



## Empirical Research Article

# Smart Tourism Development in Small and Medium Cities: The Case of Macao

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## Abstract

As a popular concept, smart tourism is widely used as a strategic tool to improve the competitiveness of world tourism destinations. Taking Macao as a case study, this research explores the relationship between government, academic research, and smart destination applications, with a view toward investigating the utilization of smart technology to achieve service innovation, effective communication with tourists, and enhance the travel experience. The study summarizes the current situation of smart tourism in Macao, finding that most of the smart services in Macao rely on users to obtain information spontaneously and do not achieve real interaction and service demand. Suggestions and advice for smart development are provided.

## Keywords

Macao; smart tourism destinations; mobile applications; VR/AR applications; Big data platform

## 1. Introduction

Smart cities and smart tourism have been popular topics in recent years (Jasrotia & Gangotia, 2018). The goal of building a smart city is to improve the quality of life for residents, which requires improving the connections between people and systems, governments, and other public and private entities. Smart tourism is a branch of smart cities that aims to provide solutions to tourists' travel-related needs (Khan, Woo, Nam, & Chathoth, 2017), improve travel experience, and enhance the competitiveness of destinations (Xiang, Tussyadiah, & Buhalis, 2015). Smart tourism is often used to promote specific political agendas and sell technical solutions, where it is frequently used in the context of open data initiatives or for rather trivial projects such as promoting free Wi-Fi or the development of mobile application (Gretzel, Sigala, Xiang, & Koo, 2015). Governments, such as the U.S., Mainland China, and South Korea, have been taking initiatives to build the requisite infrastructure and develop the necessary technologies to support smart tourism development (Ye, Ye, & Law, 2020). Shafiee, Rajabzadeh Ghatari, Hasanzadeh, and Jahanyan (2019) mentioned that destination managers, academicians, and policymakers are involved in the construction of smart tourism destinations. They proposed a framework for sustainable smart tourism destinations and stated that the smart tourism actions are influenced by context conditions (economy, technology, environment and social cultural) and also request the support from government. In other word, as Figure 1 shows, government support, context conditions and the result of academic research are important determinants that guide and influence the implementation of smart tourism destinations.

At present, although a large number of papers have proposed the system and application in the field of smart tourism,

The current literature has various limitations to provide guidance for the development of smart tourism destinations, such as the general lack of a strong theoretical background for research on smart tourism destinations and the absence of collecting a large number of tourist perspectives to determine the effectiveness of the application of smart systems are the main issues that need to be addressed in the literature. (Gretzel et al., 2015; Kontogianni & Alepis, 2020). Research on smart tourism destination development needs to be combined with theory to explore the characteristics of different destinations, and case studies can provide targeted analysis as well as referenceable cases for smart tourism destination development. Koo, Shin, Kim, Kim, and Chung (2013) targeted smart tourism development in Korea, overviewed how Korea Tourism Organization's information technology operation manages each channel, website, social networks, applications and suggests and advices for smart tourism future directions are provided base on the research findings. After analyzing the development of smart tourism in Dubai, Khan et al. (2017) concluded the key features of smart tourism destinations include the digitization of systems, processes and services; establishing higher-level connections with tourists for communities, governments and other departments in the destination; providing local residents with a platform to participate in products/services; a higher level of data generation and use through integrated smart systems; thereby achieving better management of tourists' experience. The application of destination smart tourism is the focus of most published studies. However, the context conditions of the destination, government guidelines and the research in smart tourism related to the destination are often ignored. It remains unknown whether the development of smart tourism will be affected by the weak theoretical foundation of research, government guidelines, and current development status.

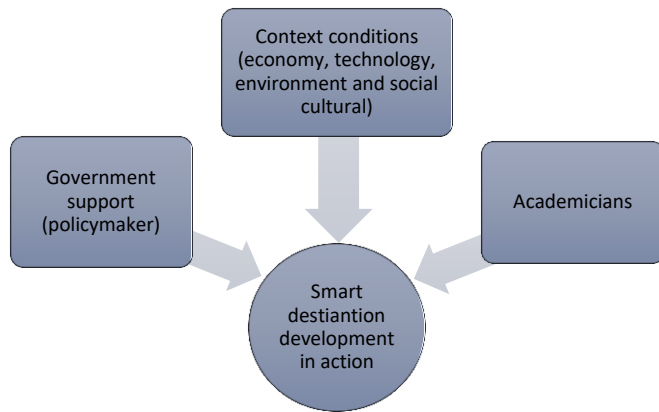
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Therefore, the aim of this paper is to provide a case study on the development of smart destinations—using Macao as the research target—to explore the relationship between government, academic research and smart destination development in action.



**Fig 1.** The relationship between government, academic research and smart development in action

## 2. Macao Tourism Industry

Macao has been a special administrative region (SAR) of the People's Republic of China since 1999, and this small city is perched on a peninsula of only 29  $km^2$  of land at the mouth of the Pearl River Delta (Greenwood & Dwyer, 2017). Macao's economic development is stable. In 2019, Macao's GDP was about US \$53.86 billion, and its per capita GDP exceed US \$86000. In 2020, despite coronavirus pneumonia, Macao's GDP was still amounted to US \$23.7 billion. The tourism industry is a key contributor to Macao's economy, and it has created many employment opportunities for local residents. Macao welcomed 39.4 million visitors in 2019, an increase of 10 percent compared with 2018, when 35.8 million people visited the territory (MGTO, 2020). Greater China markets continue to be the top sources of inbound visitors to Macao (Pang, Law, & Fong, 2019).

Macao tourism industry faces many challenges due to the rapid growth of tourism. For example, the concentration of tourist attractions in Macau makes it easy to overload the tourist areas and traffic jams often occur during the peak season. Many studies have focused on the different issues facing the tourism industry in Macao and Ageiwaah (2019) argued that the impact of tourism over-development risks should alert attention from the Macao tourism office. Luo, Lam, and Ye (2019) found that policies and regulations, economics, marketing, management, government attitudes, expertise and manpower, facilities and attractions, and infrastructure issues are the main obstacles to the sustainable development of entertainment tourism in Macao. Thus, Macao may need a more sustainable approach to tourism development that includes being a smart destination. "Sharing" tourists share tourism products such as sharing transportation, AirB&B services which could be a solution to reduce damages from tourism over-development, thus the sharing economy may be another angle for future smart tourism development in Macao. Smart tourism destinations can also aim to use resources in smarter ways and improve quality of life sustainably, not only for residents, but also for tourists (Cimbaljević, Stankov, & Pavluković, 2019). Thus, building successful smart destinations can help Macao solve the current problems in the tourism industry, demonstrating its unique characteristics while providing higher quality services to visitors and promoting their interest in repeat visiting.

## 3. Literature review

Smart tourism can be considered as a unique phase in the evolution of Information Communication Technologies (ICTs) in the tourism sector, where the physical and governance dimensions of the tourism industry have gradually merged with the digital domain, as a result that tourism information systems have achieved new levels of intelligence, and fundamental changes in the way tourism experiences are created, shared, and consumed (Gretzel et al., 2015). The development of smart tourism brings a richer tourism experience for tourists, demonstrates a more flexible market structure and offers more business opportunities for new facilities, business models, and market value. The sign of smart tourism is embodied in the combination of leveraging the information technologies and physical infrastructure, which is an integral part of smart city development, including policy, human capital, innovation and IT infrastructure, natural resources and environment (Gretzel et al., 2015; Khan et al., 2017).

Smart destinations utilize information platforms to transform user data into solutions relevant to specific needs and create personalized services for users (Koo, Shin, Gretzel, Hunter, & Chung, 2016), which also brings various challenges. These challenges are attached to the three phases in which visitors use smart services to assist them in their visits to destinations (Ardito, Cerchione, Del Vecchio, & Raguseo, 2019). In the pre-trip stage, destinations facing the challenges of its online reputation, which has direct impacts on the travel destination selections of its potential visitors. Tourists may post negative reviews online, and some information may be false misleading or motivated by bribery, or out of malice, or even due to an aversion to electronic technology (Weaver & Moyle, 2019). Due to the psychological impact of word-of-mouth behavior, consumers are reluctant to share negative reviews, which would inflate their scores. The false information is unfair to other tourists also has a negative impact on the tourism development of destinations. In the on-site stage, whether smart devices successfully play a supporting role during the trip can also affect the travel experience and satisfaction of tourists at the destination, especially when unexpected situations arise, such as tourists forgetting to charge their phones or losing them during the trip (Weaver & Moyle, 2019). Data privacy is also one of the challenges that is frequently mentioned, travelers were concerned about data privacy during their trips to different destinations (Buhalis & Amaranggana, 2013). For the use of smartphone apps usually ask for personal data, privacy concerns regarding personal security may prevent users from sharing their data, even as travelers habitually choose to decline data requests from suppliers (Ardito et al., 2019). This leads to many smart applications not being fully used, or even not being used. In the post-travel stage, value-added services such as labeling of checked luggage, mailing of souvenir products at the destination, and reimbursement of invoices are also among the challenges for smart destinations to increase tourist loyalty (Buhalis & Amaranggana, 2013). The key factor that determines the competitiveness of smart cities and smart tourism is the efficient use of information technology in destinations (Khan et al., 2017). The core of the development of smart destinations is the effective use of information technology to consolidate shared resources and ensure the sustainability of the destination (Lopez de Avila, 2015; Roberto, Presenza, & Del Chiappa, 2013).

The ingenious implementation of smart technologies in the three phases of the tourist journey (pre-, on-site and post-trip) can appropriately reduce the impact of tourism on the lives of local residents and at the same time enhance the tourist experience. Most high competitive smart tourism destinations equip with the basic structural factors of smart tourism, such as leadership, innovation and human-supported social capital, as well as enabling factors including technology applications and ICTs (Boes, Buhalis, & Inversini, 2016). The combination of theory and practice is a key to the development of any

destination, and a detailed analysis of its current situation can potentially provide insights and recommendations for the future development of smart tourism. In order to contribute to the literature and practice by providing some insights gained from investigating a case on how smart destination can be developed by exploring three data sources – literature search, government periodical archived data, and descriptions of actual smart applications. This study attempts to use Macao as a case study. It explores Macao's smart tourism from both academic and practical perspectives, firstly reviewing and summarizing the literature on hospitality and tourism in Macao, then collecting the Macao government's policies on smart tourism development and reviewing the smart applications that have been conducted in Macao. The development of smart tourism in Macao is discussed from both theoretical and practical perspectives.

#### 4. Methods

The data collection of this study is divided into three categories: 1) collect literature in the form of hospitality and tourism research publications related to Macao; 2) government guidance, represented by tourism-related plans released from official government press releases; and 3) current smart tourism applications adopted by official channels in Macao. Qualitative research is used to analyze and discuss the content of the three selected categories. The data was collected from January 8 to March 14, 2021.

##### 4.1 Macao-related Hospitality and Tourism Research

To review hospitality and tourism, Web of Science (formerly ISI Web of Knowledge) was selected as the database for searching for research articles. Web of Science is today's premier research platform for information in the sciences, social sciences, arts, and humanities. Its 10 database indexes include ISI Web Of Science - SCIE, ISI Current Contents Connect; ISI Proceedings; the Derwent Innovations Index; Biosis Previews; INSPEC; MEDLINE; ISI Journal Citation Reports; ISI Essential Science Indicators; and ISI HighlyCited.com (Clarivate analytic, 2019). An advanced search for articles published from 1995 and 2021 was conducted using the topic words "Macao OR Macau" under the hospitality leisure sport tourism category. A software-based scientometrics approach was adopted using a software application called CiteSpace to analyze the collected research articles. In early March 2021, 313 hospitality- and tourism-related research articles were found from Web of Science, dated from 1995 to 2021. Two analyses were selected: "Keywords with the Strongest Citation Bursts" and "Time-zone view of the keywords." Only one study meeting these criteria in the tourism and hospitality area was published before 2006, which is Hobson's (1995) study on the Macao gaming industry. Therefore, the analysis included studies from 2006 to 2021.

##### 4.2 Government Policies

The details of Macao's government policies related to smart tourism development was captured by consulting MGTO's annual press releases. This study collected all the annual press releases that mentioned the use of ICTs and smart technologies to develop Macao's tourism industry. Finally, data was collected from the years 2014 to 2021, from the official MGTO website.

##### 4.3 Smart Tourism Applications

Macao smart tourism applications were mainly collected from google search engine, by searching "Macao/Macau smart tourism development" "Macao/Macau smart tourism applications"

and "Macao/Macau smart phone applications" two sources are considered for collection. The first was the official announcements of Macao government departments. The second was to find popular smart applications that are promoted by the public in Macao such as news report or promotional ads. The definitions of these smart applications are obtained from the news, official webpage or the app download page. As the study was designed for smart destinations development, considering the validity and authenticity of the applications, this article only collects the smart applications provided and supported by the official, privately launched as well as the smart applications related to hotels and restaurants were not collected.

#### 5. Findings

##### 5.1 Macao-related Hospitality and Tourism Research

Table 1 displays a list of 25 keywords with the strongest citation bursts. Among the top 10 keywords, the terms "Service quality," "Casino," "Involvement," "China," "Destination image," "Gambling," "Tour guide," "Quality," "Destination," and "Experience" were popular.

From the time series, the popular terms before 2014 are "Gaming," "Casino," "Issue," "Tour guide," "Place," "China," "Interpretation," and "Quality." This indicates that academic research on Macao before 2014 mainly focuses on the study of Macao's gaming industry as well as solutions for the current problems of tourism development. For example, Gu and Siu (2009) examined the relationship between work performance and job satisfaction in Macao's casino hotels. Hsu and Gu (2010) investigated Macao's gaming boom and the planned construction of the Hong Kong, Macao and Zhuhai (HMZ) Bridge, which would present good opportunities for the three destinations to develop tourism. The transformation of Macao's destination image refers to the views of tourists and its residents, since the image of casinos is still very important in the eyes of residents and tourists. Although MGTO is trying to downplay casinos, developing attractive broad-based tourism products has remained a challenge for a long time (Kong, du Cros, & Ong, 2015).

From 2015 to 2017, the keywords are "Expectation," "Destination," "Customer satisfaction," "Service quality," "Corporate image," and "Destination image." This shows that, since 2015, academic research on Macao has begun to focus on destination development (Vong, 2013); establishing destination image (Loi, So, Lo, & Fong, 2017); improving tourists' satisfaction (Choi & Yoo, 2017); and service quality (Ji, Li, & Nie, 2017).

From 2017 to 2021, the keywords are "Behavioral intention," "Involvement," "Experience," "Corporate Social Responsibility (CSR)," "Knowledge," "Food," "Intention," "Co-creation," "Identity," and "Event." These keywords involve a wide range of research, which shows that, after 2017, Macao tourism research topics are not limited to the gaming industry, destination development and tourists' satisfaction. They have expanded to involve in various other aspects of the tourism industry. For example, Io and Chong (2020) attempted to empirically investigate Macao residents' perception and enjoyment of Cantonese opera as a traditional performing art. Chan and James (2020) examined how hospitality employees' experience of organizational politics, emotional exhaustion, job satisfaction, and turnover intention are linked.

From the time node of these keywords, Macao tourism research topics have become more abundant and profound. However, studies on the topic of the impact of ICTs on the development of tourism destinations are very few, and no influential keywords appear in Table 1. This implies that smart tourism or ICTs applications in the Macao tourism industry have not aroused attention from academia.

**Table 1.** Top 25 keywords with the strongest citation bursts

Keywords	Strength	Begin	End	2006 - 2021
Gambling	2.7217	2009	2012	
Casino	3.425	2009	2014	
Issue	2.9404	2009	2013	
Tour guide	2.6049	2010	2013	
Place	1.6459	2011	2013	
China	3.1439	2011	2014	
Interpretation	1.6459	2011	2013	
Expectation	2.1978	2012	2015	
Quality	2.3703	2012	2013	
Destination	2.2266	2014	2016	
Customer satisfaction	1.5449	2014	2017	
Service quality	4.0442	2014	2017	
Behavioral intention	1.9072	2015	2018	
Corporate image	1.9976	2015	2017	
Destination image	2.8582	2015	2017	
Involvement	3.2112	2016	2018	
Experience	2.2222	2017	2021	
CSR	1.8953	2018	2019	
Knowledge	1.8953	2018	2019	
Food	1.8953	2018	2019	
Intention	2.0165	2018	2021	
Co-creation	1.7939	2019	2021	
Identity	2.2044	2019	2021	
Event	1.7939	2019	2021	

Figure 2 shows when and for how long a topic has become prevalent. Apparently, tourism research on Macao covers a wealth of research topics. However, there is very little research on the application of smart tourism and ICTs in tourism. There was only one topic, in 2019, covering “social media.” In fact, out of 313 published articles, only 14 studies focused on the impact of ICTs on Macao’s tourism industry, including mobile applications (Lai, 2015; Li, Su, Xu, & Yao, 2019); e-word-of-mouth (eWOM) and user generated content on social platforms (Lai, 2020; Vincent, 2018; Wang, 2015); information channels (Chen, 2019; Choi, Lehto, & Morrison, 2007; Choi, Tam, Kim, & Kim, 2018); and hotel websites (Chan, Wu, & Vipulakom, 2020). This indicates limited research exploring ICTs and the development of Macao’s tourism industry, and there is almost no research on Macao’s smart tourism.

*5.2 Government Guidance in Smart Tourism Development*

The gist of Macao government guidance related to smart tourism is given in Table 2, in chronological order, for the purpose of identifying smart tourism strategies that MGTO tries to deliver for tourism development. In 2014, MGTO started a marketing effort concentrating on developing online tourism promotions and enriching information about Macao on online platforms. 2015 marked the first time that MGTO announced the setup of a new tourist information counter at the new ferry terminal at Pac On in Taipa, to foster smart tourism development and electronic marketing.

In 2016 and 2017, MGTO continued to promote development of electronic administration and promote smart tourism as one of its major priorities. It utilized ICTs as promotion methods, including partnering with well-established

online platforms and bloggers to further promote the destination on the Internet.

Since 2018, in addition to the development of smart tourism, MGTO began to establish a large tourism database for better cooperation with the tourism industry and to solve the problem of tourist carrying capacity problem in Macao. In 2019, the concept of big data was first mentioned by MGTO as it announced efforts to harness big data to analyze visitor behavior and provide grounds for studies on forming future destination marketing strategies and launching a newly designed Macao tourism promotion website.

In 2020, MGTO continued to develop its big data platform and share data on Macao tourism with the public. It also integrated the current content of its “Experience Macao,” “Step-Out, Macao” and “What’s On, Macao” mobile apps to provide a one-stop mobile application for Macao travel. Its tourism for 2021 is to open more tourism-related data via the Macao SAR Government Open Data Platform to unblock information isolation on the island while leveraging the tourism information interchange platform to compile tourism industry information and widen the potential of smart tourism development.

These findings show that Since 2014, MGTO has been performing a central role in the development of smart tourism in Macao. However, after years of efforts and promotion, the current situation of smart tourism development in Macao is still unclear. Very few studies have tried to analyze the application of ICTs or the development of smart tourism in Macao. The combination of theory and practice is the key to the development of the destination. A detailed analysis of the current situation of the destination will provide solutions for the future development of smart tourism.

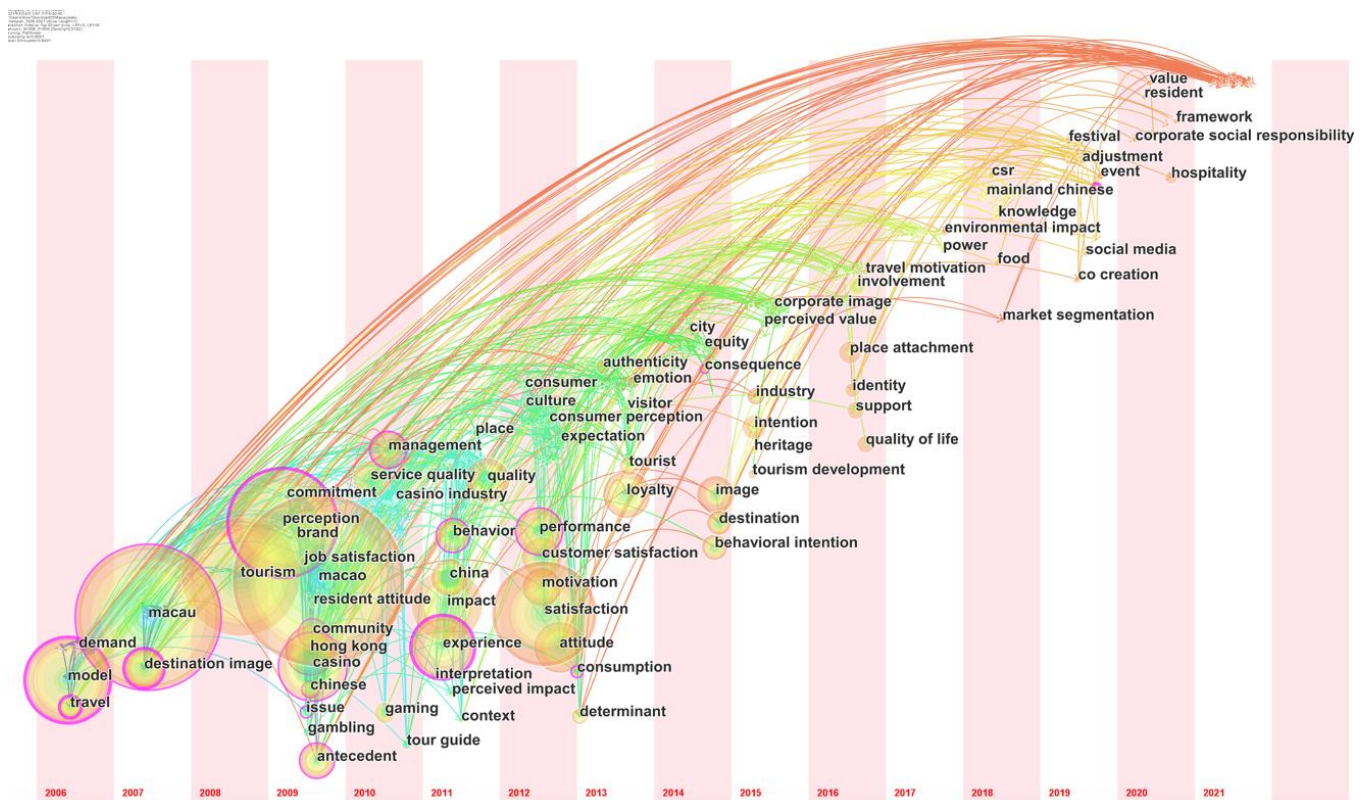


Fig 2. Time-zone view of the keywords in hospitality and tourism studies in Macao (2006-2021)

Table 2. Macao Government guidance related to smart tourism development

Year	Details of Government Guidance Related Smart Tourism Development
2014	Concentrate on developing “Useful Tourism-Info e-Platform; design a mobile application for MGTO’s publication and reform its publication of “Macao Travel Talk” by enriching its online content.
2015	Foster smart tourism development and electronic marketing.
2016	Promote smart tourism as one of the major priorities among other strategies.
2017	Continue to develop smart tourism and leverage means of technology such as popular websites, mobile applications, social media platforms, and search engines to promote Macao.
2018	Boost smart tourism development by harnessing innovative technology to enrich the travel experience of visitors, building a large tourism database as well as reinforcing management of tourism carrying capacity.
2019	Conduct data collection and dissemination for the tourism information interchange platform and build a tourism big data database.
2020	Expand the scope of application of the tourism big data database to enable travel trades to share and harness the data; develop an intelligent itinerary planner to provide tailor-made travel routes for visitors with different interests.
2021	Open more tourism-related data via the Macao SAR Government Open Data Platform to unblock information isolation on the island, while leveraging the tourism information interchange platform to compile tourism industry information and widen the potential of smart tourism development.

Source: MGTO Annual Press Conference (2014–2021) tourism planning and diversification of tourism products and markets.

### 5.3 Smart Applications in Macao Tourism Industry

Macao government issued the “Macao Smart City Development Strategy and Key Field Construction Consultation Text,” which clarified 13 key construction areas including infrastructure, big data, transportation, environmental protection, tourism, medical care, and education. At the same time, six projects including *smart streetlights*, *Macao in the bag*, *government big data platform*, *smart city logo*, *smart city application and solution project funding*, and *municipal facilities EasyGo* will be piloted in the early stage to create a people-oriented, sustainable smart city (Macao monthly, 2020). The Macao Government Tourism Office (MGTO is cooperating with the Special Administrative Region government on its “smart city” development strategy and has launched many smart tourism projects into service (Travel PR News Editor, 2019). In 2019, MGTO officially launched three smart tourism projects into service (Travel PR News Editor, 2019), which fully capitalizing on the leading technology of Alibaba Cloud on cloud computing,

big data application and other areas to push forward smart tourism.

Table 3 shows smart applications provided and supported by the official channels in Macao, with nineteen applications listed. These applications include mobile applications, virtual reality (VR), augmented reality (AR), QR codes, websites, and a tourism data exchange platform. Mobile applications are the most widely applied smart technology in the Macao tourism industry, followed by VR/AR/QR code technologies, and data exchange platforms. Most of the applications consist with the review result of Kontogianni and Alepis (2020), except the privacy preserving, context awareness and user experience. Fortunately, tourists visiting Macao have a very positive attitude towards using smart technologies (Pai, Liu, Kang, & Dai, 2020). It is important to increase the collaboration between public and private companies for the development of new or improved

ICTs-enabled tourism services towards the smart transformation of Macao (Errichiello & Marasco, 2017).

The listed applications are further categorized into five groups base on their function, these groups are defined based on the 6As from studies of Buhalis (2000) and Buhalis and Amaranggana (2013) to measure the success of a tourism destination, the 6As include *Attractions*; *Accessibility*; *Amenities*; *Available Packages*; *Activities*; and *Ancillary Services*. This study revised the 6As as following groups, *attraction* referring to the smart applications is utilized in attractions in Macao. *Ancillary* refers to smart applications that help tourists enhance their travel experience. *Activity* represents smart applications that facilitate activities that tourists may conduct in Macao. *Transportation* means smart applications that can be applied to transportation and navigating traffic in Macao, and *Data Exchange Platforms* are the online big data platforms that the Macao government is sharing with the public.

Ancillaries is the largest group and contains most of the applications, which implies that these applications more likely act as assistant tools to promote travel and help tourists search for information before and during their trips. Based on their functionality of these apps, they appear to be aimed at helping tourists in the pre-travel and on-site stages. This makes sense given that tourist behavior changes according to their travel experience and their travel phase. For example, at the pre-travel stage, they will seek more destination information for preparation and selection; during the on-site stage, they are more likely seeking destination facilities to assist their trip; and during the post-travel stage, they may share their travel experiences (Akhoondnejad, 2015). However, in Macao there is a lack of smart applications that address tourists' post travel needs.

**Table 3.** Tourism related smart applications provide by official channels in Macao

Name of the Applications	Smart Tech. Tools	Travel Phases	Description of Smart Experience	Government Departments
<b>Attraction</b>				
Macao Museum's virtual tour	Mobile app	Pre-travel On-site	A mobile app that has three functions comprising virtual reality (VR), augmented reality (AR), and QR code. Users can enjoy an immersive 720-degree panoramic view of the first, second and third floors of the Macao Museum and the Mount Fortress Garden with virtual reality (Macao Museum Macao Museum VR/AR, 2021).	Macao Museum
Macao Cultural and Creative Map	Mobile app	Pre-travel On-site	A mobile app provides relevant data on Macao's cultural and creative entities, with GPS and shop hunting functions for users' easy browsing of cultural and creative spaces and quaint shops full of peculiarities (Macao Cultural and Creative Map, 2017)	Cultural Affairs Bureau of Macao
World Heritage (WH) Macao	Mobile app	Pre-travel On site Post travel	A mobile app creates the effect of "strolling through the Historic Centre of Macao" by providing detailed descriptions of World Heritage sites; interesting multi-media information (short video clips, photographs, 360-degree views, activities related to the locale, etc.); and various interactive functions (a route guide linking the Heritage sites, Facebook functionality, etc.) (WH Macao, 2011).	Cultural Affairs Bureau of Macao,
Step out	Mobile app	Pre-travel On site	A mobile app offers eight suggested walking tour routes in Macao (Step Out, 2020).	Macao government tourism office
<b>Ancillary</b>				
Experience Macao	Mobile app	Pre-travel On-site	A mobile app offers attraction information to tourists with multiple functions including: Information of Tourist Spots, Shows & Entertainment, Accommodation, Restaurants, etc; 360-degree Panorama Photos; Audio Guide; Trip Planner; Offline Map; Augmented Reality (AR) function; and Game (Experience Macao, 2021).	Macao government tourism office
FreeWiFi.MO	Wi-Fi service	On site	The Macao Post and Telecommunications Bureau (CTT) promotes different local organizations using the uniform network name "FreeWiFi.MO" to provide free Wi-Fi service to citizens and tourists (FreeWiFi.MO, 2018).	Macao Post and Telecommunications Bureau
Macao ready go	Online platform	Pre-travel On site	An online platform introduces Macao's promotional information including dining, accommodations, shopping, entertainment, local tours, and news (Macao ready go, 2021).	Macao government tourism office
What's on Macao	Mobile app	Pre-travel On site	A mobile app introduces Macao's latest tourist attractions and monthly highlights from local events, activities, festivals, performances to exhibitions (What's on Macao, 2019)	Macao government tourism office
MGTOWeichat	Social media	Pre-travel On site Post travel	Official social media account established by MGTO Macao to ease travelers' travel experience (MGTOWeichat, 2021)	Macao government tourism office
QR Code for Cultural and Creative Venues	QR codes need assistance from smart phone devices	On site	The public can use this app to scan the QR code of "Works of Literature" with their mobile devices in order to link to the corresponding website(QR Code for Cultural and Creative Venues, 2015).	Cultural Affairs Bureau Macao
<b>Activity</b>				
Macao Light Festival	Mobile app	Pre-travel On-site	Macao Light Festival brings light installations, interactive games, and projection mapping shows accompanied by music. Visitors can participate in this festival by playing online games and downloading mobile apps (Macao Light Festival, 2019).	Macao government tourism office
Macao Grand Prix	Mobile app	Pre-travel On-site	A mobile app named Macao GP supports detailed information on this auto racing event (Macao Grand Prix, 2021)	Sports Bureau of Macao
Macao Marathon	Mobile app	Pre-travel	The Macao Marathon mobile app provides race information to its attendants and fans (Macao Marathon, 2021).	Sports Bureau of Macao

**Transportation**

DSAT-Traffic Information Station	Applications	On-site	DSAT-Traffic Information Station mainly provides traffic information in Macao. (DSAT-Traffic Information Station, 2021)	Transport Bureau of Macao
LED variable message signs	LED variable message signs	On-site	Release the traffic conditions of the key streets and the bridges to the drivers in time, so that the drivers can choose the right roads in order to avoid the traffic jam stress when there is any traffic accident and it also save the motorists 'time (LED variable message signs, 2005)	Transport Bureau of Macao
Bus Traveling System and Bus stop for the visually impaired	Mobile apps	On-site	A mobile and GPS platform for real-time bus transportation information (Bus Traveling System, 2021; Bus Stop for the Visually Impaired, 2021)	Transport Bureau of Macao

**Data Exchange Platforms**

Smart visitor flow application	Online data platform	Pre-travel On site	A free access online platform that predicts the density of visitor flow in tourist attractions for a period of four hours, 24 hours and seven days. It issues ratings that make it easier to organize visitor and tourism industry operator itineraries (Smart visitor flow application, 2019).	Macao government tourism office
Tourism data exchange platform	Online data exchange platform	Pre-travel On site	The tourism data exchange platform is the basis for "smart tourism" projects and was created in the cloud computing network of the Government of Macao, gathering together a variety of data related to tourism in the territory (Tourism data exchange platform, 2019).	Macao government tourism office
Visitor observation application	Free access online platform	Pre-travel On site Post travel	A free access online platform that provides insights into the basic attributes and group behavior of visitors It is used to take a snapshot of the situation as well as the preferences and travel behavior of visitors to Macao (Visitor observation application, 2021)	Macao government tourism office

**6. Discussion**

Research findings showed that there is a disconnect between research on smart tourism in Macao and the development of smart tourism by MGTO. Figure 3 illustrates the development of smart tourism in Macao under the influence of academia and government. This case study successfully demonstrates the different impacts of academia, government and practice on smart destinations. It confirms the common problems in the development of smart destinations, such as the lack of theoretical guidance and the over-reliance on smartphones for smart applications in destinations, most of which can only provide assistance to tourists before and during their visit, and the lack of value-added post-tour services for destinations. The detailed analysis of its findings contribute references and guidance for the current research on smart tourism destinations.

Apparently, smart tourism has become one of the important market strategies for tourism development that the Macao government has focused on since 2015, for example, promoting smart tourism, designing and increasing smart tourism related tourism applications, establishing tourism big data database and opening up related data resources. To better promote the development of smart tourism in Macao, six government departments the Macao Museum, Cultural Affairs Bureau of Macao, Macao Post and Telecommunications Bureau, Sports Bureau of Macao, Transport Bureau of Macao and MGTO are actively involved in the creation of smart applications and have launched a number of smart applications to enhance the tourism experience. However, there is a dearth of research on smart tourism in Macao, with most of the research related to smart tourism focusing on eWOM, destination image and usefulness of hotel websites. At present, there is no research to provide theoretical guidance for the research of smart tourism in Macao. And there has been no in-depth study of the current development status of smart tourism in Macao or the perceptions of tourists toward smart applications that have been applied. This phenomenon has resulted in a lack of theoretical guidance for the development of smart tourism in Macao, which has been fragmented despite strong government support, and the effectiveness of specific smart applications to help tourists is unknown. Therefore, the research on smart tourism in Macao should focus on the relevant smart applications launched by the

government and assist government policies to integrate smart services to provide effective services to tourists.

Currently, multiple smart applications are widely promoted in the Macao tourism industry. This shows the contributions and efforts of government and enterprises to enhance the competitive strength of Macao as a tourism destination. MGTO put forward a proposal for the development of smart tourism destinations in 2015, and it has since committed to the extensive development of smart applications. These include multiple mobile applications to assist tourists before and during their trip; VR/AR/QR code apps to improve travel experiences at Macao heritage and cultural sites; a tourism data exchange platform; unlocking big data platforms for translation into smart tourism services such as data sharing and monitoring tourist flow; providing smart infrastructures such as intelligent transportation systems; and launching free Wi-Fi zones in multiple public areas.

Nevertheless, this does not mean that Macao is a successful smart tourism destination. Achieving smartness is not just simply using technologies to assist tourists in traveling. More importantly, smart technologies can be used to maintain sustainable development and display the uniqueness of a destination (Pai et al., 2020). However, Macao's smart applications strive to integrate ICTs with physical infrastructure and penetrate the utility of these applications into different aspects of tourism. In fact, according to Gretzel, Ham, and Koo (2018)'s five layers of descriptions to illustrate smart tourism applications, these smart applications are applied to the first three layers: the physical layer, applied to natural and human-made touristic resources as well as transportation and service infrastructures; the smart technology layer that links to this physical infrastructure and provides back-end business solutions and front-end consumer applications; and the data later, where Macao's has limited applications such as its open data platform. Thus far, Macao has not implemented applications in the business layer, which innovates based on available technologies and corresponding data sources, or the experience layer, which consumes generated technologies and enhances the experience of data. Most of the smart services in Macao rely on users to obtain information spontaneously and do not achieve real interaction or service demand.

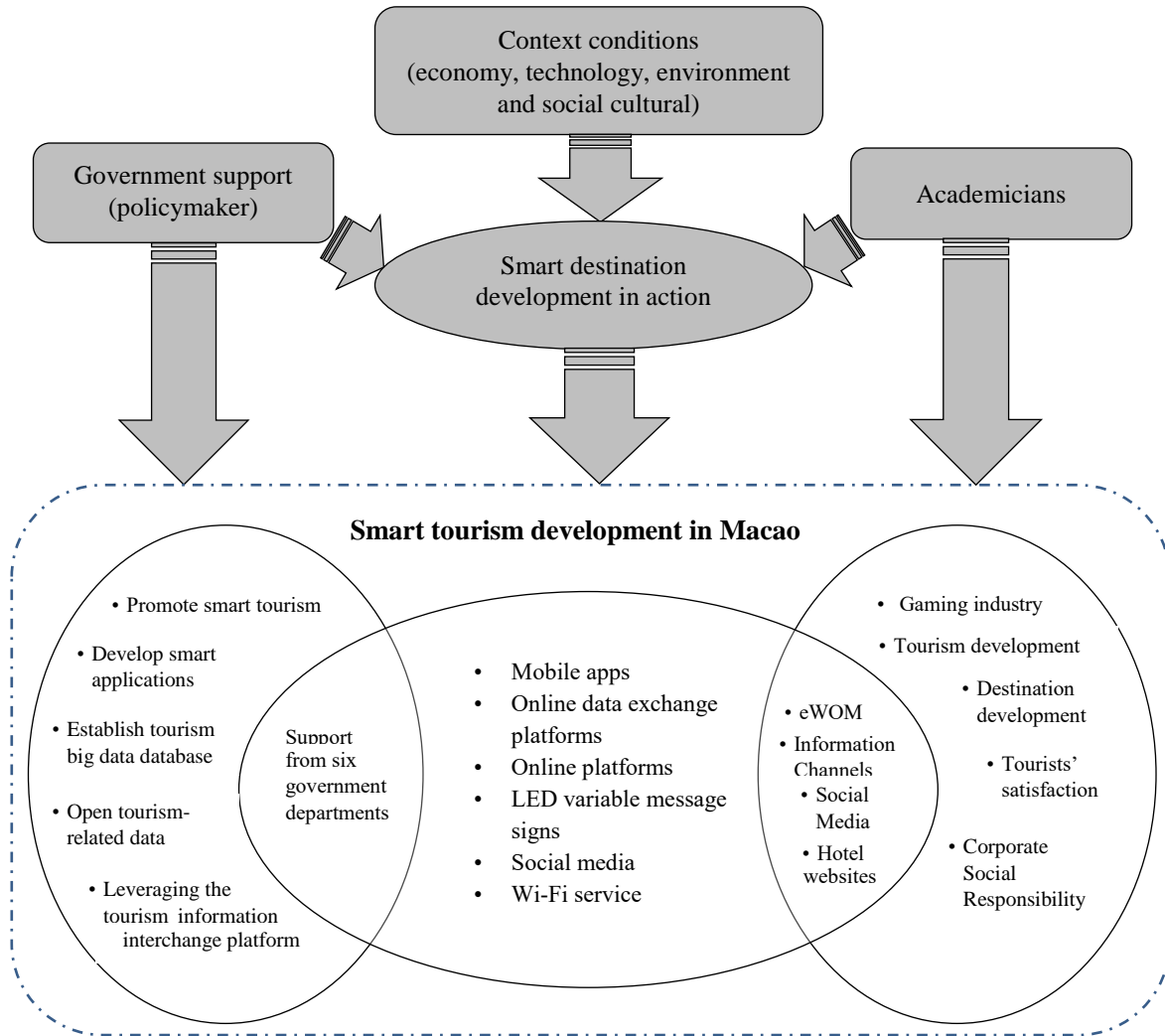


Fig. 3. Smart tourism development in Macao

In conclusion, the development of smart tourism in Macao is still in an early stage, and there is no systematic plan to provide a direction for the future development of Macao as a smart destination. Most smart apps rely heavily on smartphones as a medium and do not overcome the challenges that travelers encounter before, during, and after a trip. The development of smart tourism in Macau should focus on solving the problems of eWOM, protecting user privacy and value-added services in the post trip stage. Combining academic research with government planning to provide theoretical support for smart tourism development can further develop Macao's limited tourism resources and it can help demonstrate Macao's tourism characteristics beyond the gaming industry.

**7. Conclusion**

This study has achieved its research objectives and discussed the relationship between government policies, smart applications, and academic research on the development of smart tourism by analyzing current smart tourism development in Macao. The study found that the destination government is very active in the development of smart tourism, and many smart applications are widely used in different aspects in tourism. However, these applications are fragmented and common technologies, and they cannot improve the uniqueness of destinations. It is also crucial to conduct academic research to verify the effectiveness of these applications in tourism services. The development of smart tourism destinations is necessary to combine theoretical support

to analyze the characteristics of destinations and enlarge their advantages. Future smart tourism development should concentrate on the following key features: the digitization of systems, processes and services; establishing higher-level connections with tourists for communities, governments and other departments in the destination; providing local residents with a platform to participate in products/services; and creating a higher level of data generation to be used through integrated smart systems, thereby achieving better management of tourists' experience (Khan et al., 2017). There is no survey of people involved in smart tourism, including tourists and government officers, which is one of the limitations of the present research. Future research may consider using quantitative or qualitative research to conduct in-depth research on relevant populations.

**Declaration of competing interests**

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