IoT capabilities in regaining post-pandemic travellers' confidence through touchless travel: An empirical study for the revival of airline sector

Abstract

The unprecedented growth of Coronavirus (COVID-19) has caused a severe health crisis with significant socio-economic impact at a global magnitude. The airline and travel industries bore one of the worst brunt since the outbreak. With the gradual re-opening of economies, though airline companies are progressively bouncing back to normalcy, travellers continue to remain anxious about their safety and hygiene norms. In this regard, we examine the applicability of Things (IoT) enabled digital technologies in restoring airline travellers' confidence by offering benefits such as contactless travel, health monitoring of onboard travellers, crowd management at the airport, air quality and hygiene management inside the airport. The study sheds light on emerging travellers' preference for air travel post-COVID-19. This paper prioritizes the IoT-based application areas assessed through the theoretical lens of the theory of planned behaviour (TPB) and technology acceptance model (TAM). Our research highlights the underlying inter-relationships among the digital enablers that can be implemented for the airline industry, focusing on travellers' hygiene and safety concerns. The study is conducted in the international airports operating in India. By improving travellers' confidence, this study will help travel and airline industries to revive from the post-pandemic loss by using the capabilities of IoT technologies.

Keywords: Airline industry, Airport management, Internet of Things (IoT), IoT capabilities, GREY-DEMATEL, COVID-19, Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM)

Introduction

Since the beginning of the COVID-19 outbreak to a global pandemic, the airline industry has continued to suffer from several prohibitive travel restrictions by local and regional governing authorities to prevent the contagion of the disease among people (Gostin and Wiley, 2020). Despite meaningful progress towards discovering the COVID-19 vaccine, the absence of official prescribed medical treatment causes panic among world travellers (Zheng et al., 2021; Pan et al., 2021). Travel and tourism industries have considered this as the worst decline in the history after World War II (Kaczmarek et al., 2021). The existing studies are notably limited in suggesting information systems (IS)-enabled solutions in revival of travel and tourism industries (Amankwah-Amoah, 2016). The lack of sufficient empirical research addressing the sustainable recovery against the pandemic inspires deeper investigation.

Agrawal et al. (2020) proposed that unpacking of the technological capabilities can provide enormous possibilities and accelerate revival for a “safer world”. The Internet of Things (IoT) based technologies have demonstrated immense promise in the fight against COVID-19 by early detection, contact tracing, patient tracking, progress monitoring and recovery mapping, among others (Singh et al., 2020; Ting et al., 2020). Despite the growing acceptability of IoT in the healthcare industry, the application of IoT-enabled technologies for other industries is relatively scarce in dealing with the COVID-19 pandemic (Nasajpour et al., 2020). Past studies are seemingly inadequate in answering the critical role that IoT, that can help industries to recover from disruption, especially pandemics like COVID-19 (Wenzel et al., 2020).

The continuous and proximate reachability to the travellers’ in providing customized solutions is made possible by IoT technologies (Christaki, 2015). It is worthwhile to mention that IoT-enabled technologies are reasonably safe and efficient in the fight against COVID-19 pandemic (Singh et al., 2020). Despite IoT being credited with bringing revolutionary changes for product and service sectors (Nasajpour et al., 2020), existing research seems insufficient in unleashing its potential in the recovery of the airline industry from the pandemic. Prior to COVID-19 pandemic, the application of IoT in the airline industry is primarily focused on improving aircraft performance and onboard traveller experience (Design News, 2020). However, since the pandemic, IoT has been proven instrumental in mitigating the adverse effect of the pandemic (Ting et al., 2020). According to a Deloitte survey of airports on the use of IoT applications, IoT adoption is primarily driven by operational efficiency improvement at airports, its application in building customer experience seems to be an important area that remains largely untapped (Deloitte Insights, 2020). Therefore, exploring the potential of IoT in fighting the challenges of COVID-19 for travel and airline industries can offer favourable outcomes, which largely remains unattended in the existing research.

Motivated by afore-mentioned scholarly gaps, this research intends to make several vital contributions to the literature to support the industry in revival from the impact of the COVID-19. Given the growing acceptance of IoT technologies in the fight against the ongoing pandemic, this study attempts to extend the application of IoT-enabled solutions for the airline industry. The paper identifies the possible areas of IoT application in building travellers' confidence and sustainable industry rebound while pandemic-driven travel restrictions are still in place at a varying level. Our analysis prioritises the IoT-based digital initiatives adopted by airports and the airline industry analysed through customer acceptance. It provides an integrated framework for managerial decision-making to guide airport authorities in implementing the measures to fight against pandemics for a speedier recovery.

The remainder of the paper progresses as follows. First, we develop theoretical foundations for this research with a literature review on IoT capabilities for airport applications. Next, a research methodology framework is established, followed by its application to our work. Subsequently, we discuss the results and provide scholarly and managerial implications. Finally, the paper is concluded with mention of specific future research extensions.

2. Theoretical background and literature review

2.1 Theoretical foundations

It has been recognised that implementation of traveller-focused technologies at the airport can significantly enhance their travel experience with improvement in customer satisfaction (Bogicevic et al., 2016). The growing travellers' acceptance of smartphones, mobile applications, self-service technologies, biometric assessment, wearable devices has benefitted airport operations in creating greater value for travellers (Kalakou and Moura, 2015). Travellers' airport experience and proclivity for technologies are importantly driven by sociological and psychological perspective (Wattanacharoensil et al., 2016). Though the potential acceptability of any emerging technology is primarily dependent on its perceived benefits, it is often challenged with psychological barriers and associated impact on consumer behaviour (Joachim et al., 2018).

2.1.1 Technology acceptance model (TAM)

Among the theoretical models that deal with the acceptance of new technology such as IoT, the technology acceptance model (TAM) (Davis, 1989) is one of the most acclaimed models that explain the technological adoption comprehensively. According to this theory, the acceptance of new technology, in this case IoT, is based on two central beliefs, a) the ease of using new technology and b) perceived usefulness of the technology (Venkatesh and Davis, 2000), that determines the attitude and behavioural intention of consumer towards the adoption of the same (Hsiao and Tang, 2015). TAM has been extensively used by researchers in explicating various technology-acceptance scenarios, such as the IoT adoption in China (Gao and Bai, 2014), adoption of the Uber mobile application (Min et al., 2019). Therefore, we apply TAM as the theoretical underpinning for exploring the acceptance of IoT applications at the airport in the fight against the ongoing pandemic.

2.1.2 Theory of planned behaviour (TPB)

Impacts of psychological barriers on consumers' attitudes and behaviour towards IoT products and applications are still at nascent stage. Based on the research outcome of Quintal et al. (2010), it is evident that subjective norm is greatly influenced by social endorsements which in turn influences the attitude and perceived behavioural control of people. With the heightened possibility of COVID-19 viral transmission while exposed to an infected person will likely have a behavioural impact on passengers and frontline airport service staffs (Tuchen et al., 2020). The impact of COVID-19 pandemic has resulted in several behavioural changes among travellers owing to psychological and social risk perception (Li et al., 2020). The individual risk perception is likely to shape the behavioural intention in the fight against the pandemic (Ahmad et al., 2020). In view of changing peoples' social and health behaviour (Arora and Grey, 2020), it can be a good idea to investigate the passengers' modified behavioural pattern in the recovery of the airline industry which starts with airport facility. Therefore, to study the revival of the airline industry, the theory of planned behaviour (TPB) can provide necessary theoretical anchoring to analyse the socio-behavioural adoption in a 'new-normal' situation.

According to the theory of planned behaviour (TPB), the human behavioural intention in a complex social framework is driven by three important psychological factors (Ajzen,1991). The theory proposes that behavioural attitude, its subjective norms, and perceived control over the behaviour are three crucial factors that are likely to predict personal intention towards the behaviour. While behavioural attitude deals with a responsive predisposition towards situational decision-making, subjective norms measure the people's willingness in complying with social commendations (Moutinho, 1987), and perceived behavioural control discusses the comfort or hesitation in performing the behaviour of consideration (Ajzen,1991). TPB has received significant research attention in explaining the traveller behaviour in tourism, and hospitality sector (Bianchi et al., 2017) alongside occasional review on behavioural intentions of passengers on safety (Chang, 2012). Therefore, the acceptance and adoption of IoT capabilities are studied under the lens of TAM and TPB, which provides a theoretical rationale for further exploration (Figure 1).

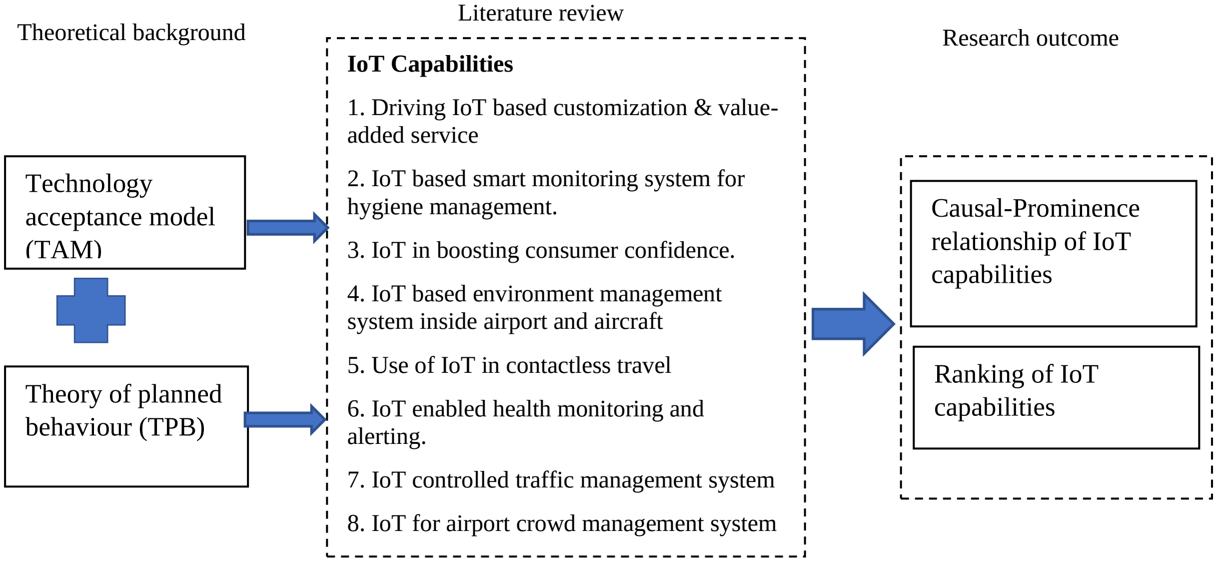

Figure.1 Conceptual framework

2.3 Internet of Things (IoT) and capabilities

IoT can be explained as the internet-enabled technology which ubiquitously connects a network of interconnected physical things embedded with intelligence (Rayes and Salam, 2017). Atzori et al. (2010) have conceptualized IoT as a paradigm constituted by the convergence of three differently oriented perspectives, which represents 'Internet', 'Things', and 'Semantic'. IoT, with dynamic capabilities that combines networking, computation, processing, storage, and retrieval, is technologically equipping industries and organizations to transform their business model in creating value for customers (Gubbi et al, 2013). The increasing applicability of IoT-enabled digital technology in tracking the phase-wise development of infectious diseases has resulted in substantial acceptance healthcare management (Christaki, 2015).

2.4 IoT capabilities for post-pandemic recovery of the airline industry

Table.1: Literature review of IoT capabilities

Sr No.	IOT Capabilities	Reference Code	Literature	Practising airport
1	Driving IoT-based customization at airport/airline for value-added service	IC1	Sohag and Poddar (2020), Mathew et al. (2018), Georgia-Pacific (2020), Choi and Rhee (2014)	Hartsfield-Jackson Atlanta International Airport, Miami International Airport, Hyderabad International Airport
2	IoT-based smart monitoring system for hygiene management.	IC2	Sun and Zhai (2020), Environmental Protection Agency (2018), Lohani and Acharya (2016)	Oliveira, (2020), Drljača et al., (2020)
3	IoT in boosting consumer confidence.	IC3	Fong et al. (2020), Tabares (2020), Nasereddin and Faqir (2019)	Majority of International Airports, Queen Alia International Airport
4	IoT-based environment management system inside airport and aircraft	IC4	IATA (2020a), Deloitte (2020)	Athens International Airport
5	Use of IoT in contactless travel	IC5	Mohamed et al. (2019), Kawamoto et al. (2017)	Helsinki Airport in Finland
6	IoT-enabled health monitoring and alerting	IC6	Chong and Ng (2016), Guo et al. (2014), DFW AIRPORT (2019)	DFW International Airport
7	IoT-controlled traffic management system	IC7	Lee and Lee (2015), Lo and Campos (2018)	Hong Kong International Airport, Most International Airports
8	IoT for airport crowd management system	IC8	Agarwal et al. (2020)	London City Airport, Miami International Airport

2.4.1 Driving IoT-based customization at airport/airline for value-added service

Application of IoT enabled capabilities, when integrated with products and services, can create a personalized and customized experience for consumers to drive value proposition. In addition, the analysis of generated data by sensors may be used in developing value-added services in conjunction with information collaboration to enhance customer satisfaction (Lee and Lee, 2015). Researchers have explored the IoT enabled customer integration and relationship management for driving customer satisfaction for various sectors/industries. It includes understanding customer preference, driving product promotion, customer relationship management of consumer-facing businesses (Lo and Campos, 2018), customer involvement in developing new features to product and service (Haddud et al., 2017), social interaction beyond boundaries (Huang et al., 2018). For example: Creating a centralised data bank supported by IoT sensors, the London City Airport integrates passengers' consumption preference with an offering of customized location-based services (Design News, 2020). IoT enabled sensors connected through mobile application can guide passengers to nearby service facilities like restroom, lounge, shopping centre etc. This concurrently can reduce the need for passenger movement, thereby decreases the chances of aerial transmission while ensuring improved customer satisfaction.

2.4.2 IoT-based smart monitoring system for hygiene management.

Combining the IoT capabilities of smart waste management (Sohag and Poddar, 2020) and healthcare management (Mathew et al., 2018), IoT-based wireless sensor network can be leveraged for smart hygiene monitoring to ensure the cleanliness of the airport facilities and environment. The proposed IoT-enabled hygiene management system is planned to be more efficient than a conventional system as it reduces the need for supervisory manpower for constant monitoring. Advanced sensor technology helps in maintaining sufficient stocks of essential hygiene products (such as toilet paper, hand sanitiser, paper towel) avoiding chances of stock-outs, and sends timely alerts to custodians for refilling, cleaning and/or waste disposal, as the need arises (Choi and Rhee, 2014). In a response to ongoing COVID-19 pandemic, the smart monitoring system designed to efficiently manage the list of cleaning and hygiene management tasks. In addition, managers can monitor and track cleaning, sanitizing, and disinfecting tasks through a hand-held device connected with the network. For example, The KOLO Smart Monitoring System, developed by Georgia Pacific for restroom hygiene management system is an IoT connected product used in Hartsfield-Jackson Atlanta International Airport. Implementation of the same may result in greater hygiene with diminished risk of cross-contamination, which finally can improve travellers' confidence (Georgia-Pacific, 2020) (see Table.1). In a similar advancement, Kimberly-Clark and GOJO Industries have jointly developed IoT based Smart Restroom Management System that can be used in airport facilities to improve customer experience (PR News Wire, 2018).

2.4.3 IoT in boosting travellers' confidence.

Zenker et al. (2021) reported that the pandemic has created deep marks in the travellers cognitive morality pertaining to their travel decisions. In this regard, regaining passenger confidence back in air travel is critically important for the recovery of the airline industry (IATA (2020b). While airline revival continues to remain sluggish during this uncertain time, Deloitte (2020) emphasized that the "new normal" situation should be inspired in instilling confidence with respect to health, hygiene, and safety, among others. It suggests that IoT-enabled digital technologies in facilitating contactless travel, hygiene management, remote healthcare monitoring can substantively boost travellers' confidence. The overall integration of IoT capabilities can create an efficient ecosystem built on greater stakeholder collaboration to enhance responsiveness.

2.4.4 IoT-based environment management system inside airport and aircraft

Indoor ventilation can be susceptible to spreading respiratory infectious disease and carrying the risk of cross-transmission through air-borne routes (Yang et al., 2015). Therefore, maintaining indoor air quality through actively managed smart ventilation system is critical to lessen the spread of COVID-19 infection, especially in confined public spaces, such as airports and aircraft (Sun and Zhai, 2020). In a report released by Environmental Protection Agency (EPA) (2018), it is inferred that the presence of several air pollutants (CO_2, mould, microbial contaminants, organic particles) in indoor air is typically two to five times higher than comparable outdoor air.

IoT-enabled environmental monitoring sensors can be integrated for effective management of the ventilation system (Mahbub et al., 2020) inside airport/airline during COVID-19 pandemic. Connecting these smart devices with centralized facility management controls can ensure timely custodial services for ventilation systems. IoT-based advanced monitoring devices can monitor indoor air quality parameters (such as airflow, relative humidity, CO_2 levels, temperature etc) (Lohani and Acharya, 2016) and trigger autonomous ventilation to keep the indoor environment comfortable for travellers.

2.4.5 Use of IoT in contactless travel

Due to the highly contagious nature of the COVID-19 virus, ensuring a safe social distance between people has proven to be an effective way to control viral infections in communities (Fong et al., 2020). To contain the contagion of the virus, administrations at various (regional/ national/ global) levels have resorted to inhibitory approaches that include limiting social gatherings and time spent in a public place, maintaining sufficient social distancing, wearing masks to suppress the transmission of the virus, especially in crowded settings.

Therefore, touchless travel supported by IoT-powered devices can potentially restrict the spread of the virus by lowering the transactional touchpoints (Agarwal et al., 2020). Globally, airport authorities and airline operators are continuously driving contactless travel experience by eliminating passenger touchpoints using contactless IoT-enabled technologies (Serrano and Kazda, 2020). Wearable IoT devices (IoT smart thermometer, IoT-based smart glasses etc) help in reducing interactions between passenger and airport/airline staff considerably. Robots linked with IoT device can enable touchless biometrics identification by facial image processing to provide document free travel (Tabares, 2020). Biometric and self-service solutions by IoT can handle processes starting from off-airport baggage drop, self-check-in at kiosks, security, immigration, and boarding.

2.4.6 IoT-enabled health monitoring and alerting.

In the fight against COVID-19 pandemic, IoT-enabled technologies are being accepted in healthcare industry due to its wide range of capabilities which include tracking, identification and validation, data collection and authentication (Nasajpour et al., 2020). IoT-based architecture and technology solutions can support in robust monitoring and controlling of COVID-19 with multi-tasking capabilities during the stages of detection, diagnosis, remote monitoring of patients while in quarantine, remote treatment, post-recovery tracking etc (Rahman et al., 2020). For example, IoT wearable wristbands, given to new arrival passengers and connected with healthcare administrative database, has been implemented at Hong Kong International airport (Hui, 2020). It tracks the new arrivals at the airport during the quarantine time of 14 days with the geofencing facility. Similarly, IoT-powered contact-tracing mobile application is one of the most followed interventions to map patient/travellers' contact information at the airport. It enables early alert in case of any contagion to nearby healthcare service centres.

2.4.7 IoT-controlled traffic management system

IoT controlled traffic management system can reduce queueing length and waiting time (Chong and Ng, 2016) for the passengers at the airport. IoT based localization and tracking mechanism is a powerful tool for mapping the movement of passengers with substantial accuracy for indoor application (Guo et al., 2014) with the installation of a large number of sensors (Ramnath et al., 2017). As a testimonial to this, Dallas Fort Worth International Airport (DFW) has implemented IoT-enabled real-time wait technology available through a mobile application, that provides wait time estimation for specific checking lanes to passengers during security check (DFW AIRPORT, 2019). The data gathered by tracking sensors are converted into speed and direction of queue movement, the number of passengers in each line, approximate wait time; and displayed in the monitor to keep the passengers informed to avoid clustering.

2.4.8 IoT for airport crowd management system

According to The Centers for Disease Control and Prevention (2020), crowded enclosed spaces are accompanied with the risk of virus transmission due to high "concentration of suspended small droplets and particles carrying infectious virus". Therefore, to reduce viral transmission, restricting and controlling a limited number of people with safe physical distance is probably one of the most implemented interventions across the globe.

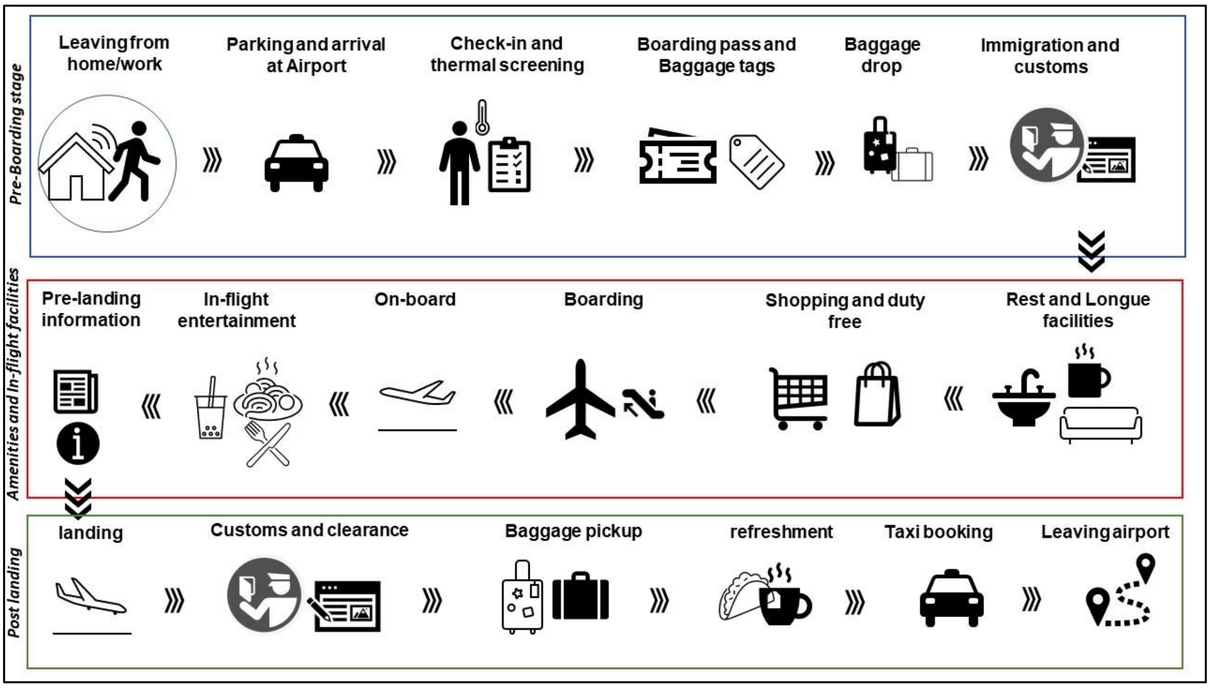

Figure. 2a: Representing the stages of passengers' journey at an airport.

IoT based crowd management system functionally works in three phases. First, the sensors collect the crowd data, then connected middleware analyses the data and notify the administrator with crowd pattern for appropriate action, and finally interface layer performs executable action at the traveller/user end for crowd management (Mohamed et al., 2019). This system guides the air-travellers/passengers with important crowd related information, such as, the flow of passengers, availability of non-crowd spaces, crowd concentration pattern, based on real-time sensor data at the airport (Kawamoto et al., 2017). These IoT based real-time crowd data, when displayed through airport screens, can signal appropriate action for airport management authorities in the distribution of passengers. The multiple stages of passengers' journey at an airport are shown in Figure 2a with potential areas of IoT implementation in Figure 2b.

Passengers → / IoT capability ↓	Leaving from work/home	Parking and arrival at airport	Check-in and thermal screening	Boarding pass and Baggage drop	Immigration and security	Rest and Lounge facilities	Shopping and duty free	Boarding and departure	On-board entertainment	Landing	Customs and baggage claim	Taxi and leaving airport
Driving customization at airport/airline for value-added services		✓		✓		✓	✓		✓		✓	
Smart monitoring system for hygiene management			✓	✓		✓	✓		✓		✓	
Boosting consumer confidence		✓	✓	✓	✓		✓	✓		✓	✓	
Environment management system inside airport and aircraft	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Contactless travel		✓	✓	✓	✓	✓	✓	✓	✓		✓	
Health monitoring and alerting	✓		✓	✓	✓	✓	✓	✓		✓	✓	
Traffic management system	✓	✓										✓
Airport crowd management system		✓	✓		✓			✓		✓		✓

Figure 2b: Potential areas for IoT implementation

We have investigated two important characteristics of the IoT capabilities, termed as 'mutual relationship' and 'uncertainty', from the perspective of the airline/tourism industry. The study aims to propose an IoT capability framework for airport applications to enable the post-pandemic revival of the industry, which largely remains unattended in the empirical literature. First, exploring the 'mutual relationship' among IoT capabilities is important as the exclusion of one capability can enhance or reduce the effect of another capability (Bai and Satir, 2020). A detailed study on interaction effect among IoT capabilities can provide necessary insights on the impact of one IoT capability on others, and how the same capability is being influenced by others. Second, to overcome the issue of inherent intangibility and ambiguity of expression by exact numerical values (Chithambaranathan et al., 2015), a grey-based methodology is adopted.

3. Methodology

A two-phase research methodology has been adopted in this research to establish the inter-relationship among the IoT capabilities that can be leveraged in post-pandemic rebound of airline industry through airport operation (see Figure 3). In the first phase, the relevant IoT capabilities are identified through extensive literature review supported by case studies of airports utilizing the relevant capabilities. During the second phase, the study uses a grey-based DEMATEL method to analyse the complex interrelationships among the IoT capabilities. The use of Multiple Criteria Decision Making (MCDM) approach offers unique advantage of combining quantitative and qualitative aspects of decision-making (Chandrasekaran and Ramesh, 1987). A brief introduction of the framework used in the current study is provided below.

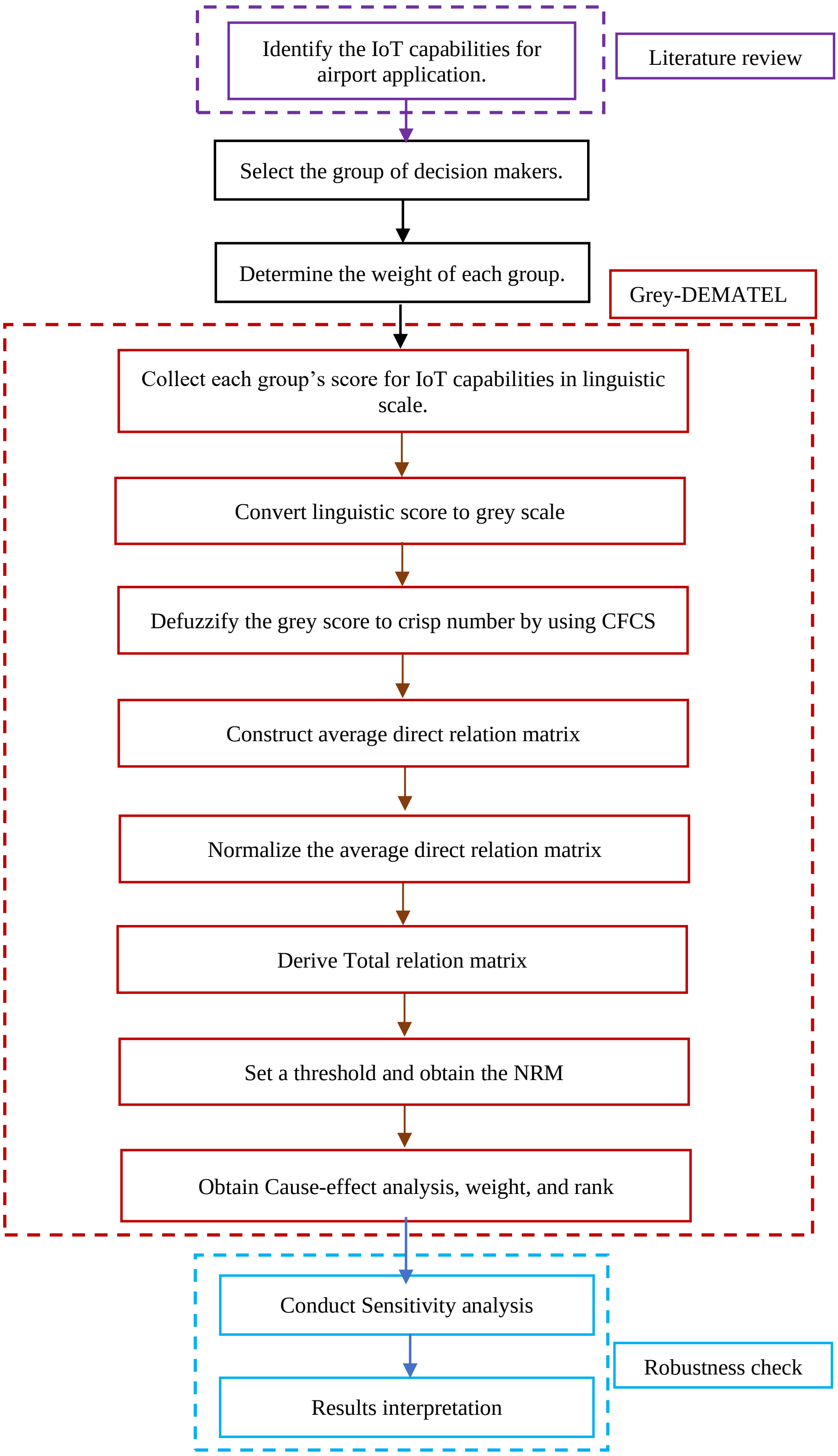

Figure 3. Proposed Grey-DEMATEL framework

3.1 Grey-DEMATEL

The DEMATEL method was proposed by the Geneva Research Centre of the Battelle Memorial Institute (Gabus and Fontela, 1973). DEMATEL is a tool for analyzing the structural interrelationship between decision criteria in terms of Cause-and-Effect diagram and Network Relation Map (NRM). Due to this inherent advantage over other contemporary multi-criterion decision making (MCDM) methods such as analytical hierarchy Process (AHP), interpretive structural modelling (ISM), and analytic network process (ANP) (Dou et al., 2018) DEMATEL has been preferred in multiple management disciplines (Dou et al., 2015), risk management (Tarei et al., 2018), SC complexity (Chand et al., 2020), etc. DEMATEL uses the Decision Maker (DM)'s belief/perception about the degree of influence of one decision criterion/factor over the other, as an input. Due to the real-world uncertainty of the problem and/or limited availability of the expertise information, it has been observed that a DM is often unable to express the influence/score as precise numbers for evaluating decision attributes (Xu and Liao, 2013). To tackle this issue, the grey system theory is used in conjunction with DEMATEL in this study to solve uncertainty problems in cases of discrete data and incomplete information. One of the major benefits of using grey system theory is that it can produce reasonable outcomes using a relatively small size of data or with great variability in factors (Xiao et al., 2012). A grey number can be expressed by an interval of lower value and upper value. To minimize the errors in the individual score/assessment of each DM/expert's score should be aggregated in a Group Decision Making (GDM environment). Methodological steps followed in Grey-DEMATEL are summarized below with detail mention in Section A1 (Appendix).

Step 1: *Construct the DRM in grey pairwise comparison scale.*

Step 2: *Converting fuzzy data into crisp scores (CFCS).*

Step 3: *Aggregation*

Step 4: *Normalization of the defuzzified aggregated IF-relation matrix.*

Step 5: *Obtain the total relation matrix.*

Step 6: *Summation of rows and columns of matrix* ***T*****.**

Step 7: *Set a threshold (alpha) and obtain the Network Relation Map.*

Step 8: Calculation of the importance (weight) of the criteria.

4. Application of the proposed methodology:

Literature review, expert guidance, and airport case studies have been used in the selection and validation of IoT capabilities that can be harnessed in the revival of airport operation during ongoing COVID-19 restrictions. Before the start of collecting responses from decision-makers on the subject, the questionnaire and content was assessed for wording and clarity improvement by three selected academicians from Indian premium management institutes with subject matter experience of more than 15 years. In the next step, the content was reviewed for verifying the clarity of IoT capabilities by four IoT experts from the airport service sector responsible for implementing customer facing IoT solutions for airports. The profile of participated academic (DM9, DM 10, DM11) and industry experts (DM5 to DM8) is presented in Table 2 and acted as decision-making participants in DEMATEL method.

4.1 Selection of decision-makers

Since the airport operation involves multiple stakeholders of the airline industry, it is imperative to include various stakeholders' perspective from the context of traveller, business, economic and public policy (Mitroff and Linstone, 1993). A multi-stakeholder involvement can be an effective way of implementing sustainable tourism practices (Waligo et al., 2013) and innovation for tourism development (Carlisle et al., 2013). Extending the same, decision-makers are purposively selected from four involved groups a) frequent airline travellers (consumers) (Group 1), b) airport facility managers (Group 2), c) industry experts and policymakers (Group 3), and d) academic researchers (Group 4) through convenience sampling method. We emphasized on the adequate participation of decision-makers from each group to ensure a composite outlook on the research objective. To capture a deeper perspective on the topic, decision-makers with more than 10 years of relevant experience are selected in each group. The experience of decision-makers is ranging from a minimum of 12 years to a maximum experience of 27 years (Mean experience: 17.3 years; Standard deviation: 3.98 years) (Table 2).

Table. 2: Group-wise details and decision maker' profile

Sr no. of Groups	Type of decision maker in the group	Decision maker code	Decision maker's profile	Location of discussion	Years of experience (travel/industry)	Number of interviews	Total duration of discussion (in minutes)
Group 1	International travellers	DM 1	Business traveller, associated with a leading Indian IT service firm and responsible for Asia-Pacific Operation	International Airport, Delhi	18	2	60
		DM 2	Frequent flying investment banker, based in Singapore	International Airport, Mumbai	16	1	45
		DM 3	A foreign tourist	International Airport, Mumbai	21	1	30
		DM 4	Head of manufacturing, MNC firm, responsible for European operation	International Airport, Hyderabad	15	1	50
Group 2	Airport facility manager	DM 5	Zonal Head, Airport Operations.	International Airport, Kolkata	22	2	60
		DM 6	Operations Manager, Customer Facility	International Airport, Mumbai	12	1	45
		DM 7	Airport Manager	International Airport, Bangalore	16	1	35
		DM 8	Deputy Manager, Airport Services	International Airport, Hyderabad	14	1	40
Group 3	Industry experts and policy makers	DM 9	Partner, a leading airline advisory firm	New Delhi	27	2	50
		DM 10	Regional Head, Market intelligence, Travel industry.	Mumbai	20	1	40
		DM 11	Internal customer service executive, a Trade Association Body for airline industry	Mumbai	18	1	35
Group 4	Academic researchers	DM 12	Post-graduate fellow, Tourism Management	A premier tourism research institute, North India	15	2	50
		DM 13	Assistant Professor, Consumer Behaviour	Institute responsible for travel and tourism management, Central India	16	1	30
		DM 14	Researcher, Tourism Industry	A leading school for business management, West India	12	2	65

4.2 Data collection

The decision-makers, in this case four groups as represented by international travellers, airport facility managers, industry experts and policymakers, and academic researchers, were approached through multiple contact links such as company website pages, email addresses from professional websites, through an extended professional network. We proposed anonymity of the decision-makers to facilitate the discussion with necessary details. It was also informed that the collected data would solely be used for academic interest while maintaining confidentiality. The response data was collected through an extensive round of interviews and meetings conducted from April 2020 to December 2020. The expert responses were collected through a) meeting in person at the airport, b) online meeting platforms, c) telephonic discussion, d) industrial and promotional events, and e) discussions during conferences and seminars on the related industry. Special efforts were made through phone calls and reminder emails to improve the response rate. The in-person meetings were conducted at five Indian international airports located at New Delhi, Mumbai, Hyderabad, Bangalore, and Kolkata and offices in those cities.

Out of total contacted 36 participants (international travellers: 12, airport facility managers: 8, industry experts and policymakers: 9, and academic researchers: 7), only 14 (international travellers: 4, airport facility managers: 4, industry experts and policymakers: 3, and academic researchers: 3) agreed to participate in the study resulting in participation acceptance ratio near 39%. Reasons cited for declining the participation are largely individual's discretion, lack of interest, non-availability of time. The brief profile of participated decision-makers with corresponding groups is shown in Table 2.

4.3 Data acquisition

Firstly, the participating experts/decision-makers are explained about the background of identified IoT capabilities (Table 1). The enabling the airport operation in restoring travellers' confidence back in airport operations for travel is highlighted as the key context. We applied the Grey-DEMATEL framework for assessing the influential relationship among IoT capabilities. Accordingly, 14 decision-makers who agreed to participate in the interview are requested to complete the pair-wise comparison based on the relative significance of IoT capabilities (IC1 to IC8) as per the individual's assessment. Linguistic terms used for the comparison of IoT capabilities is a five-point scale with N (no influence=0), VL (very low influence=1), L (low influence=2), H (high influence=3), and VH (very high influence=4)

(Table A1). Consequently, pairwise direct relation matrix (8 X 8) for identified 8 IoT capabilities using linguistic terms are obtained for each of 14 participating decision-makers.

4.4 Data Conversion

The pairwise comparison data, collected for 14 decision-makers in linguistic scale, is transformed to a numerical scale by corresponding replacement. This process results in finding 14 matrices (8 X 8) for IoT capabilities (IC1 to IC8) for each of 14 participants (Table 2). First, we calculate the category-wise average direct-relation matrix for four categories (i.e., international travellers, airport facility managers, industry experts and policymakers, and academic researchers) by assigning equal weights to each respondent corresponding to that category. The average direct-relation matrix is attained through the arithmetic mean of expert responses. As an example: To compute the average direct-relation matrix for the group of international travellers, equal weight (=0.25) is given to each participant (DM1 to DM4) (Table 2) in that category. Similarly, to calculate the average direct-relation matrix for the group of industry experts and policymaker's, equal weights (=0.33) are given individually to three participating experts levelled as DM 9, DM10, DM11. The Direct-relation matrix (at the aggregated level) is presented in Table A2. Applying mathematical operation as suggested in appendix equation A9 and A10, we obtain the aggregated Normalized-relation matrix (Table A3). Thereafter, the aggregated Total-relation matrix (Table 3) combining all four groups are determined by assigning group-wise equal weight (w=0.25) to each of all four representing groups.

Table. 3: Aggregated total relationship matrix (a= 0.421)

	IoT capabilities							
	IC 1	**IC 2**	**IC 3**	**IC 4**	**IC 5**	**IC 6**	**IC 7**	**IC 8**
IC 1	0.3077	0.4138	0.5839	0.504	0.5091	0.4123	0.4426	0.3563
IC 2	0.4463	0.3139	0.5864	0.5569	0.568	0.3951	0.4458	0.5023
IC 3	0.3622	0.2912	0.3667	0.4695	0.4145	0.384	0.2663	0.3877
IC 4	0.2597	0.2183	0.3284	0.2571	0.3305	0.2834	0.2982	0.3034
IC 5	0.3333	0.4028	0.5948	0.4746	0.3835	0.4266	0.3839	0.391
IC 6	0.4634	0.4056	0.6152	0.5435	0.5676	0.3491	0.4026	0.473
IC 7	0.3747	0.3186	0.5319	0.5305	0.5294	0.4222	0.3007	0.4705
IC 8	0.4398	0.4354	0.6475	0.5254	0.5747	0.4294	0.4314	0.3879

4.5 Graphical representation

The total-relation matrix for each category is transformed to develop causal/influential relationships among IoT capabilities. Relationships carrying more than a threshold value (a=0.421) is important in developing a network relation map (NRM). The a-cut Total-relation matrix (aggregated level) with corresponding values of elements is shown in Table A4. The group-wise influential relationship is obtained from the D+R score (prominence) and D-R score (net cause/effect). While the D+R score is plotted against the horizontal axis, the vertical axis represents the D-R score. The prominence-causal relationship of IoT capabilities as evaluated by international travellers is shown in Figure 4a. Uni-directional arrow suggests the one-way directional causality while the bi-directional arrow indicates two-way influential relation among barriers. Likewise, prominence-causal diagraphs of IoT capabilities for other three groups of participants constituted by airport facility managers, industry experts and policymakers, and academic researchers, respectively are developed (Figure 4b-4d) based on corresponding D+R and D-R score. The aggregated prominence-causal digraph representing all four groups is shown in Figure 5.

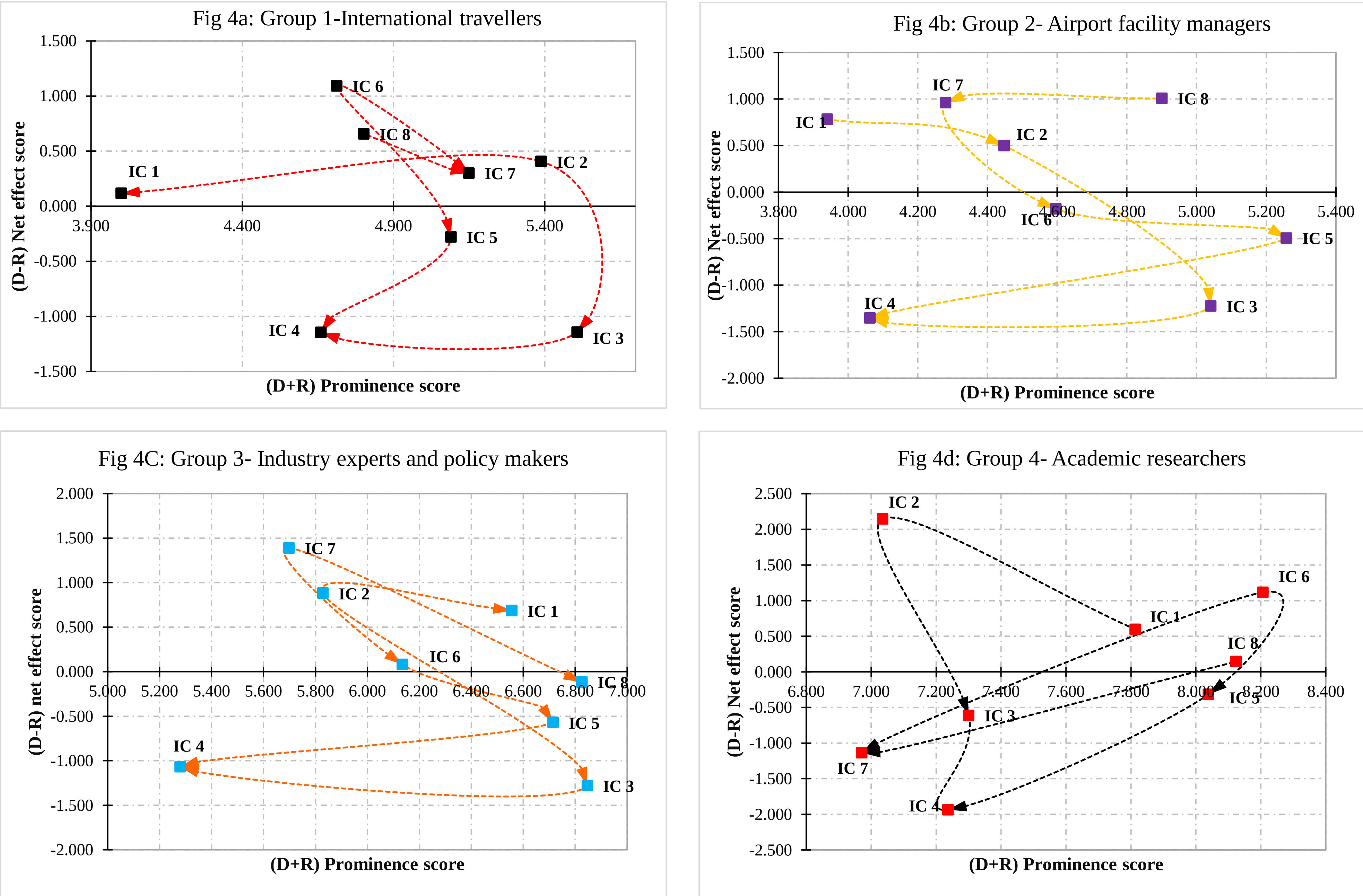
Fig 4a: Group 1-International travellers
(D-R) Net effect score
(D+R) Prominence score
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
3.900
4.400
4.900
5.400
IC 1
IC 2
IC 3
IC 4
IC 5
IC 6
IC 7
IC 8
Fig 4b: Group 2- Airport facility managers
(D-R) Net effect score
(D+R) Prominence score
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
-2.000
3.800
4.000
4.200
4.400
4.600
4.800
5.000
5.200
5.400
IC 1
IC 2
IC 3
IC 4
IC 5
IC 6
IC 7
IC 8
Fig 4C: Group 3- Industry experts and policy makers
(D-R) net effect score
(D+R) Prominence score
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
-2.000
5.000
5.200
5.400
5.600
5.800
6.000
6.200
6.400
6.600
6.800
7.000
IC 1
IC 2
IC 3
IC 4
IC 5
IC 6
IC 7
IC 8
Fig 4d: Group 4- Academic researchers
(D-R) Net effect score
(D+R) Prominence score
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
-2.000
-2.500
6.800
7.000
7.200
7.400
7.600
7.800
8.000
8.200
8.400
IC 1
IC 2
IC 3
IC 4
IC 5
IC 6
IC 7
IC 8

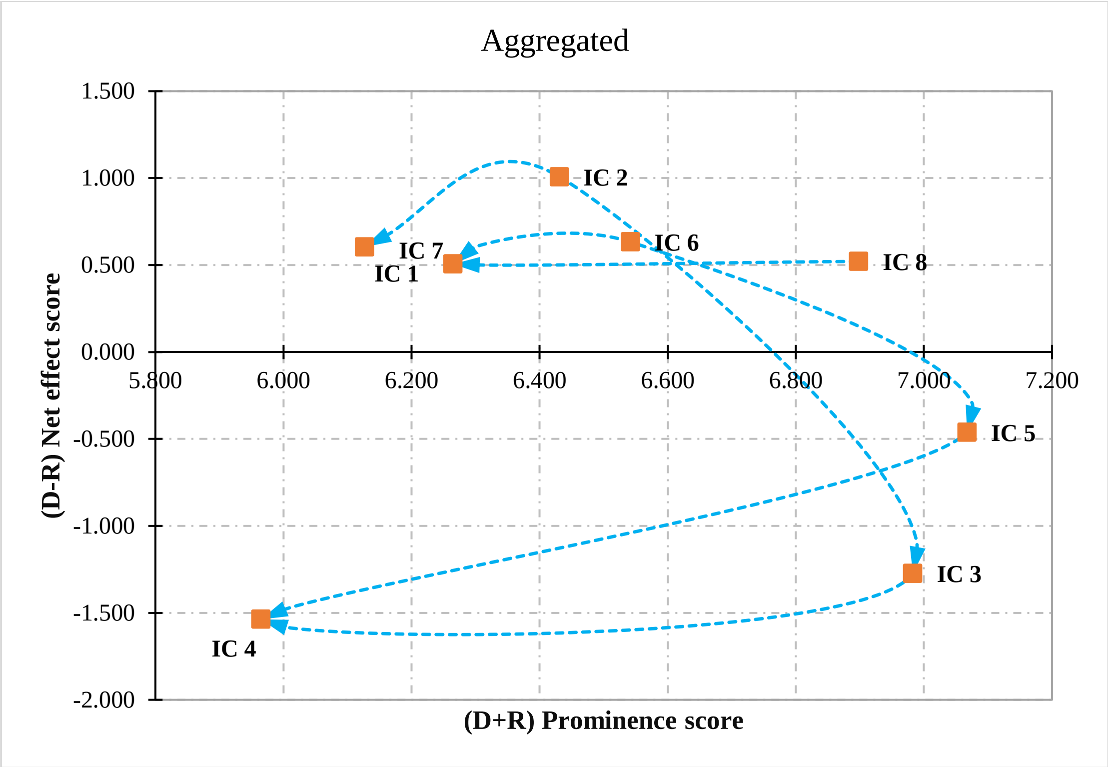

Figure 5. Aggregated cause and effect diagram of IoT capabilities

At the aggregated level, the NRM of the IoT capabilities is displayed in Figure 6. NRM at an individual group of decision-makers is presented in appendices (Figure A1).

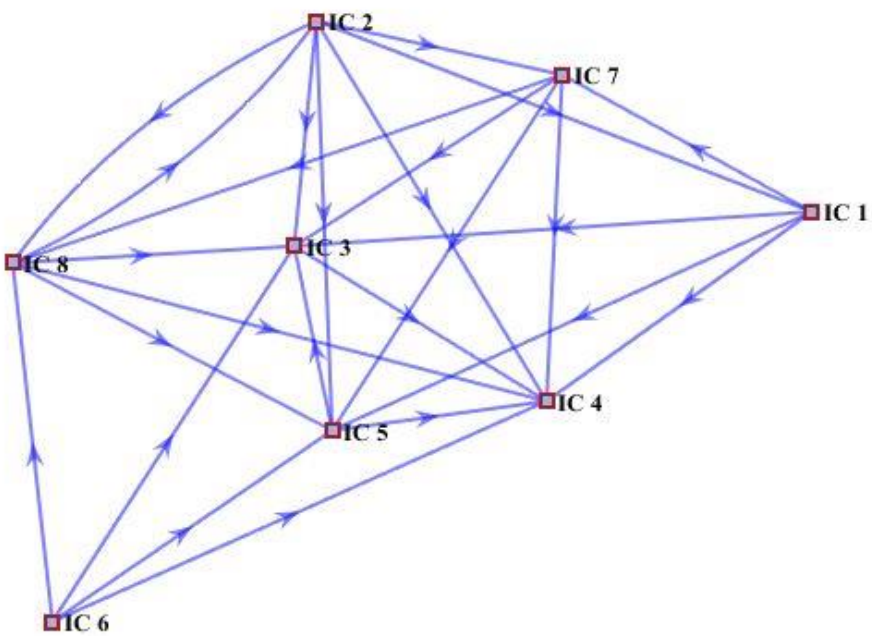

Figure 6. Network relationship map (NRM) of IoT capabilities

5. Results and discussion

5.1 Explanation of basic results

From the prominence-causal (D+R Vs D-R score) relationship of IoT capabilities at an aggregated level (Figure 5) involving four categories of decision-makers, it is evident that capabilities IC1, IC2, IC6, IC7, and IC8 forms the causal group and plays a relatively higher foundational role in the development of other capabilities (IC3, IC4, IC5). The effect group IoT capabilities is represented by IC3, IC4, and IC5. Further, based on the D+R score which suggests the prominence level, IoT capabilities are arranged in decreasing order of prominence starting with most prominent to ending with least important as IC3> IC5> IC8> IC6> IC2> IC1> IC7> IC4. On an aggregated basis, it can be inferred that IoT capabilities applied to Boosting traveller confidence (IC3), Contactless travel (IC5), Airport crowd management system (IC8) the three most prominent capabilities playing important role in developing the overall structure of IoT capabilities.

The prominence-causal relationship among IoT capabilities for the four group of decision-makers levelled as Group 1, Group 2, Group 3, and Group 4 is graphically presented in Figure 4a-4d, respectively. Notably, IoT capabilities in Boosting travellers' confidence (IC3), Environment management system inside airport and aircraft (IC4), and Contactless travel (IC5), are the common three effected capabilities across all four groups. Likewise, IoT capabilities in Driving IoT-based customization at airport/airline for value-added service (IC 1) and Smart monitoring system for hygiene management (IC 2) are two capabilities serving as causal antecedents as identified by all groups. It is worthwhile to mention that two IoT capabilities in Contactless travel (IC5) and Airport crowd management system (IC 8) are regarded to possess higher prominence as evaluated by group 2, group 3, and group 4.

5.2 Ranking of IoT capabilities

IoT capabilities are ranked based on their relative prominence as assigned by an individual group of decision-makers. The rank is calculated using D+R and D-R score as per the appendix equations A15 and A16. Group-wise prominence and net cause/effect values for the IoT capabilities (with corresponding weight, and rank) are shown in Table 4. The weight and ranking of IoT capabilities at an aggregated level graphically presented in Figure 7, and is provided in appendices (Table A5). The relative positional convergence in the rank of IoT capabilities for at least three groups can be observed for IoT capabilities as represented by IC2, IC3, IC4, IC5 and IC8. The divergence of ranking for remaining IoT capabilities IC1, IC6 and

IC7 indicate the variation in the relative importance of capabilities when viewed from a different groups' perspective.

Table.4 Group-wise prominence and net cause/effect values for the IoT capabilities

	Group 1 (International travelers)					Group 2 (airport facility managers)					Group 3 (industry experts and policy makers)					Group 4 (academic researchers)				
Criteria	**D+R**	**D-R**	**Type**	**Weight**	**Rank**	**D+R**	**D-R**	**Type**	**Weight**	**Rank**	**D+R**	**D-R**	**Type**	**Weight**	**Rank**	**D+R**	**D-R**	**Type**	**Weight**	**Rank**
IC 1	4.000	0.116	Cause	4.002	8	3.940	0.783	Cause	4.017	8	6.556	0.686	Cause	6.591	4	7.814	0.596	Cause	7.837	4
IC 2	5.388	0.406	Cause	5.403	2	4.448	0.499	Cause	4.476	5	5.829	0.882	Cause	5.895	6	7.035	2.144	Cause	7.355	6
IC 3	5.507	-1.144	Effect	5.625	1	5.041	-1.225	Effect	5.187	2	6.847	-1.280	Effect	6.965	1	7.301	-0.612	Effect	7.326	7
IC 4	4.661	-1.147	Effect	4.800	7	4.062	-1.354	Effect	4.282	7	5.280	-1.069	Effect	5.387	8	7.237	-1.935	Effect	7.491	5
IC 5	5.090	-0.279	Effect	5.098	4	5.258	-0.494	Effect	5.281	1	6.714	-0.569	Effect	6.739	3	8.039	-0.317	Effect	8.045	3
IC 6	4.712	1.092	Cause	4.837	6	4.596	-0.181	Effect	4.600	4	6.135	0.080	Cause	6.136	5	8.206	1.116	Cause	8.282	1
IC 7	5.150	0.299	Cause	5.158	3	4.280	0.963	Cause	4.387	6	5.699	1.388	Cause	5.865	7	6.971	-1.136	Effect	7.063	8
IC 8	4.802	0.657	Cause	4.847	5	4.901	1.008	Cause	5.003	3	6.826	-0.117	Effect	6.827	2	8.124	0.142	Cause	8.125	2

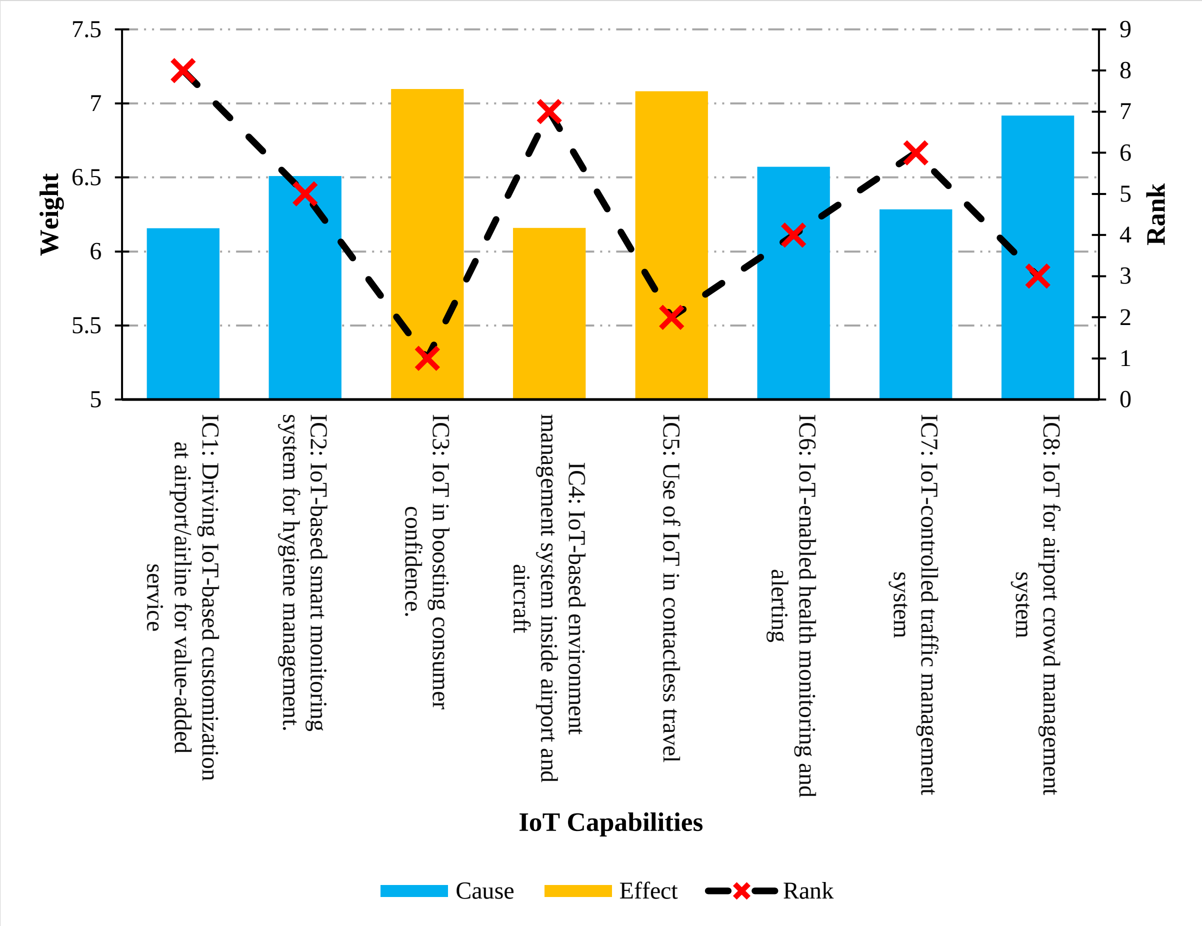

Figure 7. Aggregated weights and ranks of IoT capabilities.

5.3 Sensitivity analysis (SA)

The MCDM technique tends to rely on the subjective judgment of the decision-makers based on their individual perspective of the content. To eliminate the influential bias of any individual and to ensure the robustness of the result, a sensitivity analysis (SA) was performed (Rajesh and Ravi 2015). SA is performed by assigning relatively higher weight (0.5) to a specific group and by equally distributing the remaining weight to (0.1666) other three groups. This is aimed to check the impact of any group of decision makers on the overall outcome in ranks of IoT capabilities. In our research, participating decision makers are clustered in four groups. In the first run of sensitivity analysis (SA1), we assign a weight of 0.5 to the group 1 pertaining to the international travelers to verify its impact, with a weight of 0.1666 to the remaining groups (group 2, group 3, and group 4). With this weight adjustment, the change in rank of IoT capabilities is observed. Similarly, in the subsequent settings for sensitivity analysis levelled as SA2, SA3 and SA4, the weight of group 2, group 3, and group 4 respectively is increased to 0.5 with the corresponding adjustment of weights for the other groups (Figure 8).

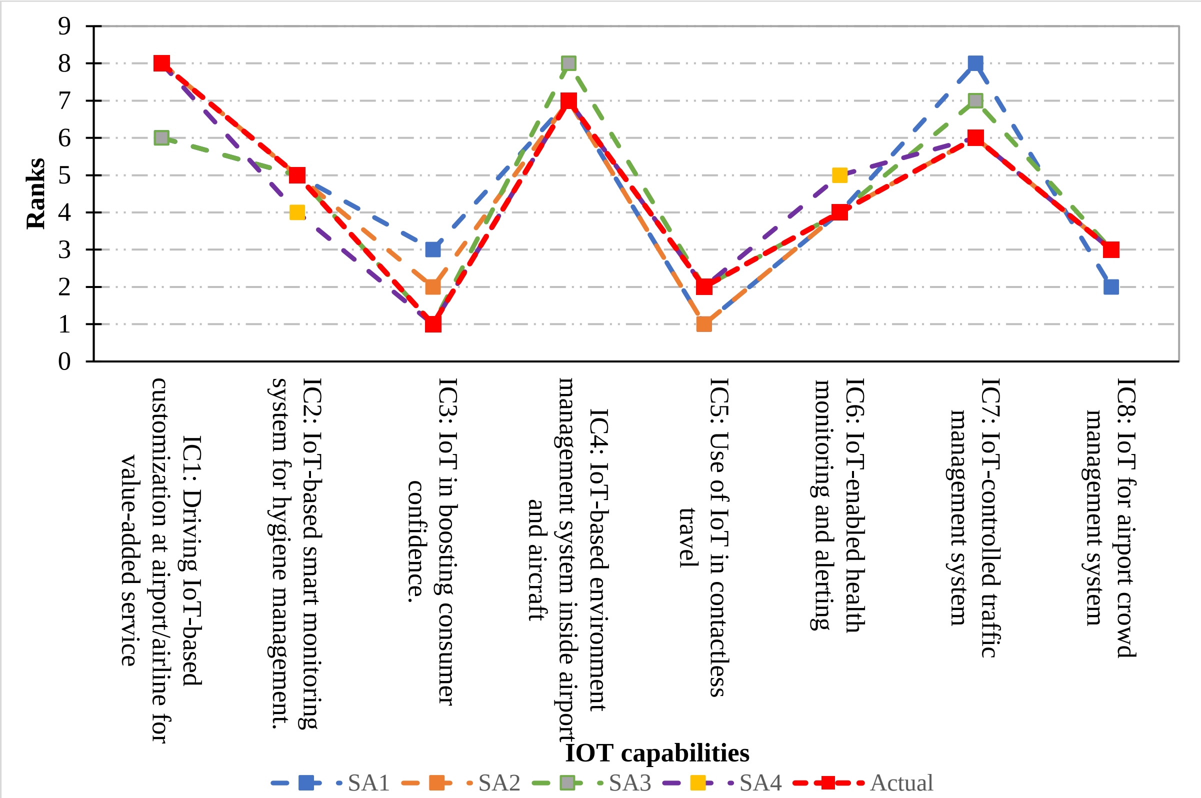

Figure 8. Sensitivity analysis

The considerable consistency observed in ranks of IoT capabilities is graphically shown in Figure 8. It suggests the absence of significant bias in decision-making. The detailed Cause-Effect analysis for all four scenarios, and the corresponding ranking of IoT capabilities are shown in appendices (Table A6). The stability in the cause-effect relationship and consistency in relative ranking among IoT capabilities render soundness to the research model and results.

5.4 Discussion

5.4.1 IoT in boosting travellers' confidence.

According to our research, use of IoT in Boosting travellers' confidence (IC3) is recognized to be one of the most prominent capabilities as regarded by multiple decision-making groups (Fig 4a-4d). This capability is often dependent on various other causal capabilities related to health monitoring, hygiene management, value-added services, among others. Given its significance on the overall context, multiple IoT based capabilities should be made in restoring confidence among passengers/travellers/consumers in air travel starting with the airport. This research outcome is in accordance with the survey conducted by IATA (2020a) involving passengers across 11 countries around the globe, which highlighted the growing need for bringing back the travellers' confidence in air-travel which is a fundamental driver for the airline industry.

The impact of the pandemic has resulted in several behavioural changes among travellers driven by psychological and social risk perception (Li et al., 2020). Therefore, with support to TPB, use of IoT in boosting travellers' confidence might result in reshaping the behavioural intention and attitude towards air travel. During our discussion with an expert on airports systems associated with a leading airline advisory firm commented, "The revival of the airline industry largely depends on regaining the confidence of customers in air travel. All the stakeholders of the industry, such as, airline companies, airport agencies, government policy-making bodies, healthcare systems, hospitality services should work cohesively in helping the travellers in coming back to the airport. Technology can certainly enable this transition."

5.4.2 Use of IoT in contactless travel

The importance of touchless travel supported by IoT-powered devices is one of the most widely acknowledged capabilities across all groups of decision-makers. This can potentially contain the spread of the virus by lowering the transactional touchpoints during travel and reduces the risk of community-spread (Fong et al., 2020). This finding corroborates the global acceptance of IoT-powered devices by airport authorities and airline operators using contactless IoT-enabled technologies (Serrano and Kazda, 2020). The operation manager of an international airport facility management company opined, "Contactless travel is going to be new normal in times to come, at least in the medium term. Hence, technologies that can facilitate in this direction will be welcome. It will also enhance travellers' confidence in air travel. Airports also can play a vital role in implementing IoT-based services towards that."

5.4.3 Application of IoT in causal capabilities

Analysis of causal IoT capabilities at the individual group level (Figure 4a-4d) indicates that Driving IoT-based customization for value-added service (IC1) and IoT-based smart monitoring system for hygiene management (IC2) are two commonly accepted capabilities. In addition, on an aggregated level, IoT capabilities represented by IC6, IC7, IC8 also acts as an enabler in generating effected capabilities (IC3. IC4, IC5). The causation arcs directing causal to effect IoT capabilities (Figure 5) suggest that controlling the causal group of capabilities can meaningfully help in managing the effect capabilities. Therefore, it can be argued that the adoption of causal capabilities (IC1, IC2, IC6, IC7, IC8) may facilitate the acceptance of resulting capabilities (IC3, IC4, IC5). The causal capabilities emphasize potential applicability and usefulness of IoT enabled products and services in support to TAM. Extending the tenets of TAM, it can be inferred that the ease and prospective usefulness of IoT-enabled solutions can encourage in travellers' confidence, which is likely to determine the attitude and behavioural intention of travellers' towards the adoption of the same (Hsiao and Tang, 2015).

6. Research implications

This research contributes to the ongoing discourse in proposing IoT-enabled forward-looking response strategies in revival of airline industry (Bodolica et al., 2021). The current study unpacks the IoT capabilities that can be extended for the airline industry in restoring travellers' confidence during the ongoing pandemic, which largely remains unattended in the empirical literature (Garrow and Lurkin, 2021). First, this study contributes towards exploring IoT capabilities at multiple airport services to facilitate the change in travellers' behaviour and attitude owing to behavioural restrictions during the pandemic. To that extent, the research outcome furthers the application of advanced information technologies to enable touchless air travel (Buhalis, 2004). Second, our research identifies the possible areas of IoT application in building customer trust while pandemic-driven travel restrictions are still in place at a varying level. Third, our analysis prioritizes the IoT-based digital initiatives adopted by airports and the airline industry. It also establishes the mutual relationship among capabilities. In addition, this study provides several important scholarly and managerial implication.

6.1. Theoretical implications

The important research question which we wanted to examine is to explore the possibilities of applying IoT-enabled capabilities in airport services in regaining travellers' faith towards the airline industry which starts at the airport. While IoT enabled technologies find multiple applications in various healthcare and airline industry independently, the usage of the same in airport services are still limited. Especially, with changing travellers' behaviour in a post-pandemic new-normal scenario, there is a growing need to revisit in the adoption of technologies in enabling the travel industry. It is important to note that the technological acceptance of IoT capabilities should be studied considering the socio-behavioural change in traveller/passenger attitude. Therefore, we applied the combined theoretical lens of TAM and TPB to explicate the adoption of IoT capabilities with changing behavioural intention. Saliently, this investigation provides novel theoretical underpinning where IoT capabilities are studied with TAM and TBP perspective.

Notably, we have established the causal-effect relationship and level of importance among the IoT capabilities which can be a starting point. Network relationship map (NRM) provides a theoretical ground for inter-relationship study among the IoT capabilities while studied from the traveller's perspective. The inclusion of multiple decision-making groups is likely to provide comprehensiveness in deciding the NRM. In addition, the robustness of result as validated by sensitivity analysis proves soundness to the theoretical framework.

6.2. Managerial implications

By investigating the importance of IoT capabilities in re-establishing travellers' confidence in airline travel, this research supports business leaders in informed decision-making towards developing IoT competence for airport operations. The causal-prominence relationship may guide practitioners in enabling the key causal IoT capabilities, as facilitating them can meaningfully improve the possibility of other effected capabilities generated from the former. The study can guide the airport management companies in prioritizing and developing the crucial IoT capabilities. Accordingly, the research outcome might help airport facility managers in allocating operating and financial resources in building the IoT capabilities. Additionally, it provides an integrated framework to guide airport authorities in implementing the measures to fight against pandemic for speedier recovery (Lohmann and Pereira, 2020).

In addition, the preference of IoT capabilities as specified by international travellers (group 1 of decision makers) tends to suggest the indicative nature of priorities from consumer acceptance perspective. Therefore, this can provide a starting point for analysing the ease of acceptance of IoT capabilities based on TAM. In addition, while airports can plan to develop IoT capabilities, it can also focus on creating tutorials on IoT capabilities to improve the ease of acceptance.

Apart from monitoring the passenger's movement and assets utilization, these technologies can be used to provide faster response to emerging threats, errors, or downtime. In addition, these IoT enabled devices collect huge data, which can be used to explore the travelling behaviours of passengers such as shopping activities. Based on travellers' behavioural pattern as emphasized in TPB, customized airport management services can be designed in alignment with the frequent patterns emerged from the analysis (Lee and Lee, 2015). In fact, the findings have discussed some areas of IoT proved to be beneficial for airline industry and highlighted the potential areas for boosting travellers' confidence.

From a policy standpoint, this framework can be successfully applied on the upcoming airport projects to equip with discussed IoT capabilities. Also, with these connected technologies, customers feel connected because they can report problems and track status in real-time, which may help them to proactively look for information. Airlines on the other hand can use all this information to personalise on-board services. Consequently, IoT capabilities might empower airline industry to effectively balance various processes and resources in driving operational excellence.

7. Limitations and future research

Although significant findings are presented in this study, there are certain limitations. First, there may be several factors that drive customer confidence in air travel. Our study is limited to exploring only IoT capabilities in airport applications to restore public confidence. Future research can investigate the drivers that can meaningfully improve behavioural intention for accessing airport services. Second, the findings of the study are based on responses from a limited number of decision makers from one country involving four groups of stakeholders. Using the framework, further research involving a larger sample size with wider stakeholder participation expanding to other geographies can be explored before sufficient generalization. Third, the effect of other technologies on customers' behavioural intention towards acceptance of IoT capabilities is outside the purview of this research.

The ongoing research on IoT with growing acceptance in multiple applications may open possibilities for newer capabilities in airport services. This can potentially create avenues for greater revenue generation. The effect of external factors on acceptance of these capabilities are beyond the scope of this research. Hence future study can explicate the factors which can have resulting impact on customer acceptance. Besides, the application of IoT capabilities in conjunction with Artificial Intelligence (AI), Machine Learning (ML), Robotic Process Automation (RPA) can be an interesting area to explore in the revival of consumer sentiment in airport operations (Buhalis, 2004). This framework can also be extended for service industries sharing similar sector dynamics.

References

Agarwal, S., Punn, N. S., Sonbhadra, S. K., Nagabhushan, P., Pandian, K. K., & Saxena, P. (2020). Unleashing the power of disruptive and emerging technologies amid COVID 2019: A detailed review. arXiv preprint arXiv:2005.11507.

Ahmad, M., Iram, K., & Jabeen, G. (2020). Perception-based influence factors of intention to adopt COVID-19 epidemic prevention in China. *Environmental research, 190*, 109995.

Airports Authority of India (2017). Regional Connectivity Scheme - UDAN. Retrieved January 23, 2021, from https://www.aai.aero/en/rcsudan

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50(2),* 179-211.

Amankwah-Amoah, J. (2016). Ebola and global airline business: An integrated framework of companies' responses to adverse environmental shock. *Thunderbird International Business Review*, 58(5), 385-397.

Amankwah-Amoah, J. (2020). Stepping up and stepping out of COVID-19: New challenges for environmental sustainability policies in the global airline industry. *Journal of Cleaner Production*, *271*, 123000.

Arora, T., & Grey, I. (2020). Health behaviour changes during COVID-19 and the potential consequences: A mini-review. *Journal of health psychology*, *25*(9), 1155-1163.

Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer networks*, *54(15),* 2787-2805.

Bai, C., & Satir, A. (2020). Evaluating green supplier satisfaction. *Modern Supply Chain Research and Applications*.

Bianchi, C., Milberg, S., & Cúneo, A. (2017). Understanding travelers' intentions to visit a short versus long-haul emerging vacation destination: The case of Chile. *Tourism Management*, 59, 312-324.

Bodolica, V., Spraggon, M., & Khaddage-Soboh, N. (2021). Air-travel services industry in the post-COVID-19: the GPS (Guard-Potentiate-Shape) model for crisis navigation. *Tourism Review*, *76*(4), 942-961.

Bogicevic, V., Yang, W., Cobanoglu, C., Bilgihan, A., & Bujisic, M. (2016). Traveler anxiety and enjoyment: The effect of airport environment on traveler's emotions. *Journal of Air Transport Management*, *57*, 122-129.

Buhalis, D. (2004). eAirlines: strategic and tactical use of ICTs in the airline industry. *Information & Management*, *41*(7), 805-825.

Carlisle, S., Kunc, M., Jones, E., & Tiffin, S. (2013). Supporting innovation for tourism development through multi-stakeholder approaches: Experiences from Africa. *Tourism Management, 35,* 59-69.

Chand, P., Thakkar, J. J., & Ghosh, K. K. (2020). Analysis of supply chain sustainability with supply chain complexity, inter-relationship study using delphi and interpretive structural modeling for Indian mining and earthmoving machinery industry. *Resources Policy*, *68*, 101726.

Chandrasekaran, G., & Ramesh, R. (1987). Microcomputer based multiple criteria decision support system for strategic planning. *Information & Management*, *12*(4), 163-172.

Chang, Y. C. (2012). Cabin safety behavioral intentions of passengers with reduced mobility. *Journal of Air Transport Management, 25,* 64-66.

Chithambaranathan, P., Subramanian, N., Gunasekaran, A., & Palaniappan, P. K. (2015). Service supply chain environmental performance evaluation using grey based hybrid MCDM approach. *International Journal of Production Economics*, *166*, 163-176.

Choi, H. S., & Rhee, W. S. (2014). IoT-based user-driven service modeling environment for a smart space management system. *Sensors, 14(11),* 22039-22064.

Chong, H. F., & Ng, D. W. K. (2016, December). Development of IoT device for traffic management system. In 2016 IEEE Student Conference on Research and Development (SCOReD) (pp. 1-6). IEEE.

Christaki, E. (2015). New technologies in predicting, preventing and controlling emerging infectious diseases. *Virulence, 6(6),* 558-565.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly,* 319-340.

Deloitte (2020). Covid-19 Induced Business Trends: Preparing for the new normal. Retrieved 02.01.2021, from: https://www2.deloitte.com/content/dam/Deloitte/de/Documents/covid-19-induced-business-trends-deloitte-whitepaper.pdf

Design News (2020). Airlines Use IOT Playbook to Battle COVID-19. Retrieved 19.12.2020, from: https://www.designnews.com/aerospace/airlines-use-iot-playbook-battle-covid-19

DFW AIRPORT (2019). DFW Airport Mobile App Now Displaying Real Time Security Wait Times. Retrieved 02.01.2021, from: http://dfwairport.mediaroom.com/DFW-Airport-Mobile-App-Now-Displaying-Real-Time-Security-Wait-Times.

Dorsemaine, B., Gaulier, J. P., Wary, J. P., Kheir, N., & Urien, P. (2015, September). Internet of things: a definition & taxonomy. In 2015 9th International Conference on Next Generation Mobile Applications, *Services and Technologies (pp. 72-77).* IEEE.

Dou, Y., Zhu, Q., & Sarkis, J. (2015). Integrating strategic carbon management into formal evaluation of environmental supplier development programs. *Business Strategy and the Environment*, *24(8),* 873-891.

Dou, Y., Zhu, Q., & Sarkis, J. (2018). Green multi-tier supply chain management: An enabler investigation. *Journal of Purchasing and Supply Management*, *24(2),* 95-107.

Drljača, M., Štimac, I., Bračić, M., & Petar, S. (2020). The Role and Influence of Industry 4.0. in Airport Operations in the Context of COVID-19. *Sustainability*, *12(24)*, 10614.

Environmental Protection Agency (EPA) (2018). Retrieved 02.01.2021, from: https://www.epa.gov/report-environment/indoor-air-quality.

Fong, S. J., Dey, N., & Chaki, J. (2020). AI-enabled technologies that fight the coronavirus outbreak. In *Artificial Intelligence for Coronavirus Outbreak* (pp. 23-45). Springer, Singapore.

Gabus, A., & Fontela, E. (1973). Perceptions of the world problematique: Communication procedure, communicating with those bearing collective responsibility. *Battelle Geneva Research Centre, Geneva, Switzerland*.

Gao, L., & Bai, X. (2014). A unified perspective on the factors influencing consumer acceptance of internet of things technology. *Asia Pacific Journal of Marketing and Logistics*.

Garrow, L. and Lurkin, V. (2021), "How COVID-19 is impacting and reshaping the airline industry", *Journal of Revenue and Pricing Management*, *20*(1), 3-9.

Georgia-Pacific (2020). Retrieved 02.01.2021, from: https://www.gppro.com/gp/solutions/kolo-smart-monitoring-system.

Goasduff, L. (2019). Gartner Says 5.8 Billion Enterprise and Automotive IoT Endpoints Will Be in Use in 2020. Retrieved 02.04.2020, from: < https://www.gartner.com/en/newsroom/press-releases/2019-08-29-gartner-says-5-8-billion-enterprise-and-automotive-io>.

Gostin, L. O., & Wiley, L. F. (2020). Governmental public health powers during the COVID-19 pandemic: stay-at-home orders, business closures, and travel restrictions. *Jama*, 323(21), 2137-2138.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future generation computer systems*, *29(7),* 1645-1660.

Guo, J., Zhang, H., Sun, Y., & Bie, R. (2014). Square-root unscented Kalman filtering-based localization and tracking in the Internet of Things. *Personal and ubiquitous computing*, 18(4), 987-996.

Haddud, A., DeSouza, A., Khare, A., & Lee, H. (2017). Examining potential benefits and challenges associated with the Internet of Things integration in supply chains. *Journal of Manufacturing Technology Management, 28(8)*, 1055–1085.

Hsiao, C. H., & Tang, K. Y. (2015). Investigating factors affecting the acceptance of self-service technology in libraries. *Library Hi Tech*.

Huang, W. J., Xiao, H., & Wang, S. (2018). Airports as liminal space. *Annals of Tourism Research*, *70*, 1-13.

Hui, M. (2020). Hong Kong is using tracker wristbands to geofence people under coronavirus quarantine. Quartz, March.

IATA (2020a). Economic Performance of the Airline Industry. Retrieved 02.12.2020, from: https://www.iata.org/en/iata-repository/publications/economic-reports/airline-industry-economic-performance-june-2020-report/.

IATA (2020b). Passenger confidence is fundamental to the recovery in air travel. Retrieved 12.12.2020, from: https://www.iata.org/en/iata-repository/publications/economic-reports/Passenger-confidence-is-fundamental-to-the-recovery-in-air-travel/.

Jankowski, S., Covello, J., Bellini, H., Ritchie, J., & Costa, D. (2014). The Internet of Things: Making sense of the next mega-trend. *Goldman Sachs.*

Joachim, V., Spieth, P., & Heidenreich, S. (2018). Active innovation resistance: An empirical study on functional and psychological barriers to innovation adoption in different contexts. *Industrial Marketing Management*, *71*, 95-107.

Kaczmarek, T., Perez, K., Demir, E., & Zaremba, A. (2021). How to survive a pandemic: The corporate resiliency of travel and leisure companies to the COVID-19 outbreak. *Tourism Management*, 84, 104281.

Kalakou, S., & Moura, F. (2015). Modelling passengers' activity choice in airport terminal before the security checkpoint: the case of Portela airport in Lisbon. *Transportation Research Procedia*, *10*, 881-890.

Kawamoto, Y., Yamada, N., Nishiyama, H., Kato, N., Shimizu, Y., & Zheng, Y. (2017). A Feedback Control-Based Crowd Dynamics Management in IoT System. *IEEE Internet of Things Journal*, 4(5), 1466–1476.

Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons*, *58(4)*, 431–440.

Li, Z., Zhang, S., Liu, X., Kozak, M., & Wen, J. (2020). Seeing the invisible hand: Underlying effects of COVID-19 on tourists' behavioral patterns. *Journal of Destination Marketing & Management*, 18, 100502.

Lo, F.-Y., & Campos, N. (2018). Blending Internet-of-Things (IoT) solutions into relationship marketing strategies. *Technological Forecasting and Social Change, 137*, 10–18.

Lohani, D., & Acharya, D. (2016, June). Smartvent: A context aware iot system to measure indoor air quality and ventilation rate. In 2016 17th IEEE International Conference on Mobile Data Management (MDM) (Vol. 2, pp. 64-69). IEEE.

Lohmann, G. and Pereira, B.A. (2020), "Air transport innovations: a perspective article", *Tourism Review, 75(*1), 95-101.

Mahbub, M., Hossain, M. M., & Gazi, M. S. A. (2020). IoT-Cognizant cloud-assisted energy efficient embedded system for indoor intelligent lighting, air quality monitoring, and ventilation. *Internet of Things*, 11, 100266.

Martin, A., Markhvida, M., Hallegatte, S., Walsh, B. (2020). Socio-Economic Impacts of COVID-19 on Household Consumption and Poverty. *Economics of Disasters and Climate Change* 4, 453–479.

Mathew, P. S., Pillai, A. S., & Palade, V. (2018). Applications of IoT in healthcare. In Cognitive Computing for Big Data Systems Over IoT (pp. 263-288). Springer, Cham.

Min, S., So, K. K. F., & Jeong, M. (2019). Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. *Journal of Travel & Tourism Marketing, 36(7),* 770-783.

Mitroff, I. I., & Linstone, H. A. (1993). The Unbounded Mind: Breaking the Chains of Traditional Business Thinking. New York: Oxford University Press.

Mohamed, M. F., Shabayek, A. E. R., & El-Gayyar, M. (2019). IoT-Based Framework for Crowd Management. In Mobile Solutions and Their Usefulness in Everyday Life (pp. 47-61). Springer, Cham.

Moutinho, L. (1987). Consumer behavior in tourism. *Journal of Marketing*, 21(10), 1–44.

Nasajpour, M., Pouriyeh, S., Parizi, R. M., Dorodchi, M., Valero, M., & Arabnia, H. R. (2020). Internet of Things for current COVID-19 and future pandemics: An exploratory study. *Journal of healthcare informatics research*, 1-40.

Nasereddin, H. H., & FAQIR, M. (2019). The impact of internet of things on customer service: A preliminary study. *Periodicals of Engineering and Natural Sciences*, *7*(1), 148-155.

Oliveira, P. P. (2020). Digital twin development for airport management. *Journal of Airport Management*, *14*(3), 246-259.

Pan, T., Shu, F., Kitterlin-Lynch, M., & Beckman, E. (2021). Perceptions of cruise travel during the COVID-19 pandemic: Market recovery strategies for cruise businesses in North America. *Tourism Management*, 85, 104275.

Patel, K. K., & Patel, S. M. (2016). Internet of things-IOT: definition, characteristics, architecture, enabling technologies, application & future challenges. *International journal of engineering science and computing*, 6(5).

Porter, M.E. and Heppelmann, J.E. (2015) How Smart, Connected Products Are Transforming Companies. *Harvard Business Review, 93,* 1-37.

PR News Wire (2018). Retrieved 02.01.2021, from: https://www.prnewswire.com/news-releases/makers-of-scott-and-purell-partner-to-offer-premium-smart-restroom-management-system-300720016.html.

Quintal, V. A., Lee, J. A., & Soutar, G. N. (2010). Risk, uncertainty and the theory of planned behavior: A tourism example. *Tourism management*, 31(6), 797-805.

Rahman, M. S., Peeri, N. C., Shrestha, N., Zaki, R., Haque, U., & Ab Hamid, S. H. (2020). Defending against the Novel Coronavirus (COVID-19) Outbreak: How Can the Internet of Things (IoT) help to save the World?. *Health Policy and Technology*.

Rajesh, R., & Ravi, V. (2015). Supplier selection in resilient supply chains: a grey relational analysis approach. *Journal of Cleaner Production*, *86*, 343-359.

Ramnath, S., Javali, A., Narang, B., Mishra, P., & Routray, S. K. (2017). IoT based localization and tracking. 2017 International Conference on IoT and Application (ICIOT)

Rayes, A., & Salam, S. (2017). Internet of things from hype to reality. The Road to Digitization; River Publisher Series in Communications; Springer: Basel, Switzerland, 49.

Rymaszewska, A., Helo, P., & Gunasekaran, A. (2017). IoT powered servitization of manufacturing – an exploratory case study. *International Journal of Production Economics*, *192,* 92–105.

Serrano, F., & Kazda, A. (2020). The future of airport post COVID-19. *Journal of Air Transport Management*, *89*, 101900.

Singh, R. P., Javaid, M., Haleem, A., & Suman, R. (2020). Internet of things (IoT) applications to fight against COVID-19 pandemic. Diabetes & Metabolic Syndrome: *Clinical Research & Reviews*.

Sohag, M. U., & Podder, A. K. (2020). Smart garbage management system for a sustainable urban life: an IoT based application. *Internet of Things*, *11*, 100255.

Sun, C., & Zhai, Z. (2020). The efficacy of social distance and ventilation effectiveness in preventing COVID-19 transmission. *Sustainable cities and society*, 62, 102390.

Tabares, D. A. (2021). An airport operations proposal for a pandemic-free air travel. *Journal of Air Transport Management*, 90, 101943.

Tarei, P. K., Thakkar, J. J., & Nag, B. (2018). A hybrid approach for quantifying supply chain risk and prioritizing the risk drivers. *Journal of Manufacturing Technology Management*.

The Centers for Disease Control and Prevention (2020). Scientific Brief: SARS-CoV-2 and Potential Airborne Transmission. Retrieved 02.01.2021, from: https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html

Ting, D. S. W., Carin, L., Dzau, V., & Wong, T. Y. (2020). Digital technology and COVID-19. *Nature medicine*, 26(4), 459-461.

Tuchen, S., Arora, M., & Blessing, L. (2020). Airport user experience unpacked: Conceptualizing its potential in the face of COVID-19. *Journal of air transport management*, *89*, 101919.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2), 186–204.

Waligo, V. M., Clarke, J., & Hawkins, R. (2013). Implementing sustainable tourism: A multi-stakeholder involvement management framework. *Tourism management*, 36, 342-353.

Wattanacharoensil, W., Schuckert, M., & Graham, A. (2016). An airport experience framework from a tourism perspective. *Transport reviews*, 36(3), 318-340.

Wenzel, M., Stanske, S., & Lieberman, M. B. (2020). Strategic responses to crisis. Strategic Management Journal.

Xiao, X. C., Wang, X. Q., Fu, K. Y., & Zhao, Y. J. (2012). Grey relational analysis on factors of the quality of web service. *Physics Procedia*, *33*, 1992-1998.

Xu, Z., & Liao, H. (2013). Intuitionistic fuzzy analytic hierarchy process. *IEEE transactions on fuzzy systems*, *22(4),* 749-761.

Yang, J., Sekhar, S. C., Cheong, K. W. D., & Raphael, B. (2015). Performance evaluation of a novel personalized ventilation–personalized exhaust system for airborne infection control. *Indoor Air*, 25(2), 176-187.

Zenker, S., Braun, E., & Gyimóthy, S. (2021). Too afraid to Travel? Development of a pandemic (COVID-19) anxiety travel scale (PATS). *Tourism Management*, 84, 104286.

Zheng, D., Luo, Q., & Ritchie, B. W. (2021). Afraid to travel after COVID-19? Self-protection, coping and resilience against pandemic 'travel fear'. *Tourism Management*, 83, 104261