019). The online survey was created using Google Forms, and the link was sent to the tourist companies with the help of an email marketing application, which enabled us to email the large number of tourist companies in an automatic way. These companies are classified in the database as tourist accommodation establishments, tourist animation enterprises, tour operators and agents, and local accommodation units (including short-term rentals and small guesthouses or hostels). This method was chosen in order to reach a high number of respondents across the country, as well as for its efficiency in terms of time and cost.

The questionnaire was designed to be answered anonymously if required, although an optional box at the end allowed the respondent to leave contact details if they wished to receive the results of the survey. An email domain was acquired in order to send the questionnaire to over 15,000 email addresses, and the number of emails sent, received and opened was monitored through the Mailtrain platform.

It should be noted that the online survey method has some disadvantages; recipients tend to ignore questionnaire links, and bulk emails are very often rejected as spam, meaning that a high percentage of the emails do not reach the recipients. Most of the emails sent in this study were rejected as spam, and, according to the Mailtrain platform, only 2550 companies opened the message. Of these, only 412 answered the questionnaire. This low response from the tourism companies highlights the main disadvantage of online questionnaires. A considerable number of email addresses were also found to be invalid, since the company email address had changed or the company no longer existed, which calls attention to the fact that the database of Portuguese tourism companies is not sufficiently up-to-date and accurate.

3.4   Data analysis

After the questionnaires had been received, the data were coded and tabulated using the IBM SPSS statistics program, thus allowing a descriptive statistics analysis to be performed based on the company profile characterisation, cross-tabulation between variables, and correlation.

4   Results

### 4.1   Characterisation of the sample

From the responses of our respondents, our sample was found to be characterised as follows: 36.9% were tourism companies with activities related to accommodation, 29.9% were involved in tourist entertainment, 21.4% were tour operators or travel agents, 7.8% worked with transport, and 0.2% with food and beverages. The remaining 3.8% represented other sectors of activity in tourism, such as events and conferences, attractions, tourism services, and adventure tourism and recreation. These were grouped in a category entitled 'others' due to the low number of responses associated with each category and to ensure confidentiality.

The higher percentages of companies in the accommodation, tourist entertainment and tour operator/travel agent sectors was as expected, since these are some of the main activities taking place at a tourist destination. The very low percentage of companies in the food and beverage sector was unexpected, however, since this is one of the pillars of tourist activity. The reason for this small percentage (0.2%) may be that food and beverage services are often combined with accommodation services.

The majority of the respondent companies were microenterprises with fewer than 10 employees (73.3%). Small businesses with 10 to 49 employees accounted for 12.4% of the sample, medium-sized businesses with 50 to 249 employees accounted for 10.4%, and large companies with more than 250 employees represented 3.9%. The locations of the respondent companies based on NUTS II (territorial unit nomenclature) are shown in Figure 1. According to our results, 27.2% of the companies were located in Lisbon,

24.5% were in the north of the country, 21.8% were in the centre, 12.6% were situated in the Algarve, and 6.3% in the Alentejo. In the archipelagos, 4.1% of the respondent companies were situated in Madeira and 3.4% in the Azores.

Figure 1 Location of the tourism companies' respondents (see online version for colours)
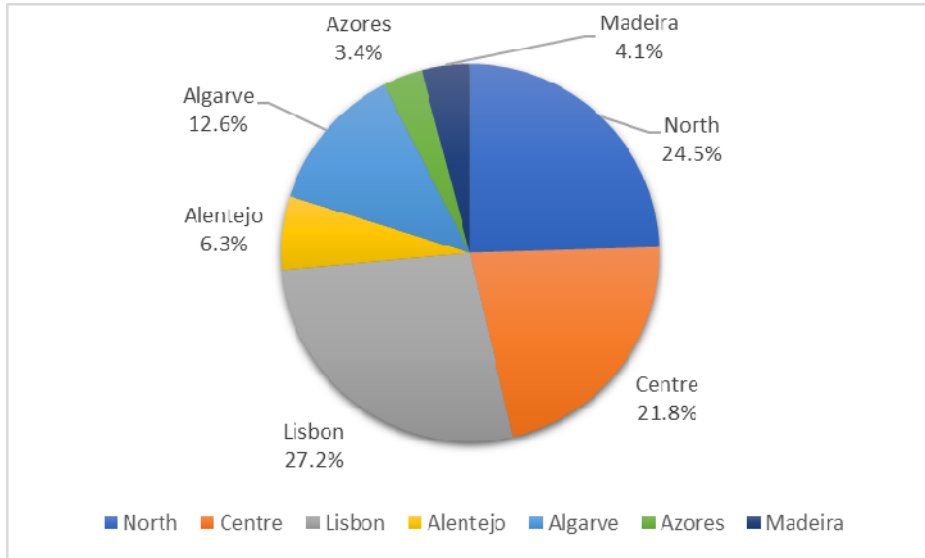
Source: Author's elaboration

4.2 Company awareness and adoption of Tourism 4.0

The first research question aimed to discover the level of awareness of the concept of Tourism 4.0 in Portuguese companies linked to tourism. Our results indicated that just over one third of the companies were aware of the concept of Tourism 4.0 (36.2%), representing 149 companies out of 412 (Table 2). Since the concept is relatively new, however, the percentage of awareness was higher than expected.

Table 2 Companies' awareness about Tourism 4.0 by location

	Azores	*Algarve*	*Alentejo*	*Centre*	*Lisbon*	*Madeira*	*North*
Not aware of Tourism 4.0 (*n* = 263)	64.3%	71.2%	**73.1%**	57.8%	65.2%	35.3%	66.3%
Aware of Tourism 4.0 (*n* = 149)	35.7%	28.8%	26.9%	42.2%	34.8%	**64.7%**	33.7%
Total of Companies (*N* = 412)	14	52	26	90	112	17	101

Source: Author's elaboration

Madeira showed the highest relative percentage of awareness regarding Tourism 4.0 (64.7%), although it should be noted that far fewer companies responded from the islands (Madeira and Azores) than from the mainland regions. Alentejo had the highest relative

percentage of companies that were not aware of Tourism 4.0 (73.1%), corresponding to 19 companies of the 26 in this region.

The relationship between awareness of the concept of Tourism 4.0 and company size revealed that as the size of the companies increased, awareness also increased (Table 3).

**Table 3**   Companies' awareness about Tourism 4.0 by company size

	Microenterprise	*Small business*	*Medium-sized business*	*Large company*
Not aware of Tourism 4.0 (*n* = 263)	**67.9%**	58.8%	51.2%	37.5%
Aware of Tourism 4.0 (*n* = 149)	32.1%	41.2%	48.8%	**62.5%**
Total number of companies (*N* = 412)	302	51	43	16

Source: Author's elaboration

4.3   *Application of Tourism 4.0 concepts by companies*

The obstacles that the respondent companies identified as hindering their adherence to Tourism 4.0 are shown in Figure 2. These were analysed to answer the second research question, which was related to the success of, and obstacles to, the application of technologies associated with the Tourism 4.0 environment in Portuguese tourism businesses.

Figure 2   Portuguese companies' obstacles to adherence to Tourism 4.0 (see online version for colours)
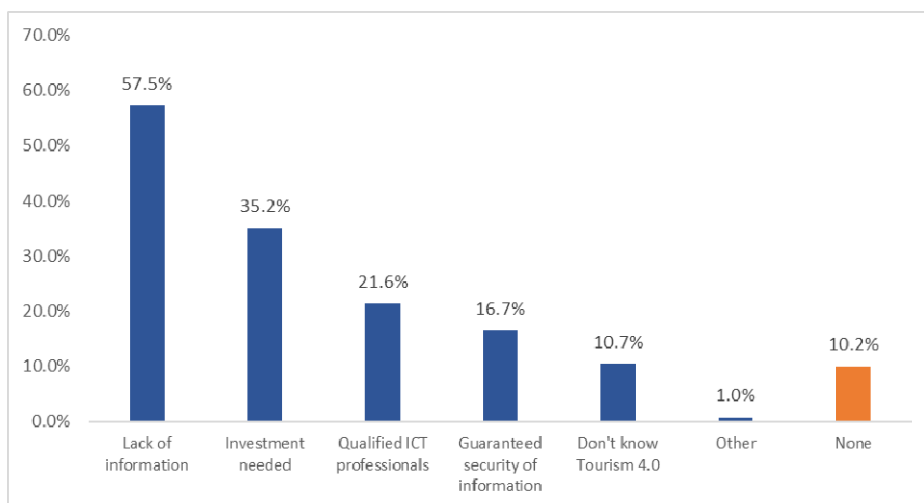
Source: Author's elaboration

The obstacles (in descending order of frequency) included a lack of information about the concept (perceived as the biggest obstacle, with 57.5%, corresponding to 237 respondent companies); the investment it required, with 35.2% (145 companies); the qualified ICT

professionals that were needed, with 21.6% (89 companies); the lack of a guarantee that information would be secure, with 16.7% (69 companies); and the fact that the company was not aware of the concept, with 10.7% (44 companies).

Other reasons (not listed in the questionnaire) were also provided by the companies, including a lack of interaction between local authorities and entrepreneurs, and the irrelevance of Tourism 4.0 to rural tourism, although the number of respondents providing 'other' answers was very low. Finally, just 10.2% (42) of respondents claimed to be aware of no obstacles to the adoption to Tourism 4.0.

The main obstacle to adoption by companies was a lack of information, for all of the sectors considered in this study, followed by the investment required and the qualified ICT professionals needed. In the transport sector, the main obstacle was a lack of information, followed by data/information security issues and the investment needed, as shown in Table 4.
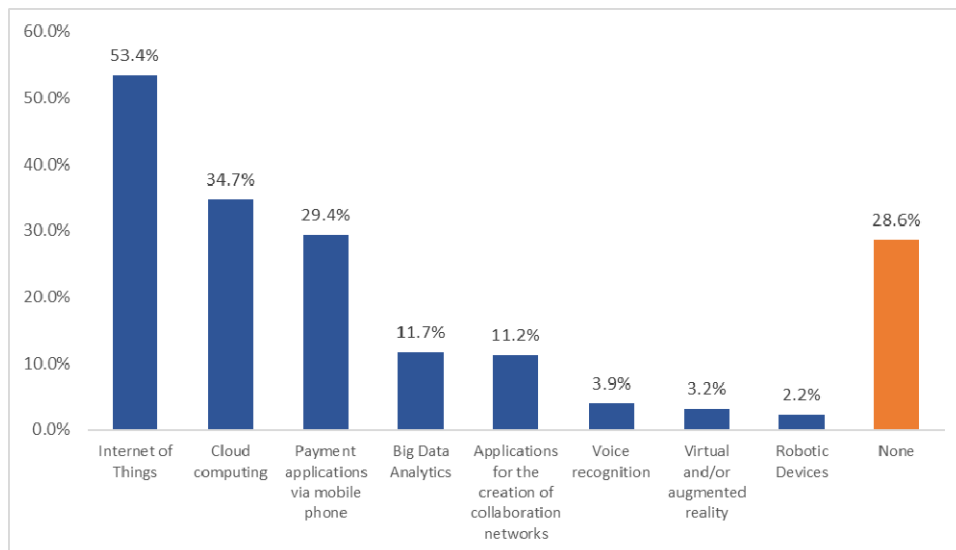
Table 4   Portuguese tourism companies obstacles to adherence to Tourism 4.0 per activity sector

	Obstacles to adherence to Tourism 4.0			
Activity sector	*Lack of information*	*Investment needed*	*Qualified ICT professionals needed*	*Data/ information security*
Accommodation	44.1%	39.5%	25.0%	20.4%
Tour Operator/Travel Agent	61.4%	40.9%	13.6%	9.1%
Tourist Animation/ Entertainment	67.5%	29.3%	24.4%	15.4%
Transport	68.8%	21.9%	18.8%	25.0%
Other	61.5%	38.5%	23.1%	23.1%

Source: Author's elaboration

In terms of the types of technological tools used, to study the application of these technologies, with regard to the diagnosis made to the tools considered associated with Tourism 4.0, the answers are represented in Figure 3. Over half (53.4%, 220 companies) of the respondents claimed to use the Internet of Things, while 34.7% (143 companies) used the cloud, 29.4% (121 companies) worked with payment applications via mobile phones, 11.7% (48 companies) used big data analytics, 11.2% (46 companies) used applications for the creation of collaborative networks, 3.9% (16 companies) worked with voice recognition, 3.2% (13 companies) used virtual and/or augmented reality, and 2.2% (nine companies) used robotic devices. It should also be noted that 28.6% (118 companies) of the respondents reported that they did not work with any of these technological tools.

An analysis of variables of Tourism 4.0 technologies and obstacles to adoption was carried out to analyse the relationship between the success (and obstacles) associated with the use of Tourism 4.0 technologies (Table 5). The results show that a lack of information was the main obstacle preventing companies from adopting technologies such as the Internet of Things, robotic devices, payment applications via mobile phones, applications for the creation of collaborative networks, cloud computing and voice recognition.

Figure 3   Portuguese tourism companies' diagnosis made to the technological tools used
              (see online version for colours)

Source: Author's elaboration

Table 5   Relationship between Tourism 4.0 technologies and adherence obstacles to the
            Portuguese tourism companies

	Obstacles to adherence to Tourism 4.0				
Technological tools	*Lack of information*	*Investment needed*	*Qualified ICT professionals needed*	*Data/ information security*	*Don't know Tourism 4.0*
Applications for the creation of collaborative networks	54.3%	52.2%	21.7%	28.3%	0.0%
Big Data analytics	47.9%	54.2%	41.7%	31.3%	2.1%
Cloud computing	51.7%	44.1%	29.4%	22.4%	6.3%
Internet of things	60.5%	34.1%	19.5%	16.8%	10.5%
Payment applications via mobile phone	62.0%	37.2%	26.4%	20.7%	5.8%
Robotic devices	55.6%	29.3%	24.4%	15.4%	11.1%
Virtual and/or augmented reality	53.8%	66.7%	33.3%	44.4%	0.0%
Voice recognition	62.5%	43.8%	25.0%	37.5%	18.8%
None	55.1%	33.1%	21.2%	11.0%	14.4%

Source: Author's elaboration

The main obstacle to the adoption of virtual and/or augmented reality and big data analytics was the investment needed. Companies that did not use any of these technologies identified the main obstacle as a lack of information, followed by the investment required.

It is interesting that 14.4% (59 companies) were not aware of Tourism 4.0, and also used none of the technological tools; this shows that the government entities associated with this sector need to provide more information on this concept, and on combinations of technologies.

To explore whether this concept was being successfully applied by Portuguese tourism companies, we investigated the relationships between variables, as shown in Table 6, such as the main technological tools used and the sector of activity. The Internet of Things was the main technological tool used in all sectors, followed by cloud computing for the accommodation and tour operator sector, and payment via mobile phone applications for the tourist entertainment and transport sectors.

Table 6 Relationship between Tourism 4.0 technologies used by the activity sector in Portuguese tourism companies

	Main technological tools used		
Activity sector	*Internet of Things*	*Cloud computing*	*Payment application via mobile phone*
Accommodation	**42.1%**	28.9%	17.1%
Tour Operator/Travel Agent	**67.0%**	50.0%	36.4%
Tourist Animation/Entertainment	**52.0%**	30.9%	31.7%
Transportation	**68.8%**	31.3%	53.1%
Other	**69.2%**	46.2%	46.2%

Source: Author's elaboration

The companies reported in an open-response question that they used practices such as storing all documents in digital format; using the internet, websites and social media; applying internal customer relationship management (CRM) and integral process management; issuing technological certifications; using tablets instead of paper; taking card payments; using online sales, payment and reservation systems; giving internal training on information technology and telecommunications; communicating via walkie-talkie; using digital invoices, catalogues/brochures and newspapers; and storing data in the cloud.

4.4 Is Tourism 4.0 beneficial for tourism businesses?

Our third research question aimed to discover whether the concept of Tourism 4.0 was perceived as beneficial by Portuguese tourism businesses. Table 7 shows that on a Likert scale from one (strongly disagree) to five (strongly agree), the companies agreed that Tourism 4.0 could benefit them, with an average score of 4.0. In terms of benefits, innovation capacity and data/information had the highest average score (4.1), followed by market dynamics, mechanisms of collaboration/coordination, and qualification in human resources (with the same value of 4.0). The lowest mean value was obtained for more adjusted and sustainable business models; however, this was still a high value (3.9).

Table 7   Perceived benefits of Tourism 4.0 for the Portuguese companies

Benefits of Tourism 4.0 for the companies	Average	Standard deviation	Mode
Data/information	4.1	0.9	5.0
Innovation capacity	**4.3**	0.9	5.0
Market dynamics	4.0	1.0	4.0
Mechanisms of collaboration/coordination	4.0	1.0	4.0
More adjusted business models	3.9	0.9	4.0
More sustainable business models	3.9	1.0	4.0
Qualification in Human Resources	4.0	1.0	4.0

Legend: 1- Strongly disagree; 2- Partially disagree; 3- Neither agree nor disagree;
4- Partially agree; 5- Strongly agree.
   Source: Author's elaboration

The highest variability in the opinions, measured based on the standard deviation of the sample, was 1.0, and the lowest was 0.9, meaning that the variability was small; that is, the difference between the average and the response amplitude varied by one absolute value at most. This was validated by analysing the mode, which differed from the average by approximately one unit.

4.5   *Tourism 4.0 and sustainability*

The fourth research question aimed to discover how Tourism 4.0 could contribute to increasing an awareness of sustainability by Portuguese tourism businesses. In terms of the benefits that Tourism 4.0 offers for sustainability, the companies considered, on average, that Tourism 4.0 was very beneficial (3.9, on a Likert scale between one, representing 'strongly disagree', and five, representing 'strongly agree'). Taking into account the sustainability concepts considered in the study, 'decent work' had the lowest average of 3.7, followed by the 'well-being of the population' with 3.8. The items of 'economic growth' and 'protection of the environment' had the highest average score of 4.1, as shown in Table 8.

Table 8   Benefits of Tourism 4.0 for sustainability

Benefits of Tourism 4.0 for the some of the Sustainable Development Goals	Average	Standard deviation	Mode
Decent work	3.7	0.9	4.0
Economic growth	4.1	0.8	4.0
Protection of the environment	4.1	0.9	4.0
Sustainable consumption	3.9	0.9	4.0
Sustainable production	3.9	0.9	4.0
Wellbeing of the population	3.8	0.9	4.0

Legend: 1- Strongly disagree; 2- Partially disagree; 3- Neither agree nor disagree;
4-Partially agree; 5- Strongly agree.
   Source: Author's elaboration

The variability of responses, measured based on the standard deviation of the sample, was centred between 0.8 and 0.9, meaning that they did not vary much from one company to another. This result was validated by the mode, which had a value of four for all of the objectives considered in the study, indicating that 'partially agree' was the most frequent response.

The Pearson correlation coefficient was used to analyse the relationship between the benefits of Tourism 4.0 for sustainability and its benefits to the companies, since the variables were quantitative and there was a linear relationship between them. The results presented in Table 9 reveal strong and very strong correlations between the two variables analysed here. The p-values are below $\alpha = 0.05$, which indicates that there is statistical evidence for a linear relationship between the same pairs of variables in the population.

Table 9   Correlation between the benefits of Tourism 4.0 for the SDG's and its benefits for the Portuguese tourism companies

Benefits of Tourism 4.0 for the companies	*Benefits of Tourism 4.0 for some of the Sustainable Development Goals*					
	Decent work	*Economic growth*	*Sustainable production*	*Sustainable consumption*	*Protection of the environment*	*Wellbeing of the population*
Data/ information	0.768	0.807	0.773	0.766	0.786	0.755
More adjusted business models	0.764	0.820	0.795	0.772	0.786	0.751
More sustainable business models	0.783	0.804	**0.823**	0.786	0.786	0.788
Innovation capacity	0.761	0.811	0.797	0.785	0.796	0.731
Qualification in Human Resources	0.757	0.783	0.766	0.752	0.766	0.733
Market dynamics	**0.791**	**0.825**	0.819	**0.792**	**0.797**	**0.789**
Mechanisms of collaboration/ Coordination	0.783	**0.826**	0.817	0.790	0.792	0.778

Source: Author's elaboration

Although all of these values were very high, a correlation analysis of the variables showed that 'market dynamics' was the benefit most often correlated with sustainability goals. The only exception was the objective of 'sustainable production', for which the strongest correlation was with 'more sustainable business models'. We can conclude from Table 9 and the levels of correlation between all the benefits and objectives that there is a strong correlation between the benefits of Tourism 4.0 and some aspects of sustainability associated with the regions.

Finally, when asked (in an open question) about their sustainability practices, the respondents stated that they applied sustainable practices, such as reusing paper; using low-energy lights and collective transport; promoting sustainable tourism; using solar panels and renewable energies; optimising farm resources in harmony with hydro-

meteorological and agricultural cycles and tourist demand, in order to avoid waste and to maximise the quality of rural tourism experiences; participating in sustainability conferences; using sustainability certifications; monitoring and controlling CO_2 emissions; using more economical hybrid and electric vehicles; ensuring the rational use of water resources; rainwater harvesting; selective waste sorting; reducing plastic waste; using recyclable and biodegradable materials; monitoring and analytically controlling water waste; installing grease separators and oil separators; using concentrated chemical products with an automatic dosage; promoting regional products; using cleaning products with environmental certification; using unbleached, recycled toilet paper; reusing organic waste for animal feed or compost; using products of biological origin; using a drop-by-drop irrigation system; and reusing water collected from wells during the winter.

5   Discussion

We found that the Portuguese tourism companies were aware of the concept of Tourism 4.0; however, they considered that there were obstacles to be overcome, such as a lack of information and the investment and qualified ICT professionals required. As mentioned in a study by Costa et al. (2018, p.711) "it is necessary to invest more and more in intelligence systems that allow the management of touristic activity". The results in regard to a lack of interaction between local authorities and entrepreneurs are in line with the work of Korže (2019), who states that the term Industry 4.0 was adopted for studies in relation to smart cities, smart destinations or smart tourism, rather than for the paradigm associated with Tourism 4.0; this implies a focus on tourist activity.

From an analysis of the extent to which this concept is being successfully applied by Portuguese companies, it was concluded that companies are perhaps applying the concept in their business without realising it, which may be an aspect to be taken into account. It was suggested by Korže (2019) that the concept of Tourism 4.0 should find a place in academic research, in order to contribute to the transfer of knowledge between academia and industry, as a way to enhance learning about the meaning of this concept, and with the objective of "clarify[ing] the difference between Tourism and 'smart' tourism" (Korže, 2019, p.45) and "work[ing] together to find ways of making their offer synergistic" (Costa et al., 2018, p.710).

An investigation of the companies' perceptions of benefits showed that innovation was ranked first, followed by data/information, market dynamics, mechanisms of collaboration/coordination and qualification in human resources. For Costa et al. (2018), the main benefits of this paradigm are economic and employment growth, as it creates jobs and opportunities, while for Korže (2019), they are the technological changes in the activity and the possibility of innovating, mainly with regard to services and commercial transactions.

With regard to the issue of whether Tourism 4.0 can contribute to increasing sustainability, our results indicate that the associated technologies can contribute to the development and implementation of adequate tools with which to achieve the SDGs. The work of Peceny et al. (2019) shows that through the use of collaborative platforms, it is possible to measure, monitor and manage the impacts generated by tourists in the local environment; that is, it is an initiated process that can be valued in different ways by entrepreneurs. However, they agree that it has advantages for development of tourist activity.

6 Conclusions and implications

Both Tourism 4.0 and the SDGs are of great importance to tourism destinations nowadays, and we can draw some conclusions from this research. Our results show that the respondent companies were mainly microenterprises with less than 10 employees, and were in the accommodation, tourist entertainment and tour operator sectors. They were mostly located in the north, in Lisbon and in the centre of Portugal. The concept of Tourism 4.0 is relatively new, and the proportion of awareness was higher than expected. Our results indicated that as the size of the company increased, the level of awareness of Tourism 4.0 also increased. The higher levels of awareness of Tourism 4.0 in the autonomous regions (Madeira and the Azores islands) might indicate a need to stay up to date on new tourism trends in order to guarantee competitiveness and ensure the survival of these destinations.

6.1 Managerial implications

There are some managerial implications for tourism destinations; for example, the main obstacles that companies felt were hindering them from acquiring these technological tools were a lack of information, the investment required, and the qualified ICT professionals needed. Another obstacle identified by the companies was a lack of interaction between local authorities and entrepreneurs. The results showed that even without knowing what Tourism 4.0 involved, companies were perhaps applying this concept in their business without realising it. The main technological tools used were the Internet of Things, cloud computing, and payment via mobile phone applications.

There is currently a great deal of concern over environmental impacts and the well-being of the population, and we, therefore, expected to observe a higher awareness regarding these matters. The sustainability practices mentioned by companies as being applied in their businesses suggest that there is a concern to improve their product by pursuing sustainability. These companies saw Tourism 4.0 as partially beneficial for their businesses and believed that Tourism 4.0 had mainly positive effects in terms of sustainable development.

6.2 Theoretical implications

From the results obtained in this study, and from a consideration of the theoretical implications, we can conclude that we accomplished the aim of the study, which was to address the research gap in regard to this subject in Portugal, and that we managed to answer our initial research questions. Firstly, we learned that a large proportion of Portuguese tourism companies were not fully aware of the concept of Tourism 4.0, despite the fact that the national tourism board had already implemented a program to incentivise adherence to this paradigm. A further drive to increase awareness of this concept among companies, and particularly among microenterprises, is therefore clearly needed. Secondly, the concept is not being applied in an entirely successful way by many Portuguese companies due to the obstacles to adoption, although many companies recognise the advantages that Tourism 4.0 offers for their businesses. Despite some companies perceiving Tourism 4.0 as having negative effects on the sustainable development of the destination, most companies believe it mostly has positive effects, and therefore consider Tourism 4.0 an adequate tool with which to achieve the SDGs.

6.3   Limitations of the study

The main limitation of the study was the low number of responses obtained from some sectors of activity, which was lower than expected. Despite receiving a total number of 412 responses, there were still sectors with insufficient responses to guarantee anonymity and allow us to draw conclusions.

6.4   Future work

In future work, it would be interesting to repeat this study at a later date, when the concept of Tourism 4.0 has been more widely adopted in Portugal, and also to investigate the ramifications of the Covid-19 pandemic and their specific effects on tourism management operations. This would allow us to gain a better overall picture of how tourism companies relate Tourism 4.0 practices to increased levels of sustainability.

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