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Airport mobile internet an innovation

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ABSTRACT

This paper studies the adoption of mobile Internet by airports. Using a new theoretical model, the study tests whether early adopters of mobile Internet for airports can be considered real innovators. Seventy-five international airports from four different geographical areas and of three different sizes are analyzed. The paper complements the analysis with an additional innovation adoption, the PC-Website, and two dimensions are analyzed: the time of adoption and the degree of maturation. Our findings show that there are four real innovator airports: London Heathrow, London Stansted, Amsterdam Schiphol and Copenhagen. Airport innovation is found to be related to geographical location and commercial revenue rather than to airport size. The four real innovator airports iPhone apps are used as case studies to identity best practices for the delivery of airport mobile services.

1. Introduction

Commercial airports are under increasing pressure from both, customer airlines and shareholders to keep prices competitive and remain profitable. Developing commercial revenues is one way for airports to please both. However, factors such as consumer trends, security developments and political changes, have made it much more challenging for airports to develop commercial revenue (Graham, 2009). To overcome some of these challenges, airports need to innovate by exploring new operating methods, one of which is the use of mobile Internet.

Mobile Internet was first used in Japan in the late 1990s and gained popularity in the search for travel information in the late 2000s (Okazaki and Hirose, 2009). The year 2009 saw some of the first airports adopting mobile Internet services. For instance, during 2009 Dallas Fort Worth airport in the USA introduced its first mobile website (DFW, 2009) and Aéroport de Paris in France its first iPhone App (Aéroport de Paris, 2009). Mobile Internet is redefining the new economy and the terms e-commerce or e-business offer new opportunities to increase revenues and reduce costs in many industrial and service sectors.

The adoption of mobile services by airports can be considered an innovation following the definition given by Orfila-Sintes et al. (2005): "... *the conversion of technological knowledge into new services*" (p. 852). These new mobile services or applications (apps) are not only communication tools that guide passengers from the check-in area to the gate, but are also nowadays used to customize the passenger experience while developing new commercial revenues (Munneke, 2014). Kaur (2013) goes even further defining this as a revolution where next generation mobile devices running next-generation mobile apps will become the major platform to conduct business in any firm or sector.

Until the introduction of the iPhone by Apple in 2007, the concept of smartphones and the communication possibilities associated with them did not exist. Since then, the number of smartphone users', as well as the new apps that have made accessing information on the Internet more convenient, have increased exponentially. Airports have benefited from this trend, and e-commerce and m-commerce (commercial transactions that can be made using internet and/or mobile devices) in particular, have become areas of future potential expansion. These apps allow airports to sell commercial services directly to customers, such as car parking, rental cars, foreign currency, food & beverage retail, access to executive lounges or any complementary ancillary activity offered at the airport (Halpern and Graham, 2013; Halpern and Regmi, 2013). Nevertheless, as Liébana-Cabanillas et al. (2014) claim, the potential success of these apps can be affected by the extent to which mobile payments are readily accepted. Despite these concerns, some services are clearly taking off. In SITA (2014a, 2014b), for example, it has been reported that 50% of airports surveyed offered flight status notifications and it is expected that this

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service will be a common practice in the industry by the year 2017. The availability of other services through mobile apps has still been relatively rare in comparison, but airports are planning to introduce other notification services such as queue time, and customized service initiatives that will include sophisticated retail notifications like rebates, personal shoppers, and other marketing campaigns. Mobile boarding passes are an increasing trend, and are expected to be common practice by the year 2017 (SITA, 2014b). This migration to mobile boarding passes represents an opportunity for airport managers to apply these technologies in the development of ancillary revenues.

The aim of this paper is fourfold: (1) to propose a theoretical model to analyze the adoption of mobile internet based on innovation adoption theory; (2) to develop a laboratory experiment to gather and analyze the data; (3) to analyze to what extent early adoption of mobile Internet is a clear sign of airport innovation and whether there is a positive relationship with commercial revenue generation; and (4) to identify best practices in the provision of airport apps.

2. The literature review

Airports need to innovate in order to develop new sophisticated instruments that generate more commercial revenue. Lin, Wu and Cheng (2015) highlight the importance of introducing new services to satisfy customers' needs and identify display technologies as a new and promising research field in service innovation. Their research uses online survey data from 545 consumers and concludes that display technology has a positive impact on customer loyalty.

The diffusion and adoption of innovation theory developed by Rogers (1995) states that: "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 259). The unit of adoption this paper utilizes is the airport – an organization of the service industry. (Buhalis and Law, (2008) classified the adoption of mobile Internet as a technological innovation and (Orfila-Sintes et al., 2005) defined technological innovation as *"the conversion of technological knowledge into new products, new services or new processes introduced in the market, as well as the significant technological changes in products, services and process"*. In this sense, mobile Internet use can be considered a technological innovation in many different areas such as electronic data interchange (EDI), e-information, e-transactions, e-commerce and e-business (Gillen and Lall, 2002). The authors distinguished between two types of innovations: marginal, in which they simply represent a new way of doing old things better; and real or true, in which they enable and facilitate new ways of doing things that in their absence would not happen.

On one hand, the knowhow airports possess of processing and guiding passengers through the airport terminal building, combined with the technological knowledge of mobile Internet gives airports the opportunity to provide a new service to passengers. Thus, airport mobile Internet can be considered as an innovation. On the other hand, as Halpern and Graham (2013) have claimed, the characteristics of airport services have important implications for airport marketing: (1) some service outcomes are determined by staff interaction so it is important to develop and maintain close scrutiny of demand; (2) it is important to reinforce brand identity and encourage loyalty especially for those airports that experience strong competition; (3) it is important to invest in quality control that improves the levels of service quality; and (4) it is important to innovate with the future needs of the demand in mind.

Huarng et al. (2015) include the term "high-tech" when referring to social networks, social media, and mobile and display technology, all of which can affect customer behavior. The use of High tech platforms can also boost innovation in tourism, services, branding and retail. Bao, Chen and Zhou (2012) indicate that organizations willing to learn technological knowledge contribute positively to the achievement of radical innovation, which is a key factor of knowledge-based competitive advantage (Wu et al., 2015). Within the research that examines the role of innovation as a source of competitive advantage in the airline industry, Lin (2015) studied the relationship between innovative brands and brand satisfaction in research carried out at Taiwan's largest Airport and concluded that there is a positive relationship between innovative airline brands and passenger brand satisfaction.

The theory of innovation is normally presented from two perspectives: Diffusion and adoption of innovation. The main difference is the level of analysis. Diffusion research mainly focuses on describing and explaining the adoption process as a process of innovation diffusion at the aggregate level (macro level). Adoption research typically studies an organization's decision to adopt a particular technology or service, at the individual level of analysis – or micro level (Pedersen and Ling, 2003). When studying the use of mobile Internet by airports, typical diffusion research would study the adoption pattern of this technology. The adoption theory, however, would study special characteristics of the airports that can be considered early adopters of mobile Internet.

"The rate of adoption of an innovation is the relative speed with which an innovation is adopted by members of a social system" (Rogers, 1995). In this case the social system is the airport. The rate of adoption is also defined as the speed with which the organization adopts innovation after the first introduction elsewhere. The rate of adoption is generally measured as the number of organizations who adopt a new idea in a specific period, for example a year (Rogers, 1995). This measure can also be used at a macro or micro level and it reflects the organization's responsiveness and its ability to adopt innovation quickly relative to its competitors within the industry (Damanpour and Gopalakrishnan, 1998) or to other sectors and industries within the economy. Some innovations are adopted much faster than others and the most important factor for this are the perceived attributes or characteristics of the innovation. Attributes can also be used to compare different innovations (Rogers, 1995: 177).

Tornatzky and Klein (1982) carried out a meta-analysis of articles concerned with innovation characteristics and their relationship with the innovation adoption and maturation. Three characteristics (*relative advantage, compatibility* and *complexity*) had the most consistent relationship to innovation adoption. Rogers (1995) found that between 49 and 87 percent of the variance in the rate of adoption is explained by five attributes that includes the three attributes mentioned above and two other additional attributes, *trialability* and *observability*. Okazaki (2006), points out that "… mobile Internet seems to satisfy the five attributes used by Roger" (p. 127).

A criticism of innovation diffusion research is that this is often only focused on the dichotomous adoption/non-adoption decision (Frambach and Schillewaert, 2002; Tornatzky and Klein, 1982). This suggests that there should be a focus on both adoption and maturation of the innovation. The degree of maturation is also called "reinvention" by Rogers (1995) because some innovations are not adopted in exactly the same form as originally conceived. Kozłowski (2015) also questions the innovation indices such as scoreboards and suggests that innovation research should maintain a methodological variety, instead of creating closed analytical tools.

An organization's decision to adopt and implement an innovation does not happen overnight. This process is part of the strategic plan of the firm and it usually consists of different stages: awareness of innovation, attitude formation, evaluation, decision to adopt, trial implementation and sustained implementation (F.

Damanpour and Gopalakrishnan, 1998). The characteristics of organizations that innovate has been widely studied among researchers F. Damanpour, 1991). Frambach and Schillewaert (2002) identified three main characteristics that affect the adoption of innovation by organizations: (1) size; (2) structure; and (3) innovativeness. Lee and Xia (2006) carried out a meta-analysis in order to find out the relationship between organization size and IT innovation adoption. The results were that organizational size has a positive effect on IT adoption. Regarding structure, the results are not as conclusive as they were for size as the adoption of innovations was too easily either facilitated or hampered by differences in structure. Some authors found a positive association between innovation adoption and structure (Aarons et al., 2010; Damanpour and Schneider, 2009; Frambach and Schillewaert, 2002), while according to other studies, this relationship can also be negative (Greenhalgh et al., 2004; Solomons and Spross, 2011).

Geographical location is another characteristic that can influence innovation adoption patterns. Kumar et al. (1998) highlight that some innovations have similar diffusion patterns because of geographical proximity and cultural or economic similarities. Kim et al. (2004) investigated cross-national differences of mobile internet usage and found that customers' preferences for various services from mobile internet businesses differed according to nationality.

Business models are usually analyzed focusing on the manner in which firms deliver value to customers and generate revenues from customers' willingness to pay. They thus reflect how managers perceive what customers want and how they want it, and decide how the firm can establish all the processes necessary to best meet those needs. This is particularly important in the provision of new products and services associated with the new e-economy in which revenue generation is usually highly constrained because customers expect that these new e-services should be free. In any case, managers need to carefully analyze not only which innovation should be adopted but also which immediate effects can be expected from the adoption. It is clear that costumers can need time to adopt the new internet mobile service, but what is more difficult to ascertain is an adequate pricing system for the new service that can be acceptable to the customer base. Consequently, the adoption of the innovation and the setting of a workable pricing system require not only an understanding of the potential alternatives, but also a good analysis of the costs, customers' willingness to pay and competitors' strategies, (Teece, 2010).

3. The theoretical model

This model aims to establish whether airports which adopt mobile Internet early can be considered real innovators. It was defined following a review of the concepts of innovation theory, which consider not only the moment when the innovation was adopted, but also its degree of maturation. Hypotheses are subsequently posited to explain the characteristics of innovator airports.

Rogers (1995) has noticed that innovation adoption follows a bell-shaped curve when the adoption by all organizations are plotted over time on a frequency basis. Mobile Internet adoption cannot be tested for normality as not all airports have adopted this new service. Thus, following the suggestion of Tornatzky and Klein (1982) to study more than one innovation in order to achieve more reliable data, this model includes a second innovation.

The adoption of PC-Websites by airports was taken as the second fully adopted innovation Table 1 compares the two innovations using Roger's (1995) five attributes. The PC-Website service provided by airports was compared to their telephone information services and the provision of mobile Internet service was compared to the services at the terminal building to guide passengers through the airport.

The comparison of the five attributes in Table 1 suggests that the two innovations have considerable similarities. As a result it is deemed appropriate to incorporate the provision of a PC-Website service by airports into the theoretical model in order to define categories of innovativeness.

The model now includes PC-website adoption (fully adopted) and airport mobile Internet adoption (not yet fully adopted by all airports). Both innovations are assumed to follow a bell-shaped curve of adoption (Rogers, 1995).

The adoption of mobile internet is defined as the point in time when an airport starts to provide mobile Internet services. However, the service will evolve over time and change since the service was first adopted. For instance, Amsterdam's Schiphol airport adopted its iPhone application in March 2011 and in April 2011 released a new version in English in which new functionalities were included such as the possibility of booking car parking directly from the app (Apple.com, 2012). Therefore, to measure the innovation of airports by looking only at the time when the mobile Internet was first implemented was found to be insufficient (Frambach and Schillewaert, 2002; Tornatzky and Klein, 1982. The degree of maturation of the innovation enriches the data reliability and is therefore also included in the model.

The model aggregates the first three Rogers (1995) categories of innovator, early adopter, and early majority into one, namely *early adopters*, and the last two categories: later majority and laggards into *late adopters* (Rogers, 1995). The degree of maturation axis has another two levels: *Low Degree of Maturation* – scores from 0 to 0.49 – and *High Degree of Maturation* – scores from 0 to 0.49 (see Fig. 1).

Taking these two dimensions into account, "Innovator" is defined as an airport which adopts the innovation early and has a high degree of maturation at the time of analysis. Fig. 1 shows the area where airports considered innovators will appear when plotting time of adoption and degree of maturation.

Real innovators are defined as those airports which fell into the innovator category in the two innovations under study (PC-website and mobile Internet). It will then be possible to analyze some of their characteristics or attributes in order to distinguish associations between these variables and innovation, namely size, geographical location, and commercial revenues.

4. Data

The data used for this research can be divided into three parts: (1) airports' general data, (2) airports' PC-website data; and (3) airports' mobile Internet data. Primary data (2) & (3) was gathered from a laboratory during January and February 2012.

4.1. General data of airports

An airport database with the 145 busiest airports was obtained from the Airports Council International (ACI, 2009), in which the total number of passengers in 2009, International passengers, the geographical location of each airport, and the size of the airport were included.

The total revenue and commercial revenue during 2008 was gathered from different sources (Airport annual reports, FAA, ICAO and ACI). Revenue data was found for 100 airports out of the 145 airports originally selected.

ACI classifies the airports by size as shown in Table 2. The target airports included commercial airports of more than 8 million passengers in 2009 (i.e., "M", "L" and "XL" airports). It was assumed that the provision of information to passengers while passing through the airport terminal was more relevant for larger than for

Table 1
Airport mobile internet and PC-internet innovation.

	Airport PC-website	Airport mobile internet
	Vs. providing telephone services	*Vs. providing airport terminal information panels*
Relative advantage	Similar services were provided 24 h a day at a lower cost	Information can be personalized (e.g. gate number)
Compatibility	With airport telephone services	With airport terminal panels
Complexity	Limited as most information and services were already provided	Limited as most information and services were already provided
Trialability	needs to be provided with a new platform (PC website)	needs to be provided with a new platform (mobile web or mobile application)
Observability	is easy to see other airports' adoption	is easy to see other airports' adoption

Source: Derived from Roger's (1995).

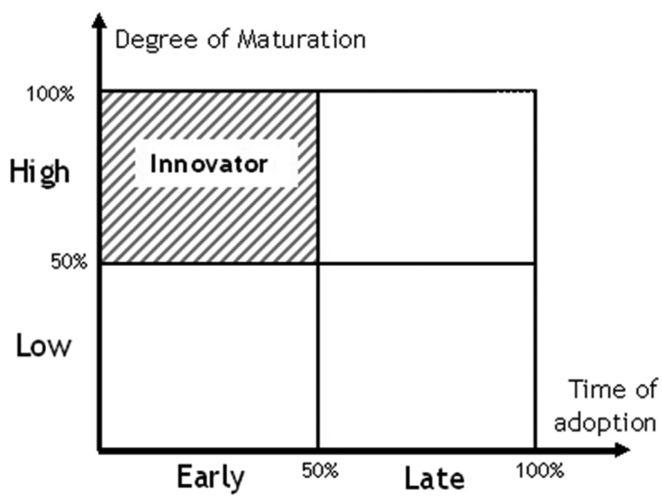

Fig. 1. Innovator area.

Table 2
Airport categorization by size.

Airport group	Passengers a year [million]	Label
1	>25	XL
2	10–25	L
3	5–10	M
4	<5	S

Source: Derived from airport association ACI.

smaller airports as walking distances tend to be longer.

ACI also categorizes airports by geographical location according to the following regions: North America, Latin America-Caribe, Europe, Middle East, Africa and Asia Pacific. In addition, larger airports tend to have a greater number of international airlines and international passengers who will demand similar services across the world.

From the original database, a final list of 75 airports was included in the analysis. Including airports from: North America (32), Latin America and Caribe (1), Europe (30), and Asia Pacific (12). In principle, our idea was to include as many airports as possible it was evident that some airports would be eliminated from the sample due to a lack of data.

4.2. Airports PC-Website data

For each of the airports analyzed, the PC-website data included the following variables: (1) The Internet address (URL); (2) The time when the first website was launched; and (3) the degree of maturation of those websites at the time this research was carried out.

The data source for obtaining airports' Internet addresses (URL) was the search engine Google. Time of adoption was measured as the time airports reserved their website domains (e.g., 23 August 1998 for bcia.com.cn - Beijing Capital International Airport). The date when each airport reserved its domain and the date when the first webpage was launched were not expected to be far apart. This difference was tested with four airports in Japan where data was available. The longest interval observed was 5 months for KIX (Kansai airport) which launched its PC-Website in 1997 and the shortest 3 days for ITM (Fukuoka airport) launched in 1999. Thus, taking the date when the domain was reserved as the date of adoption of the website appears permissible, and to carry little risk of distorting bias.

The registration date for each airport's website domain was searched using the sources indicated in Table 3. The methodology used was to first look for each domain's registration date and the Email address of the contact person. If the domain holding the email was different from the airport domain first checked, it was tested as an alternative way to reach the airport's website. In the cases where there was an alternative domain to access the airport's website, the registry data was also searched for this second domain and the domain with earlier registry date was taken as the date of adoption.

Some top level domains, for example ".de" from Germany, ".au" from Australia or ".gov" from the US, did not provide the registration date. In those cases, an alternative domain was searched. For instance, for Sydney's airport domain (syd.co.au), the alternative domain sydneyairport.com was used. However, this option was not always available as in the case of Düsseldorf airport (duesseldorf-international.de). For this reason, as mentioned above, due to the lack of domain registration date availability, some airports were discarded.

PC-Website adoption started in 1995 with 14 airports, reaching the peak of adoption during 1998 with 16 airports and completed in 2002 with the last 3 airports.

The degree of maturation, also called re-invention, occurred as the innovation was modified by users to fit their particular conditions (Rogers, 1995, p. 304). This research aimed to assess airport innovation as a way to analyze how commercial airports are introducing this innovation to develop more commercial revenues. For this reason a checklist of all the commercial areas included on the website was considered to measure the degree of maturation of the airport PC-websites.

Commercial revenue represented 48.1% of an airport's total revenue during 2006 and the most important items were: Retail, Parking, Car rental, Property and Advertising (Graham, 2009). Some of those services were also offered on some airports' websites. In addition, other ancillary services such as airline tickets and hotels were also available on some airports' websites. When allocating the weight to each group of variables considered in the lab exercise, greater weight (75%) was placed on the main commercial items mentioned above (shopping, parking and car rental), and less (25%) on the other online services (transport, flights, hotels and others). For each subgroup, the same weight was allocated to each variable

Table 3
Network information centers (NIC) for domains.

URL	Domains	Notes
www.who.is	.com, .uk, .cn, .kr	
www.whois.ausregistry.com.au	.au	Register date – Not available
www.dns.be	.be	
www.nic.ch	.ch	Register date – Not available
www.denic.de	.de	Register date – Not available
www.nic.es	.es	
www.nic.gr	.gr	
www.domainregistry.ie	.ie	Register date – Not available
www.nic.it	.it	
whois.jprs.jp	.jp	
www.govcert.nl	.nl	Register date – Not available
www.dot.ph	.ph	Register date – Not available
www.nic.ru	.ru	

Source: Authors' own creation.

Table 4
Airport PC-website degree of maturation. Variables and weights.

Online booking	Weight	Definition
Shopping	0.25	Book and collect or book and delivery
Parking	0.25	Book parking
Car rental	0.25	Book car rental or link to their website
Other	0.25	Avg. of the following four variables
Trans to/from		Book taxi, train or bus
Flights		Book flights
Hotel		Book hotel or link to hotel website
Other		Book currency, VIP lounges, etc.

(i.e. 0.75/3 and 0.25/4) – (see Table 4). It is evident that this is also an important limitation and a further refinement for these particular weights could be foreseen by contacting airport managers. Thus, individual weights could be obtained for each airport according to the percentage of revenues over the total revenues obtained by the innovation. This is a promising area of future research because as can be seen in (SITA, 2014b), 44 percent of the airports confirmed that the new revenue generation accrued by the innovation fell below expectations.

Each airport website was assessed in order to find out which online services were available. By applying the weight for each variable included in the analysis, the degree of maturation was calculated. The total number of airports included in the sample was 75.[1]

4.3. Airport mobile internet data

The provision of mobile Internet services by airports analyzed in this paper included two mobile type of platforms: (1) Mobile Websites which are websites designed for small screens (Léopold, 2009: 217); and (2) Mobile Applications which is a special software designed for a specific mobile operating system. Mobile websites were accessed using a web browser; however, mobile applications first have to be installed in the mobile device before they can be used to access the online information. Only applications from iOS (Apple) and Android (Google) were analyzed as together they represent a worldwide penetration of almost 40% (Statcounter.com, 2011).

The source used to identify airports providing mobile websites were their own websites. The source for iPhone applications was the iPhone Application Store (Apple.com, 2012), and the source for Android applications was the Android Market – later called Google Play (Android.com, 2012). Each airport website was accessed with an iPhone via its Safari web browser in order to find the airports that provided a mobile website. Airport websites were also accessed with a laptop using the Firefox web browser. To our surprise, out of the 75 airports, only 22 airports (29.3%) were found to provide a mobile website.

The methodology followed to obtain mobile applications was similar to the one used to look for Website URLs. Out of the 75 airports, 17 airports were found to provide an iPhone application and 13 to provide an Android application.

The overall number of airports providing mobile Internet, either by one or more mobile platforms was 32 (42.7%). It is expected that sometime in the future all the 75 airports analyzed will adopt mobile Internet. In fact it is still surprising that by far the most common mobile service available, flight status notifications, was offered by only 50% of airports since this will become a basic service in the industry by 2017. The availability of other services through mobile apps was relatively low in comparison, but over the next three years more than half of all airports are planning to introduce other mobile services, such as queue times, and more personalized information, such as opt-in services and customer service initiatives, as well as retail services (SITA, 2014b).

The sources for data on the time of implementation of airport mobile Internet were airports' press releases available on their websites.

Airports have just started to adopt mobile Internet, so the prevalence of easy access for passengers willing to use the service was considered important at this early stage. Accessibility has been a common variable used to assess Internet websites, also labeled as easy to use (Park and Gretzel, 2007). In this particular case, accessibility was measured on how easy it was to access airport mobile services.

The methodology followed to calculate the degree of maturation was first to look at whether the airports under analysis were

[1] The complete detailed data for each website evaluation can be directly obtained from the authors.

providing each of the three platforms (mobile website, iPhone application and Android application). Mobile Website was used because it can be accessed from any mobile device with a web browser. iPhone iOS and Android operating systems were chosen as they had a world penetration of 22.09% and 17.63% respectively (Statcounter.com, 2011). The definition and weight of each variable to calculate the degree of maturation of airport mobile Internet can be found in Table 5.

Mobile websites can be accessed by any mobile device with a web browser, including iPhone and Android devices. Thus, this variable was weighted with 0.5. However, the accessibility differs depending on the features included. For instance, a link between the PC-Website and the mobile website facilitated the access (Budiu and Nielsen, 2009).

The variable of mobile website was calculated by evaluating four variables defined in Table 5. The largest weight was given to the provision of a mobile website (0.35) and the other three variables (Auto load, Switch to PC and Switch to Mobile) helped to differentiate the accessibility of those mobile websites and each was weighted with 0.05.

The iPhone and Android operating systems (OS) together represented almost 40% of worldwide penetration. These two OS together had 430,000 applications at the end of 2010, compared with 43,000 observed for their nearest competitors, Blackberry and Nokia (Distimo.com, 2011). Thus it was assumed that these mobile devices would be used more than others and were weighted with 0.5 (i.e. above their worldwide penetration rate of 40%). The world penetration of iPhone and Android was used to allocate the weights (i.e. 0.28 vs. 0.22).

The equipment used for the research was a laptop, Internet access with a WiFi router and a Smartphone (iPhone 3.0) with Wi-Fi access.

5. Analysis and results

This section consists of three parts: (1) Normality on the adoption of PC-Websites; (2) Characteristics of Innovator Airports; and (3) Best practice on airport Apps using case studies.

5.1. Normality on the adoption of PC-Websites

We first analyze whether the PC-website innovation followed a normal distribution. The adoption of PC-website observed and the estimated bell-shaped form is represented in Fig. 2. In addition, the Chi-Square goodness-of-fit test is calculated. The result doesn't show significant differences to the normal distribution, thus the hypothesis of normality is supported.

Fig. 2 shows that the left portion of the figure presents the most significant deviations with respect to the normal distribution, but still the fit was adequate. There are at least two reasons that can partially explain the observed deviation: First, the different time delays in activating the websites; and second, the fact that PC-website adoption happened simultaneously for different industries and sectors.

Table 5
Airport mobile internet degree of maturation variables.

Variables	Weight	Definition
Mobile site	0.35	Airport providing dedicated mobile site
Auto load	0.05	Automatically loaded when accessing URL
Switch to PC-website	0.05	Mobile website link to PC-Website
Switch to mobile	0.05	PC-Website link to Mobile website
iPhone application	0.28	iPhone application provided by airport
Android application	0.22	Android application provided by airport
Total	1	

Source: Authors' own elaboration

5.2. Real innovator airports

One of the objectives of the research was to find out if early adopter of mobile Internet airports could be considered innovators. The scatter plots in Fig. 3 show the innovator airports, for both innovations under analysis. The PC-Website adoption (left chart) includes 15 airports (20.0%) and mobile Internet adoption includes 10 airports (13.3%). These percentages are in line with those obtained by Rogers (1995) when combining innovators and early adopters – 16%.

The model used the term "real innovator" for those airports which were found to be innovators in both innovations under study. Four airports (Amsterdam Schiphol - AMS, Copenhagen – CPH, London Heathrow – LHR and London Stansted – STN) fell under the category of real innovators and represented 5.3% of the total number of airports analyzed. These results are again not far from the percentage obtained by Rogers (1995) - 2.5%.

The results showed that, surprisingly, these two innovations, which should apparently be related, were introduced by airports very differently. It can be seen that only four airports, considered the real innovators, appear in both sets of Fig. 3, while the other 17 airports have preferred to focus the innovation on one process only, either PC-website or mobile internet. It is important to note that results could be affected by the fact that the degree of maturation has also been taken into account. In a less formal analysis, considering only time adoption and a binary variable to indicate whether the airport has adopted the innovation or not, the results could be different.

5.3. Characteristics of innovator airports

It seems that size and geographical area might influence the time of adoption or the degree of maturation achieved by the PC-Website innovation. For this reason, one-way analysis of variance was used to examine whether there are significant differences that can be ascribed to these particular factors. Table 6 shows the standard Anova table, which divides the variability of the PC-Website innovation into two parts: variability due to the differences of the mean among the factor groups (variability between groups); and variability due to the differences between the individual airport observation in each group and the group mean (variability within groups).

The results of the Anova show that the null hypothesis, i.e., the average PC-Website innovation adoption by the airports is equal, independently of the size of the airport and the geographical area location. The p-value, shown in the sixth column, casts doubt on the null hypothesis and suggests that the size does not have any effect on this type of innovation but depends to some extent on the geographical area. For more precise information we use a multiple comparison procedure, for which we choose the Tukey-Kramer test in order to determine the representative groups that are significantly different according to geographical location and each of the innovation variables under study (i.e. adoption times and the degree of maturation).

The mapping of every group to one other would mean to form six different pairwise comparisons to obtain their mean differences dependent upon their geographical area. Differences with a 95% confidence interval were obtained, but for the ease of the exposition only the main observed differences are discussed. Regarding the adoption time North-American airports are more earlier adopters than East-Asian Pacific airports. With respect to the

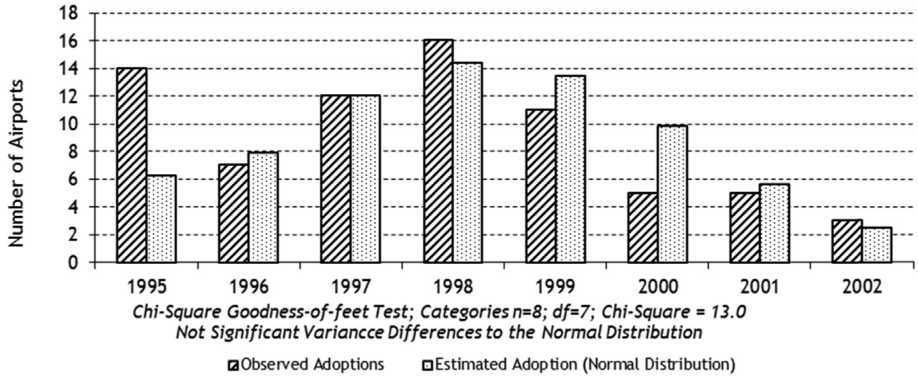

Fig. 2. Adoption of airport PC-internet: Observed vs. normal distribution.

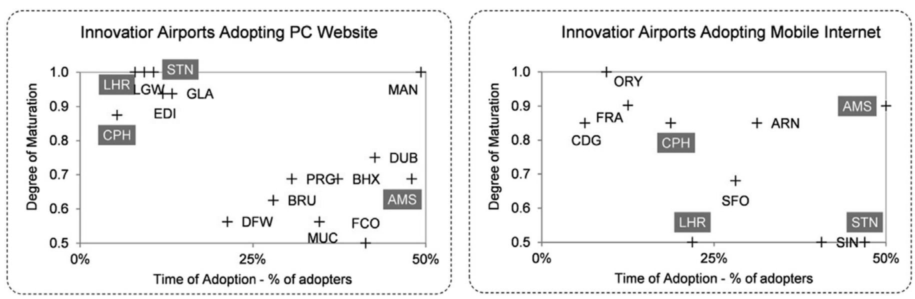

Fig. 3. Innovator airports: Adoption and degree of maturation.

degree of maturation, the results were even clearer showing that European airports develop more sophisticated PC-Websites than the rest of the airports since the three comparisons with the rest of the geographical regions presented a marked difference.

Table 6
One-way analysis of variance. PC-website innovation.

Days	Df	SumSq	MeanSq	Fvalue	Pr(>F)
Size	2d	1,107,175	553,588	0.82	0.444
Residuals	72	48,580,322	674,727		
Geographical area	3	4,264,728	14,221,576	2.222	0.093.
Residuals	71	45,422,769	639,757		
Grand mean: 1139.33					
Degree of maturation					
Size	2	0.04	0.01979	0.261	0.77
Residuals	72	5.456	0.075		
Geographical area	3	1.52	0.50	9.08	3.6 E-05***
Residuals	71	3.97	0.05		
Grand mean: 0.3775					

	Size factor means		
	M	L	XL
Days	1048 (13)	1301 (27)	1048 (35)
Degree of maturation	0.40 (13)	0.39 (27)	0.35 (35)

Geographical area factor means

	East Asia & Pacific	Europe	Latin America & Caribbean	North America
Days	1609 (12)	1090 (30)	2011 (1)	982 (32)
Degree of maturation	0.31 (12)	0.54 (30)	0 (1)	0.25 (32)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.
(*) The number of airports appears between the parentheses for each of the factor means.
Source: Own elaboration.

These results are consistent with the left portion of Fig. 3, as it can be seen that most of the airports included in this figure are located in Europe except Dallas/Fort Worth International airport (DFW) in North America. The four airports (London Heathrow, London Stansted, Amsterdam Schiphol and Copenhagen), identified as real innovators, were all in Europe and were located within a triangle with the longest distance of 981 Km. Thus, we can conclude that the geographical location of airports is a characteristic that helps to explain innovation.

To end the analysis, a classification and regression tree CART model is used to obtain some insights into the importance and the effects of the PC-website innovation on the generation of commercial revenues. CART analysis is an appropriate methodology for analyzing whether the unitary commercial revenues per passenger is affected by the innovation measured by the two dimensions analyzed in the research, the time of adoption and the degree of maturation.

CARTs have a number of benefits compared to other widely used parametric models. The main advantage of the CART model is that plots show the basic information of the analysis in a very intuitive way. Fig. 4 represents the results in a sort of framework of "If-then" rules. Moreover, the CART analysis allows the researchers to use a large set of explanatory variables to be processed. The most important variables are easy to find because are included in the final structure of the tree. In this case, variables of different nature were used, some of which were continuous, such as the percentage of international passengers, the degree of maturation of the PC-Website innovation, and the time of adoption, and others were categorical or factor variables, like the size and the geographical area of the airports.

Another advantage of the CART analysis is that it does not need to specify a functional form or any other assumption about the

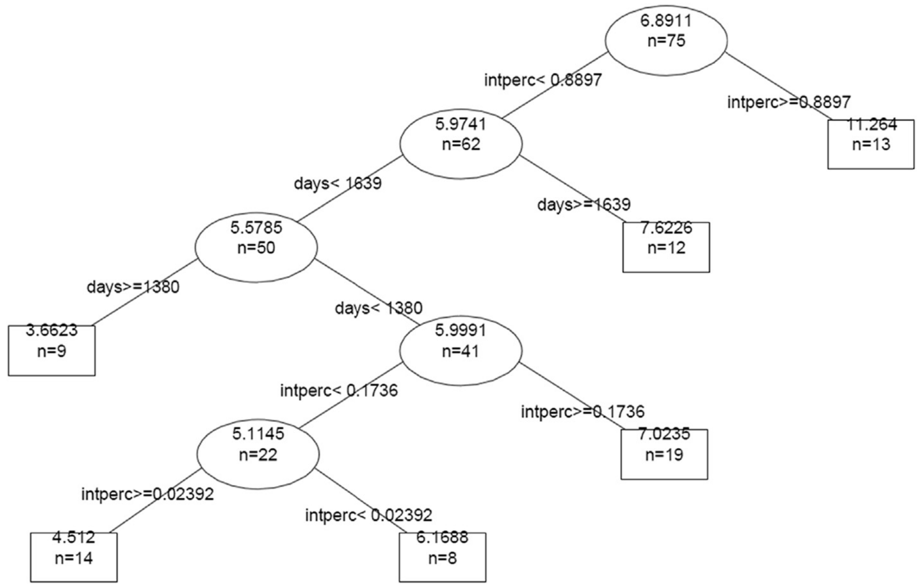

Fig. 4. Unitary revenues per passenger. CART Plot.

variables included in the analysis. In other econometric models results can be biased if the model is erroneously specified or any assumption about the variables included, or the error terms are violated, as for example error invariance or multicollinearity problems.

Fig. 4 shows that the unitary revenue per passenger depends very much on the type of traffic that the airport services. As a general observation, it can be seen that there are only two variables out of the five that affect the unitary commercial revenues, namely the percentage of international passengers and the time of adoption of the innovation. The other variables were not included in the final model. In particular, it can be seen that there seems to be a positive trend between the percentage of international passengers and the unitary commercial revenues. It can be seen that the tree represents an increase of unitary revenues from left to right, and that in the majority of cases international participation is also ordered in the expected manner except in the lower part of the tree. In fact, this part is affected by those airports that have been more innovative as can be seen in the node containing 50 airports with average unitary revenue per passenger of 5.5785, from which it is clear that the innovation increases the unitary revenues per passenger. In this case, the airports should include the PC-Website before 1380 days. However, the results are not so conclusive in the upper part of the branches in which another threshold figure is observed at 1639 days. There were 12 airports that present more unitary revenues despite postponing the innovation adoption. Of course CART was obtained with the observed units and it is very difficult to conjecture what would have happened in these airports had they been more innovative as another tree would have been obtained. For our purpose, this model is very appealing as only the identification of important effects is needed, and other techniques could be used in the future to obtain more casual modelling.

5.4. *Best practice for airport apps using case studies*

The iPhone apps of the four airports identified as real innovators were taken as case studies to explore best practices for airports providing Internet mobile services. This analysis was carried out during April 2016 and three of the success factors identified by Park and Gretzel (2007) on destination marketing research (easy use, information quality and advertising/persuasion) were adapted to the airport environment. The variables assessed on airport Apps were extracted from the 34 attributes used by the Airport Council International (ACI) when measuring airport service quality – ASQ – (ACI, 2009).

5.4.1. *Easy access*

It is recommended that unlimited free WiFi access is provided to passengers. Although many local passengers will travel with Internet access through their mobile providers (e.g. 3G or 4G), free WiFi becomes very relevant for international passengers. This service was provided by all four airports analyzed; only Stansted provided a limited time of 60 min, which is not recommended as this is a way to “double” penalize passengers who are experiencing delays.

New passengers to one specific airport might access the airport website through their mobile browser. In these cases it is recommended that websites are mobile responsive, so airport websites are adapted to the mobile screens. This feature was provided by all four airports.

Passengers accessing airport websites with their browser might be interested in downloading the App when available. Thus airports should make it easy to download the mobile Apps. From the airports analyzed three (LHR, AMS and CPH) provided easy access in downloading Apps.

5.4.2. *Information quality*

Information quality was measured by looking at the 15 information variables identified that help departing passengers (see Table 7). Six of the information variables evaluated were provided by all four airports' mobile services: *Airline name, flight number, destination, date of departure, Scheduled time of departure and flight status*. The information provided by all four is recommended to be made available to departing passengers.

Four variables were provided by three airports: *Estimated time of departure, notifications of flight status, terminal number/area and gate number*. STN did not provide these four variables. The lack of terminal number/area information might be because STN is a

Table 7
Airport apps case study evaluation.

			LHR	AMS	CPH	STN
Easy access						
1	WiFi	Free WiFi	1	1	1	1*
2	Mobi	Auto mobile website	1	1	1	1
3	App	Apps easy access	1	1	1	0
Quality of information						
4	Airline	Airline name	1	1	1	1
5	Flight	Flight number	1	1	1	1
6	Web	Link to airline's website	1	1	0	0
7	Destination	Destination name	1	1	1	1
8	Date	Date of departure of the flight	1	1	1	1
9	Scheduled	Time departure schedule time	1	1	1	1
10	Departure	Time departure estimated time	1	1	1	0
11	Flight status	Status of the flight	1	1	1	1
12	Status update	Status of the flight notifications	1	1	1	0
13	Terminal	Terminal number and/or area	1	1	1	0
14	Map	Maps of the terminal	1	1	0	0
15	Check-in	Check-in desk numbers/area	0	1	1	0
16	Queuing	Avg waiting time at the security point	0	0	1	0
17	Distance	Walking distance	0	1	0	0
18	Gate	Gate number to board the flight	1	1	1	0
Dining and Shopping						
19	Dining	Dining info while departure info	1	1	0	0
20	Shopping	Shopping info while departure info	1	1	1*	0
			85%	95%	75%	35%

* Limited to 60 min.
Source: Authors own creation

smaller airport. However, it is recommended that this be included on the mobile services, together with the other three variables, which are considered a very relevant piece of information for departing passengers.

Three variables were provided by two airports: *Airline web link, terminal maps and check-in desk numbers/area*. The airline's web link and check-in information are basic services that can save passengers time. One good practice in this case is AMS which provides general info about the airline (including web link, telephone, social media, etc.) as well as check-in information, including the link to the airlines' mobile website. Maps are also information that can help passengers to navigate the terminal and again AMS follows a good approach, keeping information simple for the user. STN for instance provides map info, but not at the same time as the departure information, which makes the information search more difficult. Thus map information should be available while passengers look for flight departure information.

Two variables were provided by only one airport: *Average waiting time at the security point and walking distances*. These two variables can help the passenger to better plan the route to the gate and the time needed to get there.

5.4.3. *Dining and shopping*

A passenger on their way to the gate can be interested in eating and shopping. Thus, in this evaluation dining and shopping information was evaluated for passengers checking flight departure information. AMS specially provide a good practice as the commercial information is dynamic and it is only shown to the passenger while there is time available before boarding the aircraft. In the case of CPH shopping info is provided but only in the local language.

After completing this evaluation, Fig. 5 shows that the AMS App included the largest number of the variables evaluated (i.e. 95%), followed by LHR and CPH. The Amsterdam Schiphol App, in addition to providing the most evaluated information, often providing a very good praxis on the way information should be presented.

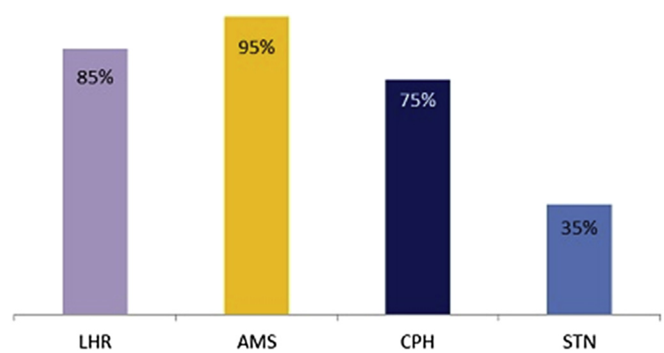

Fig. 5. Percentage of variables evaluated included in App.

6. Conclusions and final remarks

The analysis of airports regarding the early adoption of mobile Internet is still in its infancy, and at the time of the experimental lab of this research, the degree of penetration of this innovation was still very limited. However, as Information, Telecommunications and Technology budgets at airports are increasing annually, and the appearance of new technology such as geo-location, near field communication, ibeacons and others improves, this field needs to be studied and analyzed as in the near future mobile apps will be considered basic services. Airports are still at the very early stages of leveraging all the potential uses of websites and mobile devices. As Gillen and Lall (2002) advise, the first initiative airports can take is to improve their websites.

In this research, we first provided a theoretical model to establish the framework used to analyze what defined airports that can be considered real innovators. In our case, this was based on two complementary innovations, the PC-Website and mobile internet. These two innovations were analyzed through two different dimensions: the adoption time and the degree of maturation.

The database was compiled through the application of an experimental lab that not only took into account the date at which the innovation was launched but also the degree of maturation with the help of the characteristics of both the PC-Website and mobile internet. Following the assumptions included in the experimental lab regarding the selection of proper weights and a prior list of the 145 busiest airports in terms of passengers, the final database consisted of 75 international airports covering, albeit unevenly, four geographical areas and three different size types. The main reasons for dropping airports from the sample were the lack of revenue data and/or dates for when the airport PC website or mobile Internet services were launched.

Real innovators were defined according to the eight quadrants analyzed using both innovation processes and the four quadrants created with the help of the performance data for each of the dimensions. Finally, we showed the existence of four airports that were considered real innovators: Amsterdam Schiphol (AMS), Copenhagen (CPH), London Heathrow (LHR) and London Stansted (STN).

Analyzing the pattern of the distribution of the adoption time for the PC-Website innovation, it was shown that the pattern of innovation adoption follows a bell-shaped curve or a normal distribution.

Three airports' were analyzed according to the characteristics of size, geographic area, and the unitary commercial revenue per passenger. For the first two characteristics, models based on Anova were applied and the conclusion was drawn that geographical area rather than size appeared to explain innovation, European airports were found to have developed their PC websites and mobile Internet services more than the rest of the airports. The third characteristic, the unitary commercial revenue per passenger, is affected by the timing of the adoption of the innovation.

The iPhone Apps of the four airports identified as real innovators were evaluated in detail in order to come up with best practices for usage of airport apps. A detailed list can be found in the results section. The Amsterdam Schiphol was identified as following the best practices.

There are at least two limitations to this research. First, the sample only includes very busy airports (i.e. medium, large and very large airports). Mobile Internet seems to be more relevant for larger airports, but the inclusion of smaller airports will better test if the size of airports can explain airport innovativeness. Second, it was only possible to analyze three airport characteristics (size, geographical region, and unitary commercial revenue per passenger) in order to explain innovation. There are other potential variables that can be analyzed in the future with the intention of getting more thoughtful insights, for example airport networks, importance of low-cost carriers (LCCs), percentage of IT&T budget over total, marketing staff, and R + D staff. Airport competitiveness in particular can be highly affected when vertically differentiated products are simultaneously offered through the Internet, an additional commercial product, for example, such as car parking, car rental, hotel reservation, F&B, or money exchange (Bracaglia, Alfonso and Nastasi, 2014).

Finally, another interesting topic for future research is the analysis of airport' innovation as a complement of other agents involved in tourism and travel, especially for those destinations that depend very much on air transport, for example airports on islands. Some guidelines could be obtained from researching the synergies discerned between the travel and tourism industry and social media, especially Facebook and Twitter. Reservations and payments for restaurants and other attractions is a topic that deserves attention in the case of airports with a large percentage of passengers travelling for tourism. Airports make little use of Facebook and other currently popular information sharing platforms to communicate marketing campaigns to passengers, and the number of relevant posts is still very low, but according to Wattanacharoensil and Schuckert (2015), more attention should be given to this aspect of airport communication. This issue therefore could also be used to analyze a third innovation process.

Although there are bound to be technological changes that will add potential innovations relevant to this mode of investigation, the authors are confident that those covered in this paper provide a sound basis for further research.

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