

Tourists' Satisfaction on the Use of Biometrics Technology: A Conceptual Framework

Han-Foon Neo, Devinaga R., David Yoon Kin Tong, and Chuan-Chin Teo

Abstract—Biometrics fingerprint recognition technology has been installed in Malaysia's Immigration to tackle the problem of immigrants' influx and overstayers, and to increase the total security of border control. This mandatory system is used by all inbound tourists travelling to Malaysia. Since there is no alternative to the biometrics fingerprint system, it raises the importance to assess what affect tourists' satisfaction in using the biometrics fingerprint system. In this paper, a conceptual framework of tourists' satisfaction based on Expectancy Disconfirmation Theory is proposed. Seven variables used to assess tourists' perception are categorized as performance expectancy, effort expectancy, facilitating conditions, physical privacy, accuracy, information privacy and contamination fear. The first five refer to performance expectations which tourists could anticipated before the actual use of the biometrics fingerprint system. As a result, these expectations will be either positive disconfirmed (experience exceeds expectations), negative disconfirmed (experience falls short of its expectations) or reached the congruency level (expectations are confirmed). Mixed-method approach will be used for data collection from a sample of 500 target participants. Consequently, data analysis will be conducted to summarize and interpret the relationship between the variables. It is expected that the research findings will provide useful insights for policy makers, government, and industries.

Index Terms—Biometrics, expectancy disconfirmation theory, fingerprint, satisfaction, tourist.

I. INTRODUCTION

Forged travelling documents, overstay and misuse of visas, passes and work permits are the common problems faced by the Malaysia's Immigration Department [1]. Asia One News [2] reported that three per cent of the 24.4 million inbound tourists who had visited Malaysia in 2010 had been involved in various crimes. Additionally, the number of tourists entering Malaysia is increasing yearly. According to Tourism Malaysia [3], the total number of tourists in 2007 was 20.9 million, subsequently increase to 25.03 million in 2012.

In an effort to curb the aforementioned problems and at the same time to improve border control security, the Malaysian

Immigration Department had introduced biometrics passport in 2010. Biometrics passport, also known as e-passport, is in compliance with the version of the International Civil Aviation Organization (ICAO) [1]. The compliance enables the passport to be read by countries

whose passports are also compliant to the standard. Hence, many countries utilize biometrics system as a method of identity verification: Airports in United Kingdom [4], UAE [5], Amsterdam [6] and Canada [7] are using iris technology; airports in Indonesia [8], Japan [9], Malaysia (Immigration Malaysia, 2011) and United States [10] are using fingerprint technology; airports in Australia [11], Korea [12] and Taiwan [13] are using facial recognition technology.

Under the implementation of biometric passport, National Foreigners Enforcement and Registration System (NERS) was introduced and implemented in 2011 whereby all inbound tourists to Malaysia are required to provide biometric fingerprints of both index fingers at all immigration entry points [1]. However, it exempted children below 12 years of age, tourists with finger disabilities and diplomatic passport holders [14]. When a tourist arrives at an Immigration checkpoint, his fingerprints will be taken and expected to be registered in 20 seconds [15]. This process is known as enrolment / registration of biometric data. NERS is linked to the police's existing Biometric Fingerprint Identification System (BIOFIS) to grant law enforcers accessing to the movements of foreigners with criminal records [1]. In this way, if a tourist who have overstayed their visa, a warning slip will be issued and the immigration officer will be notified immediately [1].

After all, the usage of biometrics fingerprint system at Malaysia's immigration checkpoints is compulsory for all inbound tourists, there is no alternative to actual use. Brown et al. [16] raises the question: "if individuals must use a system, why do we care about the factors or antecedents to mandated use?" The authors further justified the reasons that while employees in a company may use the technology, their job satisfaction and feelings toward their supervisors and loyalty toward the organization can be affected severely and negatively [17]. Based on this proposition, it will be notable to determine what constitute tourists' satisfaction when they participate in the mandatory programme.

Most studies on biometrics in the social science perspective recognise the initial acceptance as a critical step toward realising adoption success [18], [19]. The focus of biometrics studies had been mainly based on established models such as Technology Acceptance Model (TAM) [20]-[24], Unified Theory of Acceptance and Use of Technology (UTAUT) [25], [19], Dynamic acceptance model for the re-evaluation of technology-based applications (DART) [26] and Innovation Diffusion Theory [27]. However, performance expectations from tourists' perspective are left unexplored.

In this paper, a conceptual model based on Expectation Disconfirmation Theory [28] is proposed. The proposed

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model will be used to determine the antecedents of tourists' satisfaction on the use of biometrics fingerprint system at Malaysia's immigration.

The remainder of the paper is organized as follows. Theoretical background and the formulation of research framework are presented in Section II. This is followed research methodology in Section III. Expected result is described in Section IV and finally, conclusion in Section V.

II. THEORETICAL BACKGROUND AND THE DEVELOPMENT OF CONCEPTUAL FRAMEWORK

A. Expectancy Disconfirmation Theory

The concept of consumer satisfaction/dissatisfaction is being studied continuously and extensively in the marketing, consumer behaviour, tourism and IS domain. The widely

used approach to explain consumer satisfaction/dissatisfaction is expectancy disconfirmation theory as shown in Fig. 1, [28].

According to this theory, consumers purchase goods and services with pre-purchase expectations about the anticipated performance. Once the product or service has been purchased and used, outcomes are compared against initial expectations. During comparison, if the outcome matches expectation, confirmation is reached. On the other hand, disconfirmation is achieved when there is a difference between user's initial expectation and outcome. Negative disconfirmation refers to outcome which is less than expected and thus the product does not meet user's expectation. On the contrary, positive disconfirmation occurs when the outcome is greater than user's initial expectation and hence the product performance is much better than expected.

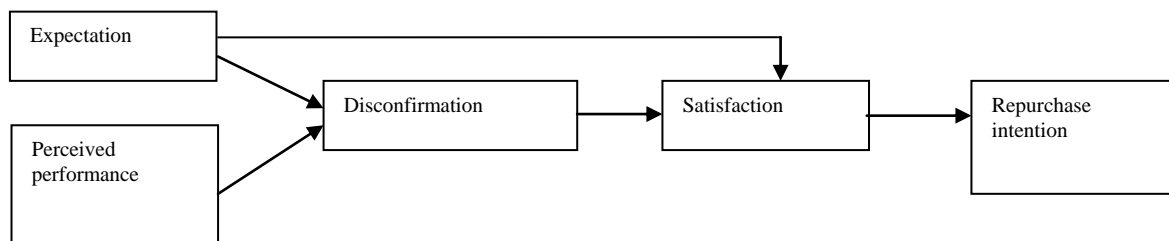


Fig. 1. Expectancy disconfirmation theory (Oliver, 1980)

In this paper, satisfaction acts as the dependent variable. Two different satisfaction conceptualizations are suggested in the literature i.e. transaction specific and cumulative. The former measures satisfaction in terms of a function of pre-purchase expectations and post-purchase perceived performance of the respective product/service [29], [28]. On the contrary, the latter measures satisfaction as an overall evaluation based on total purchase and consumption experience with the respective product/service [30], [31]. In this context, user satisfaction refers to an overall evaluation of biometrics system used at the immigration checkpoint. It can be seen as an additive combination of the expectation level and the resulting disconfirmation.

B. Development of the Conceptual Framework

Airport security procedures which were challenged by terrorists were forced to undergo a rigorous transformation [32] post 9/11 event. This includes a 100% scanning of all checked baggage for explosives at all US airports, passengers were subject to much more meticulous screening procedures and "watch lists" were drawn up to prevent suspected terrorists from flying. An effort to make sure that the person who is travelling is genuine is by using biometrics authentication.

Most of the biometrics research in social science did not conform to any theoretical models; they were merely based on questionnaire and descriptive statistics. For example, Furnell et al. [33] had conducted a survey to examine user attitudes towards a range of authentication techniques and attitudes such as keystroke analysis, face recognition, mouse dynamics, voice verification, signature analysis, iris scanning, hand geometry and fingerprint analysis. It was found that password was the most preferred authentication method,

followed by voice verification and fingerprint recognition.

Besides, some researchers developed their own models to assess biometrics perception. For instance, Murphy and Rottet [18] conducted biometrics acceptance in the hotel industries. Some processes that could use biometrics include identity recognition, information request, booking/reservation, activation of devices, payment and access control. A conceptual model was developed which consisted of technology behaviour, holiday characteristics, hotel processes, biometric technologies and issues constructs. It was found that majority of hotel customers were willing to use biometric devices and fingerprint recognition as the preferred device for specific hotel processes.

Based on past literatures, factors such as inaccuracy, poor facilitating conditions and privacy concerns affect tourists satisfaction were not well addressed. Thus, this had lead to the formulation of the following independent variables: performance expectancy, effort expectancy, facilitating conditions, physical privacy, accuracy, information privacy and contamination fear.

1) Performance expectancy

Venkatesh et al. [34] defined performance expectancy as "the degree to which an individual believed that using the system would help him or her to attain consistent quality in their job performance". Performance expectancy is equivalent to the construct of perceived usefulness (PU) in the TAM. In this paper, performance expectancy refers to the degree to which a user believes that using the biometrics system will be beneficial. Such circumstance can be achieved by using the biometrics system to authenticate / verify the identity of the tourist at the Malaysian immigration as the automated system works faster compared to manual

verification. Furthermore, biometrics system enabled the users to perform the task without supervision which saves a lot of waiting time. Hence, the effectiveness of user identification will be increased. Most importantly, biometric system will be able to increase total security quality of border control. This leads to the formulation of the following hypotheses:

H1a: Performance expectancy has a positive relationship to disconfirmation.

H1b: Positive disconfirmation of performance expectancy has a positive influence on satisfaction.

2) Effort expectancy

Effort expectancy refers to the “degree of ease associated with the use of the system” [34]. Collaterally, it is equivalent to perceived ease of use (PEOU) in the TAM. Ho *et al.* [20] had used the original definition to the context of biometrics i.e. “the degree to which a person believes that using a particular system would be free of effort”. He had added external variables such as convenience, perceived safety and hygiene to PEOU. In James’s *et al.* [35] work, PEOU was found to have a significant impact on PU. This is due to the user’s perception of how easy the device would be and this would in turn influence the technology’s PU. Similar to [20], Chan *et al.* [36] had identified convenience as an external factor related to this construct. He found that because of conveniences, users were very likely to adopt and use electronic government services which is self-service and accessible on a 24/7 basis. Needless to say, an individual is more likely to use a technology if it is effortless and convenient. Thus, this has led to the hypotheses of H2a and H2b as follow:

H2a: Effort expectancy has a positive relationship to disconfirmation.

H2b: Positive disconfirmation of effort expectancy has a positive influence on satisfaction.

3) Facilitating conditions

Facilitating conditions refers to “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system” [34].

Poor facilitating conditions such as hardware failure or unfriendly staff would lead to bad experience. Attended by unfriendly staff would also cause the users to be unsatisfied to cooperate. User gets the feeling of unhappy to interact with system that impose a high physical or mental workload, or require them to perform actions they find distasteful. Disabled would have difficulties in providing certain biometrics identifier in which they would feel rejected and disappointed to left with no travel opportunities. This has led to the formulation of the following:

H3a: Facilitating conditions has a negative relationship to disconfirmation.

H3b: Negative disconfirmation of facilitating conditions has a negative influence on satisfaction.

4) Physical privacy

Privacy is always the central issue related to using of biometrics. Physical privacy is associated with many factors. (1) feeling of stigmatization; it occurs when the user felt that it was associated with criminal behaviour, and they were

treated like potential or suspected terrorist; (2) perception of harm; (3) contradictory with tourist’s religious beliefs.

There are some critics who have argued against basic and personal behavior while using biometrics. For a minority group of people, it could be a discomfort experience to interact with biometrics technology due to cultural, religious or personal beliefs [37]. On the other hand, physical privacy is also associated with the actual harm that users emulated. Although the technology is in fact harmless, the perception of harm may cause users to feel discomfort or reluctant to use the biometrics system. For instance, iris scanners work to capture the image of an iris, and yet some users may be concerned about damage to their eyes. They are concerned about the safety of using the system, whether it will cause any physical harm for instance if the biometrics system used will emit radiation and cause hazardous to personal health in the long run. 46% of respondents were concerned where in the future, criminals would steal body parts information to get around a biometric device [38]. Thus, the following are formulated:

H4a: Physical privacy has a negative relationship to disconfirmation.

H4b: Negative disconfirmation of physical privacy has a negative influence on satisfaction.

5) Accuracy

Inaccurate biometrics system hinders user’s interest to use and thus reduce tourists’ satisfaction towards the system. For example, problems associated with enrolment and recognition which include failure to acquisition and long duration of the enrolment or recognition. Failure to acquire was due to low quality fingerprints such as chapped, worn and dried prints. Hence, accuracy is another important predictor to determine tourists’ satisfaction [39].

Ho *et al.* [20] defined accuracy as “the degree to which the system is able to correctly match a biometric sample with its pre-existing template in a real world setting”. The accuracy of biometrics system has been the major subject of much research because it is one of the important determinants of biometrics feasibility [20]. Accuracy is determined by the error rates of the system. The False Non-Match Rate (FNMR) or False Rejection Rate (FRR) (Type I error) is the percentage of chance that the system rejects a genuine user. False Match Rate (FMR) or False Acceptance Rate (FAR) (Type II error) is the percentage of chance that the system accepts an imposter, someone who is supposed to be rejected. Sasse [40] justified that the experience of the user being falsely rejected could create many psychological barriers for the user towards biometrics especially if this occurs in a public environment. This lead to the hypotheses:

H5a: Accuracy has a positive relationship to disconfirmation.

H5b: Positive disconfirmation of accuracy has a positive influence on satisfaction.

6) Information privacy

The other aspect of privacy is information privacy which has always been a dormant issue in using biometrics system. Privacy proponents argued that this violates individual privacy. In addition, there also might be invasive implications such as disclosure of biometrics identification

information to third parties and any invasive information which might be additionally obtained as part of the biometric identifier [41]. This happens due to the storage of biometric data, and whether it is safe from hacking and leakage to terrorist organisation. Biometrics acts like passwords; they are unique identifiers but they are not secret. Individuals can be traced if their biometric information is stored in a database.

Smith *et al.* [42] had developed and validated an instrument that identified and measured the primary dimensions of individual's concerns about organization information privacy practices. The instrument consists of 15 items that reflects four factors of information privacy ie. Collection, errors, secondary use and unauthorized access. Smith found that too much of data was being collected and much of the data collected was inaccurate, for corporations' use of personal information for undisclosed purposes and also that corporations failed to protect access to personal information. Hence, hypothesis 6 is formulated:

H6: Information privacy has a negative relationship with tourists' satisfaction.

7) Contamination fear

Hygiene is a dominant factor for users especially mysophobia, whom would be fear of germs and dirt which are trapped in the biometrics system used by countless individuals [40]. Fingerprint technology required direct contact with the device at immigration checkpoints. The

procedures of fingerprint capturing and reading imply physical contact between the skin and the surface of the sensor. Successive users will align their fingers on the same surface area. Transfer of microorganisms from environmental objects to human then become absolute [43].

Contamination fear is one of the most prevalent obsessions. It is defined as "fear of becoming personally contaminated through one's own actions, being contaminated by others, contaminating others, or different combinations of any of these" [44]. The fear of coming into contact with real things such as viruses, bacteria, bodily waste or secretions, people who appear ill or unclean, poisons, radiation, or toxic chemicals and imaginary things (bad luck, the names of illnesses, or other people who may seem to have some bad or dislikeable traits) are perceived as harmful.

Some people would be reluctant to use biometrics system when they think that the sensor is dirty. Hygiene of the system clearly influences the user's satisfaction to use a biometrics system [20]. 27.1% of respondent commented the biometrics devices are unsanitary [38]. On the other hand, users may felt uncomfortable placing their faces against a machine to have their retinas scanned after many others have done so or touching a hand-geometry scanner during flu and cold season [41]. This leads to the formulation of:

H7: Contamination fear has a negative relationship with tourists' satisfaction.

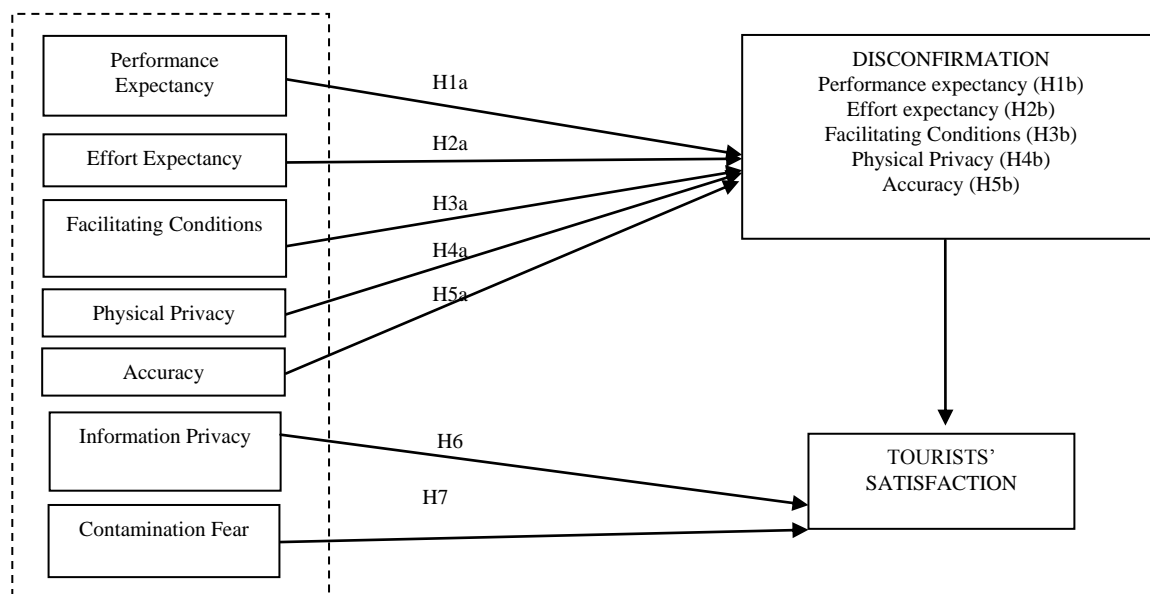


Fig. 2. Proposed conceptual framework for tourists' satisfaction in using biometrics technology.

III. METHODOLOGY

According to Kaplan and Duchon [45] and Mingers [46], [47], there is limited research that has employed methodological pluralism in the IS literature. Venkatesh et al., [48] mentioned that the use of mixed method approach (ie. to use both qualitative and quantitative) in IS field is lack.

To provide a multiple worldview of this research, quantitative and qualitative methods will be conducted

concurrently. The first stage of this research is to be conducted by using quantitative method. Data will be collected by distributing questionnaire to 500 target tourists. At the same time, face-to-face interview will be conducted to selected participants. This way, this research will achieve complementarity (more holistic view) and completeness (rich and insightful explanation qualitative findings) where additional insights would be obtained from qualitative study.

IV. RESULT

The data collected will be analyzed with statistical software IBM Statistical Package for the Social Science (SPSS) version 20 and the structural model will be computed using IBM SPSS Analysis of Moment Structure (AMOS) version 20.

The first phase of the analysis is to evaluate the conceptual framework by using SPSS. Descriptive and inferential analysis will be useful to summarize and interpret the relationship between variables. Factor analysis will be used for pilot study, follow by reliability test and correlation analysis.

Subsequently, AMOS will be used in the second phase which is concerned among the appraisal of the structural relationships along with latent variables known as structural equation modelling (SEM). To compute the structural model, all the derived exogenous and endogenous factors will be confirmed by first-order confirmatory factor analysis (CFA) by identifying and deleting the items with standardised regression weights (SRW) of less than 0.5. Consequently, the specified model will be formed based on the research framework to be analysed. This second-order CFA measures the relationships between the factors.

Apart from that, data analysis for qualitative is as important. The quality of inferences from qualitative and quantitative studies will contribute greatly to the process of developing high quality meta-inferences [48]. Meta-inferences is defined as theoretical statements, narratives or a story inferred from an integration of findings from mixed method approach [48]. Onwuegbuzie and Johnson [49] have identified nine new types of legitimation that come to the fore as a result of combining inferences from the quantitative and qualitative components of a mixed research study to form meta-inferences. This research will generate meta-inferences from sample integration ("The extent to which the relationship between the quantitative and qualitative sampling designs yields quality meta-inferences"), inside-outside ("The extent to which the researcher accurately presents and appropriately utilizes the insider's view and the observer's views for purposes such as description and explanation") and paradigmatic mixing ("The extent to which the researcher's epistemological, ontological, axiological, methodological, and rhetorical beliefs that underlie the quantitative and qualitative approaches are successfully combined or blended into a usable package").

V. CONCLUSION

In this paper, tourists' satisfaction was measured by using the variables from different theories. There were seven variables from tourists' perspective to be examined: performance expectancy, effort expectancy, facilitating conditions, physical privacy, accuracy, information privacy and contamination fear. The first five were the performance expectations that tourists could anticipated before the actual use of the biometrics fingerprint system. These expectations need to be disconfirmed to establish whether the actual experience exceeds or falls short of expectations.

This paper introduced a conceptual framework examining the relationship between the above mentioned variables and tourists' satisfaction. The contribution of this research will be three-folds; the findings from the research will be able to serve as recommendations to computer science researchers so that the fingerprint system designed for mandatory programme is able to achieve a break-even point that met tourists' expectations. The findings generated from meta-inferences would also served as policies to the Immigration Department and Tourism Ministry. This way, tourism statistics and national Gross Domestic Product (GDP) will be increased as tourism is the second major contributor to the national GDP in Malaysia [50]. The recommendations and policies suggested could realize the interoperability of biometrics fingerprint system where it can be applied to various domains for instance all government offices.

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