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An empirical examination of U.S. travelers' intentions to use biometric e-gates in airports

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ABSTRACT

The current air travel security challenges call for innovative solutions. Among those solutions, biometric e-gates allow security agencies to allocate their resources efficiently while making travel more fluid in sensitive areas of airports. Using data from a nationwide sample of U.S. air travelers, this study constructed and validated empirically a conceptual model explaining travelers' intentions to use biometric e-gates in airports. It was found that performance and effort expectancy had the highest impacts, while privacy concerns had low impacts on intentions. Several implications for theory and practice are discussed.

1. Introduction

The challenges associated with maintaining a secure air travel system are increasing in scope and importance. Due to a sustained business globalization, turbulent regional crises, the current security threats, and an expansion of air travel services to unprecedented levels, today's traveler flows are increasing (International Air Transport Association, 2016). Specifically, the proliferation of low cost air carriers and a clearer differentiation between the core and ancillary services offered by legacy carriers, the emergence of shared economy lodging/ground transportation business models at global scale (e.g., Airbnb, Uber), and the development of newer leisure destinations resulted in unprecedented leisure travel volumes. Moreover, the contemporary global business cycles and the development of attractive frequent traveler reward programs are creating new dynamics within business travel. In this context, the security organizations must allocate a limited amount of resources to safeguard the security of the increasingly interconnected global travel system and fend off threats (Wong and Brooks, 2015). Biometric systems play a critical role in this complex system of hardware, software, and business/administrative models, due to their ability to uniquely ascertain travelers' identity (Morosan, 2011).

Characterized by higher accuracy relative to rival systems (Jain et al., 2011), biometric systems have been successfully deployed in a variety of air travel and related border control settings (Farrell, 2016). Importantly, the accuracy of biometric systems relative to rival systems facilitated the development of biometric-based trusted traveler programs, which increased the efficiency of air travel and border control traveler processing (e.g., Global Entry, Nexus, Sentri, TSA PreCheck). The success of such programs is predicated upon: (1) the opportunity to redeploy resources to screen travelers with unknown backgrounds (i.e., higher risk) and thus realize substantial resource savings (Kosner, 2014), and (2) the benefits (e.g., convenience, processing speed) offered to enrolled (i.e., trusted) travelers (Morosan, 2012). The tremendous recent progress made in the development of biometric systems and the travelers' seeming acceptance of self-service technology facilitated the transcendence of legacy biometric systems into newer systems. Among those, biometric electronic gates (thereafter called "e-gates") represent one of the latest solutions for automatic air traveler processing when entering national territories, accessing secure areas, and boarding commercial flights (Caldwell, 2015).

E-gates are biometric systems based on single- or multi-modality biometric (e.g., face, fingerprint) and biographic (e.g., travel documents) information verification (Gohringer, 2015). Most e-gates have been deployed in border control settings, in airports in Europe and Asia, and the number of airports deploying e-gates is increasing (n.a., 2014). As the e-gate technology develops, the tasks addressed by e-gates are evolving as well. For example, adhering to contemporary newer "fast travel" initiatives, e-gates are currently being tested at Bengalore airport in India to ascertain if they can

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extend the task environment from predominantly border control to streamline traveler processing in domestic travel (Bengaluru Airport, 2015). While collaboration among critical stakeholders (e.g., airports, airlines, government security agencies) is necessary, e-gates could improve the end-to-end experience of travelers and the security of the overall travel system by including multiple tasks within the same travel experience, such as check-in, luggage services, or boarding (Farrell, 2016).

There is an increasing interest in understanding travelers' utilization of e-gates. The current trade literature unanimously points toward the increasing size and scope of e-gates deployment (Caldwell, 2015). However, there is no academic insight into the factors influencing intentions to use e-gates by travelers in voluntary settings, thus marking a critical research lacuna. While scholars continuously called for a systematic examination of adoption of biometric-based systems (Nelson, 2010), a number of academic articles offering initial insight into travelers' development of intentions to use general registered traveler systems have emerged (e.g., Morosan, 2011, 2012). However, the unique characteristics of e-gates (e.g., multi-modality biometrics, potential for broad deployment) and their unique role within the travel system make understanding the antecedents of intentions to use e-gates critical for two main reasons. First, e-gates represent one of the most viable security solutions to the challenge of identity verification of an increasing number of travelers (Farrell, 2016). Second, insight on how travelers use such systems can be incorporated into subsequent design of e-gates to facilitate use, which is especially important in a market that is poised to grow to $1.2 billion in annual revenues by 2020 (n.a., 2014).

The extensive information systems (IS) adoption (i.e., intentions to use, actual behavior) literature documents increasing calls from scholars to address another critical research lacuna: that of focusing predominantly on system perceptions as antecedents of intentions and actual behavior (Benbasat and Barki, 2007). To address this lacuna, scholars have strongly suggested designing IS theoretical models that include constructs better describing the nature of the personal processes involved in stimulating IS intentions (Limayem et al., 2007). To simultaneously address the critical research lacunae outlined above, this study developed and validated a conceptual model that explicated air travelers' intentions to use e-gates for boarding commercial flights. Based on theoretical foundations offered by the classic (Davis, 1989) and neo-classic technology adoption theory (Venkatesh et al., 2012), augmented with theoretical artifacts originating in social psychology theory (Dinev et al., 2013; Malhotra et al., 2004), this study followed two specific objectives: (1) to ascertain whether performance expectancy still remains the focal element in impacting intentions to use e-gates, and (2) to understand the roles of personal characteristics of travelers (e.g., privacy concerns, information sensitivity) in influencing their intentions to use e-gates.

2. Review of literature

2.1. Developing the core theoretical foundation

The rich literature on IS adoption converges toward a number of seminal theories, of which the Technology Acceptance Model (TAM) (Davis, 1989) remains, to date, the most popular (Schepers and Wetzels, 2007). However, despite its wide replication, the TAM has been criticized, especially for being too parsimonious (Venkatesh and Davis, 2000) and for not always being able to capture the full meaning of specific task-technology contexts (Benbasat and Barki, 2007). As a result, it was continuously augmented with constructs that are not native to the IS literature, but are good descriptors of the societal and individual contexts of IS adoption, thus creating a broader neo-classic theoretical base (Lian, 2015). Among the prominent neo-classic theories, the Unified Theory of Adoption and Use of Technology (UTAUT) and its newer version UTAUT2 (Venkatesh et al., 2012) stand out, as they are able to better capture the social context of IS intentions and behaviors. Given its broad empirical validation and strong theoretical base (Lin, 2007), the core UTAUT2 model was used in this study as the main theoretical base, retaining the core constructs of performance expectancy, effort expectancy, and intentions to use a technology that most critically reflect the task-technology fit (Venkatesh et al., 2012).

2.1.1. Performance expectancy

Performance expectancy reflects the extent to which an IS facilitates the completion of a task (Venkatesh and Bala, 2008). Representing a fundamental part of the core UTAUT2 theory, performance expectancy was often conceptualized by relying on attributes that are descriptive of the task-technology fit, which included efficiency, accuracy, and speed in the completion of a task (Venkatesh et al., 2012). The literature overwhelmingly provides support that IS characterized by high performance are likely to increase users' intentions to adopt such systems (Montazemi and Qahri-Saremi, 2015). E-gates are designed to accurately ascertain travelers' identities and expedite traveler processing, thus optimizing the security/revenue processes that are required in airports. This should facilitate increased use by travelers in order to make their processing more streamlined and contribute to a more secure air travel system. Accordingly, the following hypothesis was developed.

H1. There is a positive relationship between air travelers' e-gates performance expectancy and their intentions to use e-gates in airports.

2.1.2. Effort expectancy

Effort expectancy represents another core system perception, and reflects the amount of effort that is necessary for an individual to use a particular IS (Venkatesh et al., 2012). That is, the lower the users' effort in utilizing an IS, the higher the adoption of that IS (Venkatesh et al., 2012). Originating in the seminal TAM model, where it was named perceived ease of use, effort expectancy was retained as a core adoption construct even as the theories transcended and the name changed (Venkatesh and Bala, 2008). It was retained even through hypothesized links between ease of use and intentions were not always validated empirically (Baptista and Oliveira, 2015), or were found to be minor (Pascual-Miguel et al., 2015), thus rendering its role in stimulating intentions unclear. However, in studies regarding biometric system adoption in hotels/air travel using the TAM, it was found that effort expectancy (i.e., ease of use) directly impacted attitudes, and indirectly impacted intentions (Morosan, 2011). Moreover, designed as self-service technologies, e-gates are expected to be designed to facilitate fast learning by users and unaided use. Thus, travelers' effortless use of e-gates should translate into intentions to use (Slade et al., 2015). Accordingly, the following hypothesis was developed.

H2. There is a positive relationship between air travelers' e-gates effort expectancy and their intentions to use e-gates in airports.

Most studies based on the original TAM have documented a significant link between IS ease of use (e.g., effort expectancy) and usefulness (i.e., performance expectancy) Saber Chtourou and Souiden, 2010), even in situations in which usefulness was not found to be a significant predictor of attitudes/intentions (Lu et al., 2008). Although the UTAUT2 did not include such links, a hypothesized relationship between effort expectancy and performance expectancy was included in this study to clarify the role of effort expectancy in influencing intentions directly, and indirectly via performance expectancy. Therefore, the following hypothesis was developed.

H3. There is a positive relationship between air travelers' e-gates effort expectancy and their performance expectancy.

2.1.3. Intentions

The intentions to perform a behavior are effects of conscious decision-making (Davis, 1989) and represent the strongest predictors of actual behavior (Davis, 1989). Accordingly, intentions to use IS have been used extensively in the IS adoption literature as surrogates of actual behavior (Hess et al., 2014), especially in cases where system deployment has not been uniform or actual behavior evaluation is unfeasible. Thus, following the methodologies established in numerous IS adoption studies (e.g., (Baptista and Oliveira, 2015), this study uses intentions to use e-gates as the final dependent variable in the conceptual model.

2.2. Augmenting the model

While the literature abundantly validated the core components of the UTAUT2 theory, scholars have, over time, augmented it in order to adapt it to the specific context of their task-technology examinations (Schepers and Wetzels, 2007; Slade et al., 2015). A variety of constructs have therefore been added to the core model, mostly originating in social psychology, business administration, or psychology (Kim and Forsythe, 2008; Weir et al., 2009). Given the unique aspect of biometric information (e.g., irrevocable, accurately descriptive of someone's identity, etc.) (Jain et al., 2011; Pons and Polak, 2008) three additional constructs were added to this core model in order to comprehensively explain e-gate intentions. The augmentation was based on only three constructs to return to a more parsimonious theoretical base (Straub and Burton-Jones, 2007) and to offer a scalable model that could serve as a core theoretical base for future studies on biometric system adoption.

2.2.1. Privacy concerns

Given the unique nature of biometric information, privacy concerns regarding e-gates was added to the model. Privacy concerns reflect individual users' concerns about the capability of an IS to safeguard their privacy (Kim et al., 2008b). They have been routinely incorporated in studies of IS intentions that are based on sensitive data that are of high importance to the users. The recent literature documents conceptualizations of privacy concerns, especially as such concerns take two forms: (1) general privacy concerns, reflecting users' concerns about their privacy in general (Li et al., 2011), and (2) system—specific privacy concerns, reflecting the privacy concerns of users vis-à-vis a specific IS (Paine et al., 2007). Due to the uniqueness of this technology, this study uses the second conceptualization, and focuses on specific privacy concerns regarding e-gates in airports.

System-specific privacy concerns are instrumental in individuals' intentions to use IS, as such concerns generally inhibit the utilization of IS (Li et al., 2011). Biometric systems generally use information from users that can be detrimental to the user in case of privacy loss (Jain et al., 2006) as such information can reveal important intimate information (e.g., heath conditions) and is irrevocable (McPhee et al., 1997). Moreover, such systems are relatively novel, and there may not be enough public evidence about their privacy protection capabilities. Thus, a negative relationship between the privacy concerns associated with e-gates and intentions to use e-gates should be expected in airport settings, according to the following hypothesis.

H4. There is a negative relationship between air travelers' privacy concerns regarding e-gates and their intentions to use e-gates in airports.

2.2.2. Information sensitivity

While IS users can develop privacy concerns in relation to the systems they use, it is important to recognize that such concerns are not necessarily uniform, but are rather aligned with the types of information that are required to be disclosed to systems (Dinev et al., 2013). In such situations, users perceive certain information types (e.g., medical, financial, personal identification) to be more critical than others (e.g., most biographic information, some behavioral data) (Metzger, 2004). According to such views, information sensitivity has been recognized as an important attribute of personal information that reflects the level of discomfort perceived by an individual when facing a decision to disclose personal information to an IS (Dinev et al., 2013). The IS and consumer psychology literature agree that privacy concerns are directly related to the types of information required by organizations (Phelps et al., 2000). In this context, travelers' perceptions of the sensitivity of the biographic and biometric information required by the use of e-gates should result in higher privacy concerns, in line with the following hypothesis.

H5. There is a positive relationship between air travelers' information sensitivity perceptions and their privacy concerns related to using e-gates in airports.

The e-gates rely on biographic and generally multimodal biometric information, which are perceived to be intimate and irrevocable by users (Morosan, 2012). Moreover, behavioral data from such systems could, in theory, be descriptive of travelers' behaviors (e.g., destination choices, travel patterns, duration of stay, methods of payment). As a result, the extent to which air travelers view the information necessary to use e-gates as sensitive can encourage or inhibit the use of such IS (Malhotra et al., 2004), as requiring sensitive information may be viewed as risky (Dinev et al., 2013), therefore altering users' system perceptions of performance. Accordingly, the following hypothesis was developed:

H6. There is a negative relationship between air travelers' information sensitivity perceptions and their performance expectancy of e-gates in airports.

2.2.3. Compatibility

Compatibility reflects the congruence between an IS and the characteristics of the user and use setting (Karahanna et al., 2006). Indicative of a user's system of socio-cultural values and beliefs surrounding the use of an innovation (Rogers, 1962), compatibility was linked to users' values (Ramiller, 1994), past and present experiences (Moore and Benbasat, 1991) or current practices (Rogers, 1995). Such links are predicated upon the levels of familiarity of users and their corresponding positive affect (Agarwal and Karahanna, 2000; Davis, 1989). Introduced as an important system belief in the early technology adoption literature (Moore and Benbasat, 1991), compatibility has seen an interesting evolution (e.g., omission from the TAM/UTAUT, difficult measurement) (Karahanna et al., 2006). However, the literature recognizes the relationships between compatibility and IS adoption behaviors (Moore and Benbasat, 1991), with important implications for innovation life-cycles (Kim and Qu, 2014).

At the time of this writing, e-gates were still new to the majority of airports, and they still represented a novel technology for the majority of air travelers, especially for the infrequent leisure travelers. Yet, basic biometric technology has been available for some time to consumers (e.g., authentication on mobile devices, time and attendance management at the workplace), demonstrating potential benefits to consumers (e.g., efficiency, speed, predictable task completion). Such benefits can be attributable to e-gates, and can produce value for air travelers. Thus, in line with the existing literature that validated links between compatibility and intentions to use IS (Kim and Qu, 2014), a match between the values, past experiences and the needs (e.g., accurate verification, high processing speed, a more secure travel system) of travelers and their intentions to use such systems should exist. Thus, the following hypothesis was developed.

H7. There is a positive relationship between air travelers' e-gates compatibility perceptions and their intentions to use e-gates in airports.

Based on the discussion above, a conceptual model has been developed. It is illustrated in Fig. 1 below.

3. Methods

3.1. Instrument development and administration

The ample IS and consumer psychology literature provided the foundations for the online survey instrument that was used in this study. The scales for performance expectancy and effort expectancy were adapted from the work of Venkatesh et al. (2012) and included five and four items respectively. The scale for information sensitivity included three items adapted from the work of Dinev et al. (2013). However, one item displayed a very low loading onto its latent construct, and it was dropped and the model was respecified. Privacy concerns were measured using three items adapted from Kim et al. (2008b), and were reverse-coded. Compatibility was measured using a three-item scale adapted from Kim and Qu (2014). Intentions were measured using four items adapted from Venkatesh et al. (2012). All latent constructs were measured using five-point Likert scales, with values ranging from 1 (strongly disagree) to 5 (strongly agree).

The instrument started with a short descriptive paragraph defining the e-gates, presenting examples of their current utilization, and explaining how they would work to assist travelers when boarding a commercial flight. Specifically, the description explained respondents that the e-gates would be used for authentication to check-in and board commercial aircraft, and listed some potential types of information requested by such systems. The description also explained the basic authentication steps taken by the system. A picture of an e-gate was also presented. Since the technology is currently available predominantly in border control settings and not widely available to facilitate boarding yet, the respondents were presented a scenario: they were instructed to imagine that they would take a flight for which there is an option to use an e-gate. The survey concluded with demographic and behavioral sections for classification purposes. Data were collected online using the Qualtrics survey environment.

3.2. Sampling and data collection

Data were collected in September 2015, using the services of a market panel company who had access to panels of U.S. consumers. A total number of 3000 email invitations to the survey were sent. The respondents were asked a qualifier question: whether or not they had traveled on a commercial aircraft during a period of 12 months prior to the study. Upon screening out the unqualified respondents, a total of 538 responses were returned. Upon removing the records displaying heavy or systematic missing values, a total data set containing 511 responses from a nationwide sample of U.S. travelers was retained (net response rate 17 percent). Due to the threat of non-response bias that characterizes research using self-reported measures, a non-response bias analysis was performed by comparing early to late respondents (Ary et al., 1996). As no significant differences were found between early and late respondents, it was concluded that there was no non-response bias, and that this data set was appropriate for further analyses.

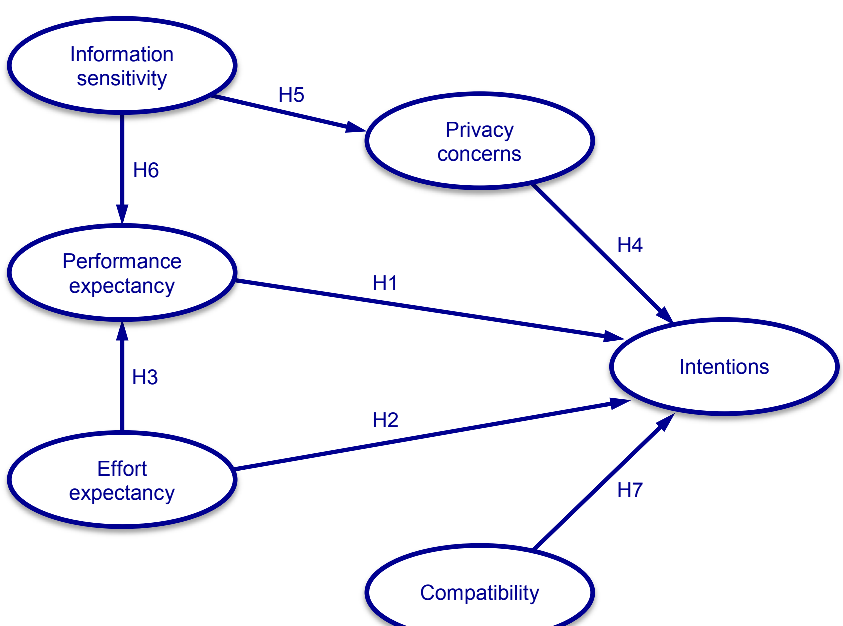

Fig. 1. Conceptual model and hypotheses.

4. Results and discussion

4.1. Preliminary analysis

The analysis started with the demographic (Table 1) and behavioral (Table 2) profile of the respondents. The demographic profile (Table 1) showed that the sample was relatively evenly split between males and females, and conformed to a similar age distribution as the U.S. general population (e.g., most respondents above 51 years old). Most respondents (44.7%) earned between 50,001 and 100,000 per year and had a Bachelor's Degree or equivalent (e.g., 49.6%). The behavioral profile of respondents (Table 2) revealed that more than three quarters of respondents did not use biometric technology (76%), that they traveled relatively infrequently (approximately 80% traveled between one and eight times a year by air), and mostly for leisure purposes (50.7% exclusively leisure).

4.2. Measurement model analysis

An analysis using Mardia's coefficients (Mardia, 1970) was conducted to determine if the data fit a multivariate normal distribution. Although all the variables conformed to univariate normal distributions individually, the data set did not display multivariate normality. As a result, the analysis used in both the measurement and research models used estimators that were robust to violations of multivariate normality (Muthén and Muthén, 2003).

To test the psychometric properties of the instrument, the measurement model was subjected to a confirmatory factor analysis (CFA) using the Mplus v.5 software package (Muthén and Muthén, 2003). The analysis indicated that the model fit the data well, with a chi-square of 389.104 ($p < 0.001$), and d.f. $= 173$, resulting in a normed chi-square of 2.25. The model also had good fit indicators, with a Comparative Fit Index (CFI) of 0.97, a Tucker-Lewis Index (TLI) of 0.96, and a Root Mean Standard Error of Approximation (RMSEA) of 0.051 (Fig. 2) (Browne and Cudeck, 1992; Fornell and Lacker, 1981; Hair et al., 2009).

Table 1
Demographic profile of respondents.

Variable	Percent
Gender	
Male	47.7
Female	52.3
Age	
25 or younger	1.7
26-30	5.7
31-40	15.3
41-50	21.4
51-60	20.6
61-70	25.0
71 or older	10.2
Annual household income	
$50,000 or less	17.1
$50,001–$100,000	44.7
$100,001–$150,000	24.1
$150,001–$200,000	8.8
$200,001 or more	5.3
Education	
High school degree or equivalent	16.5
Bachelor's of Science/Arts or equivalent	49.6
Master's degree or equivalent	22.5
Doctoral degree or equivalent	4.3
Medical or law degree or equivalent	4.1
Other	2.9

Table 2
Behavioral profile of respondents.

Variable	Percent
Have used biometric technology	
Yes	24.0
No	76.0
Frequency of air travel	
Less than once a year	5.7
Approximately 1–2 times a year	41.9
Approximately 3–8 times a year	38.3
Approximately once a month	8.5
Approximately once a week	4.7
More than once a week	0.8
Travel purpose	
Exclusively business	1.2
Mostly business	8.1
Combined business and leisure	18.3
Mostly leisure	21.8
Exclusively leisure	50.7

The good model fit allowed for further analysis of reliability and validity (Tables 3 and 4). First, to establish reliability, composite construct reliabilities (CCR) for each latent construct were calculated, and were found to exceed 0.8, which indicated appropriate reliability (Toh et al., 2006). Convergent validity was examined by calculating the average variance extracted (AVE) from each latent construct. All the AVE scores were greater than 0.5, indicating appropriate convergent validity (Fornell and Lacker, 1981). In addition, the standardized loadings of all the items pertaining to the latent constructs were greater than 0.7, and their corresponding squared multiple correlations exceeded 0.4, also indicating appropriate convergent validity (Toh et al., 2006). The assessment of discriminant validity consisted of a comparison between the AVE scores of each latent construct and the squared inter-construct correlations. The AVE scores were greater than 0.5 and, except for one value, were greater than the corresponding squared inter-construct correlations, indicating appropriate discriminant validity (Fornell and Lacker, 1981).

4.3. Research model analysis and discussion

Once the psychometric properties of the instrument were validated, a structural equation model analysis was performed. The model demonstrated good fit, with a chi-square of 527.861 ($p < 0.001$), and d.f. $= 178$, resulting in a normed chi-square of 2.96. The good fit was also underscored by values of the following indicators: CFI of 0.94, TLI of 0.93, and RMSEA of 0.063 (Fig. 2) (Hair et al., 2009).

The analysis of the model's paths revealed interesting results. Overall, all the hypotheses were supported in their predicted directions, which indicated that this model is appropriate for the examination of air travelers' intentions to use e-gates. Of all the predictors of intentions, performance expectancy was the strongest ($\gamma = 0.464$, $p < 0.001$), which is in line with most empirical studies that confirmed the critical role of usability of biometric IS (Morosan, 2011). However, the high magnitude the path coefficient stands out from the literature (Ha et al., 2007; Kim et al., 2008a,b), and emphasizes the unique role of users' perceptions of high reliability and functionality of biometric systems in influencing intentions. Of all the other predictors of intentions, effort expectancy ($\gamma = 0.275$, $p < 0.001$) and compatibility ($\gamma = 0.234$, $p < 0.001$) had similar impacts on intentions. A lower impact of effort expectancy was somehow anticipated, as in most adoption studies effort expectancy typically has a very low significant or a non-significant impact on behavioral dependent variables (Pascual-Miguel et al.,

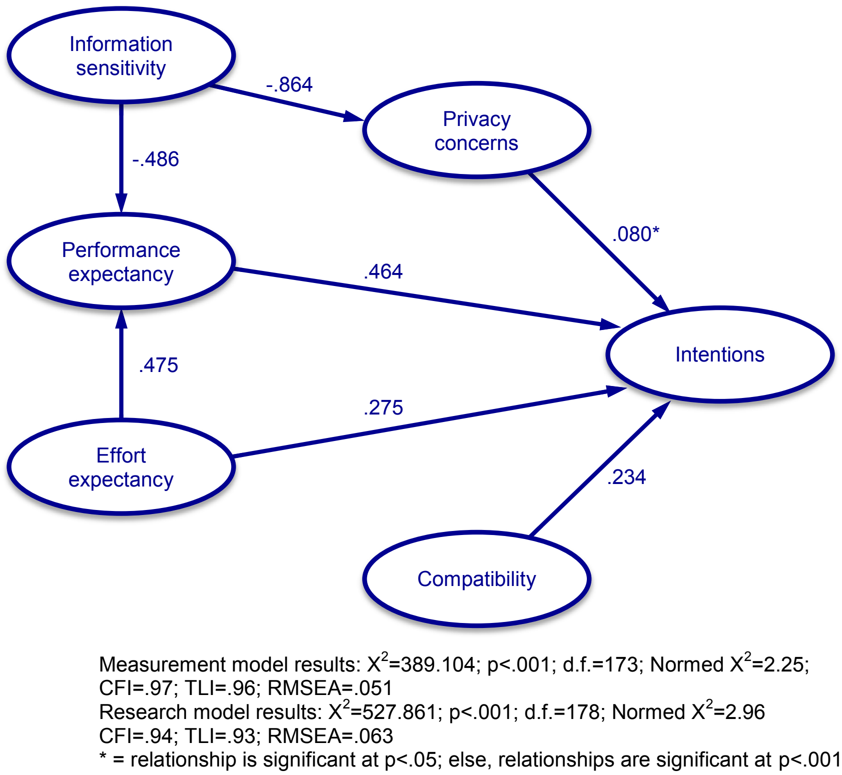

Fig. 2. Model testing results.

Table 3
Reliability and validity test results.

Constructs/items	Loadings	SMC[a]/CCR
Performance expectancy		0.902
PE1	0.791	0.626
PE2	0.837	0.701
PE3	0.766	0.587
PE4	0.794	0.630
PE5	0.839	0.704
Effort expectancy		0.890
EE1	0.779	0.607
EE2	0.828	0.686
EE3	0.858	0.736
EE4	0.806	0.650
Privacy concerns		0.910
PC1	0.878	0.771
PC2	0.843	0.711
PC3	0.913	0.834
Information sensitivity		0.782
IS1	0.842	0.709
IS2	0.760	0.578
Compatibility		0.893
CO1	0.770	0.593
CO2	0.885	0.783
CO3	0.913	0.834
Intentions		
INT1	0.868	0.753
INT2	0.842	0.709
INT3	0.863	0.745
INT4	0.844	0.712

[a] SMC = Squared multiple correlations. CCR = Composite construct reliabilities.

2015). However, the relatively lower impact of compatibility on intentions indicates that despite travelers' orientation toward technologies that assist in the task optimization, a match between IS use lifestyles and perceptions of novel technologies (e.g., biometrics) could still influence their intentions to use such technologies.

Interestingly, the privacy concerns did not have a strong impact on intentions ($\beta = 0.080$, $p < 0.05$). This finding stands out from the literature that generally documented not significant links between privacy concerns and intentions (Kim et al., 2010), and indicates that air travelers could be likely to understand and accept the implications for privacy of using e-gates in airports. Such concerns seem to have a minimal impact on their intentions to use e-gates, which could be explained by a tacit trust that such systems do not represent threats to privacy. As expected, information sensitivity had a high impact on the travelers' privacy concerns ($\gamma = -0.864$, $p < 0.001$). The high magnitude of its path coefficient seems to indicate that the biometric information required by the utilization of e-gates in airports is sensitive enough for travelers to stimulate concerns. However, while having privacy concerns, air travelers' intentions to use e–gates would only be marginally impacted.

A surprising result was found regarding the relationship between information sensitivity and performance expectancy. Information sensitivity had a relatively strong negative impact on performance expectancy ($\gamma = -0.486$, $p < 0.001$), indicating that air travelers' evaluations of performance expectancy could be biased by their perceptions of information sensitivity, thus finding such systems less appropriate to facilitate task completion. Since this is the first study to examine such a relationship, this result is unique in the literature. A significant impact, however, was found to exist between effort expectancy and performance expectancy ($\gamma = 0.475$, $p < 0.001$), which was supported by the previous literature (Davis, 1989; Davis et al., 1989). This result indicated that air travelers who perceive the e-gates to be easy to use are likely to bias their evaluations of performance expectancy, finding them more appropriate

Table 4
Discriminant validity test results.

Constructs	Construct	1	2	3	4	5	6
Performance expectancy	1	**0.649**					
Effort expectancy	2	0.497	**0.670**				
Privacy concerns	3	0.415	0.237	**0.772**			
Information sensitivity	4	0.133	0.030	0.261	**0.643**		
Compatibility	5	0.521	0.413	0.508	0.169	**0.737**	
Intentions	6	0.764	0.619	0.454	0.128	0.635	**0.730**

Note: The values on the diagonal (in bold) represent the Average Variance Extracted values for the latent constructs. The values below the diagonal represent the squared inter-construct correlations.

to facilitate task completion, thus exercising an opposite effect, relatively similar in magnitude to information sensitivity on performance expectancy.

5. Implications, limitations, and directions for further research

5.1. Theoretical implications

While the increasingly rich literature on biometric systems is generally technical in nature, empirical studies focusing on models that explicate consumer use, the privacy associated with such systems, or the societal impacts of biometrics are inherently rare. Against such important backdrops, this study brings substantial theoretical implications, as it is the first to provide empirical validation using a nationwide sample of U.S. air travelers to a model that explains air travelers' intentions to use e-gates in airports in contexts that span beyond the current border control settings.

First, given the unique nature of biometric technology, and the complex implications for the security of the travel system that it provides, this study offers a blueprint of the factors that lead to travelers' intentions to use e-gates. Yet, given the predominant deployment of e-gates in border control settings, this study brings to light critical insight into the factors that lead to intentions to use e-gates for different tasks (e.g., boarding). Thus, this study addresses the first research lacuna by expanding the current knowledge of e-gate use. Among the factors examined here, this study ascertained the critical role of performance expectancy as the main determinant of intentions, thus extending the IS adoption literature, which is focused mostly on generic or web-based IS.

Second, in order to provide a more precise theoretical foundation for the study, the core UTAUT2 conceptual model was augmented with constructs originating in the social psychology literature, but adapted to the unique IS context of biometric systems, which addressed the second important lacuna: that previous research focused predominantly on system perceptions. This approach is a direct response to calls from numerous scholars to broaden the base of possible antecedents of adoption behavior constructs, as the IS theory alone is sometimes insufficient in capturing all elements that properly define the task-technology fit. For example, the significant, although relatively low, impact of compatibility on intentions found in this study represents an important step forward in the development of newer theoretical models, which can explain more comprehensively the social context of technology use. Thus, by validating compatibility as a significant predictor of intentions, this study extends the neoclassic literature on IS adoption. At the same time, the study advances the general literature in consumer behavior, as it blends IS-related beliefs with general evaluations of technology-related consumption practices.

Third, this study investigated the role of information sensitivity in influencing two key determinants of e-gates adoption. Especially, the link between information sensitivity and privacy concerns outlines that the IS research should move more systematically into the direction of examining the privacy implications of biometric systems, especially in transient utilization contexts as those outlined in this study (e.g., airports, leisure travel). Given the irrevocable character of biometric information, incorporating constructs beyond simple privacy concerns produces a richer evaluation of the social context in which biometric technology is being viewed and utilized today. Accordingly, this study represents a first step in developing the systematic examination of the social context of biometrics that is instrumental to the understanding of consumers' use of biometric systems in voluntary settings. Thus, this study bridges the gap between the technical biometrics field, which explains the functionality of biometric systems, and social sciences field, which explains how such systems are utilized in real life contexts by individuals.

5.2. Practitioner implications

Addressing for the first time the adoption of e-gates in the unique context of the U.S. air travel, this study offers several implications for practitioners. As it lays out a mapping of the factors that influence intentions to use e-gates, this study's results can provide viable solutions to decision-makers, which may serve instrumental practical roles when such systems are deployed in the U.S. As most e-gates today are deployed toward border control, this study shows primarily how travelers can develop intentions to use e-gates in voluntary settings for boarding, and possibly other related tasks. Such knowledge place the air travel stakeholders in a better position to employ risk-based approaches for traveler segmentation to better manage the increasing traveler flows and improve the security of the air travel system. In addition, depending on the size/scope of the e-gate ecosystem development and that of the supported business models, e-gates could work in conjunction with airlines' loyalty programs or trusted traveler programs to facilitate priority processing/boarding for certain groups of travelers.

First, as the central role of performance expectancy in stimulating intentions was validated, it indicates that decision-makers should design e-gates that perform their main tasks seamlessly. Yet, such tasks are symbiotically related to all other business- and security-related tasks required by today's complex commercial air travel system. In this context, decision-makers could integrate the e-gates' specific tasks into the broader context of airport tasks, and ensure that the completion flows are seamless from one task to the other. Moreover, as the air travel system is sometimes characterized by irregular operations (e.g., weather delays), proper system functionality must be ensured to facilitate the normal operational flows.

Second, the role of information sensitivity was critical in stimulating both the perceptions of system performance and travelers' privacy concerns. To diminish the negative effect of such perceptions, decision-makers can engage in communication strategies that are designed to better inform the traveling public about the functionality of such systems, their level of security and how it is safeguarded. Finally, the role of compatibility on intentions to use e-gates, while minor, was significant. This finding can be transposed in practice by understanding the role of e-gate identity verification within the complex system of tasks of air travel, and by deploying e-gates that align with the task completion sequences of other systems that are integral parts of air travelers' everyday life. Such systems should have intuitive user interfaces that could mimic the utilization and workflow of other tasks.

5.3. Limitations and directions for further research

Like all the studies based on different versions of the TAM/UTAUT theory, the study has potential limitations that are related to: (1) the task environment, and (2) the use of self-reported measures via surveys. As in all IS research, the model-based predictions are weaker outside the task environment. To address this innate limitation, future research should investigate the adoption of other systems by air travelers and ascertain how they engage in the use of such systems. Such an approach is likely to provide a more comprehensive validation of the relationships among the IS-native constructs and those adapted from other disciplines, and should be stable beyond a particular task environment. In addition, incorporating additional variables that are better descriptors of the social context of technology adoption would add value to the understanding of biometric system adoption. To address the second limitation, further research should replicate this study with different samples, or consider longitudinal methodologies.

In conclusion, this study was designed to respond to increasing calls from academics and practitioners who emphasized the potential viability of e-gates in airports. While this study fully validated the conceptual model that was set out to examine, more academic effort is necessary to build a solid understanding of consumers' adoption of this unique, yet fascinating technology.

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