IoT Capabilities in Regaining Travelers' Confidence Through Touchless Travel: An Empirical Study for the Revival of the Airline Sector

Pushpendu Chand, Pradeep Kumar Tarei, Rajan Kumar Gangadhari, and Patrick Mikalef

***Abstract*—In the past few years, the airline and travel industries have suffered unprecedented crisis during COVID-19 pandemic. With the gradual reopening of economies, airline companies are progressively bouncing back to normalcy. While airline traffic has come back to normalcy, travelers still continue to remain cautious about their health, hygiene and safety. In this regard, we examine the applicability of Internet of Things (IoT) enabled digital technologies in reassuring airline travelers' confidence by offering benefits, such as contactless travel, health monitoring of onboard travelers, crowd management at the airport, air quality, and hygiene management inside the airport. The study sheds light on emerging travelers' preference for air travel post-COVID-19. This article prioritizes the IoT-based application areas assessed through the theoretical lens of the theory of planned behavior. Our research highlights the underlying inter-relationships among the digital enablers that can be implemented for the airline industry, focusing on travelers' hygiene and safety priorities. The study is conducted in the international airports operating in India. By improving travelers' confidence, this study will help travel and airline industries to revive from the postpandemic loss by using the capabilities of IoT technologies.**

***Index Terms*—Airline industry, airport management, COVID-19, grey-DEMATEL, Internet of Things (IoT), IoT capabilities, theory of planned behavior (TPB).**

I. Introduction

"IF WE have the information at hand that we need, then we can offer a better experience and will resolve a lot of stress [customers] have."[1] The statement was made by digital program manager of Air-France KLM, a Franco-Dutch airline, in the context of IoT connecting multiple aspects of travel and airport management. The airline and travel industry has significantly bounced back to normalcy after suffering unprecedented disruptions during COVID-19 pandemic. With removal of travel restrictions at local and global level, passengers' traffic has improved considerably, in many cases reaching prepandemic level [1]. While airline traffic has come back to normalcy, travelers still continue to remain cautious about their health, hygiene, and safety. Airport acts as a key stakeholder in managing customer relationship for airline industry. Technological capabilities of Internet of Things IoT can accelerate the airlines revival for a "safer world" [2]. The IoT based technologies have demonstrated immense potential in offering solutions to ensure sustainable and resilient airport operation [3], [4]. Furthermore, IoT can be instrumental in transition to "smart airport." Despite the growing acceptability of IoT in several industry, the application of IoT-enabled technologies for airport management is still at nascent stage [5]. Past studies are grossly limited in suggesting IoT-enabled solutions towards operational sustainability of airline and travel industries [6]. The lack of empirical research on IoT-enabled digital technologies inspires deeper investigation.

The continuous and proximate reachability to the travelers in providing customized solutions is made possible by IoT technologies [7]. It is worthwhile to mention that IoT-enabled technologies are proved to be safe and efficient in fighting pandemic [3]. The application of IoT in the airline industry is primarily focused on improving aircraft performance and onboard traveler experience [8]. IoT being credited with bringing revolutionary changes to product and service sectors [5]. Still, existing research seems insufficient in unleashing its potential for recovery and sustainability of the airline industry. However, IoT has been proven instrumental in mitigating the adverse effect of the pandemic [4] 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 [9]. Therefore, exploring the potential of IoT in bringing customer confidence for travel and airline industries can

Manuscript received 8 December 2022; revised 11 March 2023; accepted 7 May 2023. Date of publication 7 June 2023; date of current version 5 April 2024. This work was supported by the Slovenian Research Agency (www.arrs.gov.si) through Research Program P5.0441. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. Review of this manuscript was arranged by Department Editor T. Papadopoulos. *(Corresponding author: Patrick Mikalef.)*

Pushpendu Chand is with the Research Technology and Innovation Centre, Thermax Limited, Pune 411003, India (e-mail: pushpendu.chand@gmail.com).

Pradeep Kumar Tarei is with the Indian Institute of Management, Jammu 180016, India (e-mail: pradeep.tarei@gmail.com).

Rajan Kumar Gangadhari is with the Operations and IT Department, ICFAI Business School, Hyderabad 501203, India (e-mail: rajan.gangadhari.2018@nitie.ac.in).

Patrick Mikalef is with the Department of Computer Science, Norwegian University of Science and Technology, 7052 Trondheim, Norway, also with the Department of Technology Management, SINTEF Digital, 0373 Oslo, Norway, and also with the School of Economics and Business, University of Ljubljana, 1000 Ljubljana, Slovenia (e-mail: patrick.mikalef@ntnu.no).

Digital Object Identifier 10.1109/TEM.2023.3276779

[1][Online]. Available: https://internetofbusiness.com/klm-gets-connected-take-stress-flying/: Internet of Aviation in Heathrow, London, 2021.

offer favorable outcomes. Till date, there is no or little mention of IoT capabilities in the existing research in reassuring customers' health and safety expectations. Also, IoT offers immense potential benefits of integrating sensor-information that can be interoperated in designing multiple airport management services for customers [10]. The Internet of Things (IoT) has been widely adopted in various industries, including transportation and aviation. However, there is a research gap in exploring the usefulness of IoT in ensuring travelers' confidence at airports. While many studies have investigated the role of IoT in enhancing airport security and operational efficiency, few have examined its impact on travelers' confidence. In a post-pandemic era, passengers are increasingly concerned about the contagion risk during air travel. Therefore, exploring how IoT can be utilized to in restoring travelers' confidence is critical. This research gap presents an opportunity to investigate the potential of IoT in addressing the needs and expectations of travelers, enhancing their overall airport experience, and contributing to the recovery of the aviation industry. This study aims to explore the relationships among the capabilities of IoT in regaining travelers' confidence. The current study aims to address the following research questions (RQs).

RQ 1: What is the role and importance of IoT capabilities in regaining air travelers' confidence?

RQ 2: What is the interrelationship between the IoT capabilities with due consideration to travelers' behavioral preference and technology usefulness?

To address the above-mentioned research questions, the following research objectives (RO) have been formulated.

RO 1: Exploring the role of IoT capabilities to enable airport services in travelers' confidence

RO 2: Analyzing the importance and inter-relationship among IoT capabilities based on travelers' behavioral preference and technology usefulness.

This research intends to make several contributions to the literature and the industry. First, this study attempts to extend the application of IoT-enabled solutions in airport management to strengthen consumer confidence, particularly in a postpandemic scenario. To do that, the article identifies the possible areas of IoT application in building travelers' confidence. Second, we prioritize the IoT-based digital initiatives adopted by airports and the airline industry in light of customer acceptance. Third, the analysis provides an interconnected structure among IoT capabilities to explain their interoperability. To that end, we apply the grey-scale technique to establish underlying interrelationships among IoT capabilities to counter the ambiguity caused by decision-makers (DM) subjective judgments. Finally, we propose a managerial decision-making framework to guide airport authorities in implementing the measures for sustainable airport management. The growing acceptance of IoT technologies posits the relevance of this work.

The rest of the article 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 a mention of specific future research extensions.

II. Theoretical Background and Literature Review

A. Theoretical Foundations

It has been recognized that the implementation of traveler-focused technologies at the airport can significantly enhance their travel experience with improvements in customer satisfaction [11]. The growing travelers' acceptance of smartphones, mobile applications, self-service technologies, biometric assessments, and wearable devices have benefitted airport operations in creating greater value for travelers [12]. Travelers' airport experience and proclivity for technologies are importantly driven by sociological and psychological perspectives [13]. 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 behavior [14].

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) [15] 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, 1) the ease of using new technology and 2) perceived usefulness of the technology [16] that determines the attitude and behavioral intention of consumer toward the adoption of the same [17]. TAM has been extensively used by researchers in explicating various technology-acceptance scenarios, such as the IoT adoption in China [18], adoption of the Uber mobile application [19]. Currently, passengers are given the option of choosing an increasing number of technological products and services in the airport to reduce human touch points. IoT-enabled technologies have augmented considerable capabilities to service airport passengers with readiness to consent to behavioral change. Acceptance of technology can change the behavioral interaction of customers. Therefore, we apply TAM as the theoretical underpinning for exploring the acceptance of IoT applications at the post pandemic airport management.

2) Theory of Planned Behavior (TPB): According to the theory of planned behavior (TPB), the human behavioral intention is driven by three important psychological factors [20] as behavioral attitude, subjective norms, and perceived control over the behavior. These three factors are likely to predict people's intention toward the behavior. Behavioral attitude deals with a responsive predisposition toward situational decision-making. Subjective norms measure the people's willingness in complying with social practices [21]. Subjective norm is greatly influenced by social endorsements, which in turn influences the attitude and perceived behavioral control of people. Furthermore, perceived behavioral control discusses the comfort or hesitation in performing the behavior [20]. TPB has received significant research attention in explaining the traveler behavior in the tourism, hospitality sector [22], and safety practices [23].

According to modified TAM [24], the perceived near-term usefulness of technology motivates behavioral intention of users,

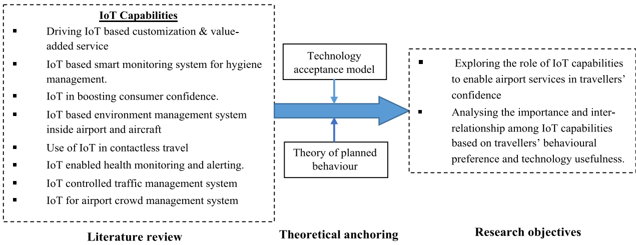


Fig. 1. Conceptual framework.

thereby connecting TPB. The impact of the pandemic might have resulted in several behavioral changes among travelers due to varying psychological and social risk perception [25]. Individual risk perception is likely to shape the behavioral intention [26]. Therefore, the postpandemic normalcy will likely have a behavioral impact on passengers and airport service staff [27]. This might result in alteration in peoples' social and health behavior [28]. Accordingly, the change in behavioral patterns may affect airport management. Post-pandemic normalcy will likely have a behavioral impact on passengers and frontline airport service staffs [27]. In view of changing peoples' social and health behavior [28], the TPB can provide necessary theoretical anchoring to analyze the socio-behavioral adoption in a 'new-normal' situation. Therefore, the acceptance and adoption of IoT capabilities are studied under the combined theoretical lenses of TAM and TPB (see Fig. 1).

B. 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 [29]. Atzori et al. [30] have conceptualized IoT as a paradigm constituted by the convergence of three differently oriented perspectives, which represent "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 [31]. The increasing applicability of IoT-enabled digital technology in tracking the phase-wise development of infectious diseases has resulted in substantial acceptance in healthcare management [7]".

C. IoT Capabilities for Postpandemic Recovery of the Airline Industry

To investigate the IoT capabilities in the postpandemic recovery of airline industries, a structured literature review method was used. Google Scholar and Scopus were the bibliographic databases used for this literature analysis. The search is conducted using bi-level phrase combinations such as "Internet of Things" OR "IoT" AND "airline" OR "airport" OR "air passenger" OR "air traveler" OR "Aviation" OR "Air transport" OR "Smart Airport." The search results from the literature review were iteratively used to categorize different IoT capabilities into eight main dimensions, as shown in Table I. To further enrich the search results pertaining to the practicing airports of the IoT

TABLE I
LITERATURE REVIEW OF IOT CAPABILITIES

Sr No.	IOT Capabilities	Academic literature	Industry report	Practicing airports
IC1	Driving IoT-based customization at airport/airline for value-added service	[32], [33], [34]	[35]	Hartsfield-Jackson Atlanta International Airport [36], Miami International Airport [37], Hyderabad International Airport [38]
IC2	IoT-based smart monitoring system for hygiene management	[39], [40], [41], [42]	[43], [39]	Mega hub airport in Europe [44]
IC3	IoT in boosting consumer confidence.	[45], [46], [47]		Majority of International Airports, Queen Alia International Airport [48]
IC4	IoT-based environment management system inside airport and aircraft	[9]	[49]	Athens International Airport
IC5	Use of IoT in contactless travel	[50], [51]		Helsinki Airport in Finland [52]
IC6	IoT-enabled health monitoring and alerting	[53], [54]	[55]	DFW International Airport [56]
IC7	IoT-controlled traffic management system	[57], [58]		Hong Kong International Airport [59], Most International Airports
IC8	IoT for airport crowd management system	[2]		London City Airport [60], Miami International Airport

capabilities, some industry reports and airport websites were also referred through public search engines.

1) IC1: Driving IoT-Based Customization at Airport/Airline for Value-Added Service: The 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 [57]. 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 [58], customer involvement in developing new features to products and services [61], and social interaction beyond boundaries [62]. For example, by creating a centralized data bank supported by IoT sensors, the London City Airport integrates passengers' consumption preferences with an offering of customized location-based services [8]. IoT enabled sensors connected through mobile applications can guide passengers to nearby service facilities like restrooms, lounges, shopping centers, etc. This concurrently can reduce the need for passenger movement, thereby decreasing the chances of aerial transmission while ensuring improved customer satisfaction.

2) IC2: IoT-Based Smart Monitoring System for Hygiene Management: Combining the IoT capabilities of smart waste management [32] and healthcare management [63], an 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 sanitizer, and paper towel) avoiding chances of stock-outs, and sends timely alerts to custodians for refilling, cleaning and/or waste disposal, as the need arises [34]. The smart monitoring system is 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 to 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 travelers' confidence [35] (see Table I). 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 [64].

3) IC3: IoT in Boosting Travelers' Confidence: Zenker et al. [65] reported that the pandemic has created deep marks in the travelers' cognitive morality about their travel decisions. In this regard, regaining passenger confidence back in air travel is critically important for the recovery of the airline industry [66]. While airline revival continues to remain sluggish during this uncertain time, the Deloitte report [9] emphasized that the "new normal" situation should be inspired by instilling confidence concerning health, hygiene, and safety, among others. It suggests that IoT-enabled digital technologies in facilitating contactless travel, hygiene management, and remote healthcare monitoring can substantively boost travelers' confidence. The overall integration of IoT capabilities can create an efficient ecosystem built on greater stakeholder collaboration to enhance responsiveness.

4) IC4: 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 [67]. Therefore, maintaining indoor air quality through an actively managed smart ventilation system is critical, especially in confined public spaces, such as airports and aircraft [39]. In a report released by Environmental Protection Agency [43], 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 [68] inside the airport/airline. 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.) [40] and trigger autonomous ventilation to keep the indoor environment comfortable for travelers.

5) IC5: Use of IoT in Contactless Travel: Ensuring a safe social distance between people has proven to be an effective way to control viral infections in communities [45]. Therefore, touchless travel supported by IoT-powered devices can potentially restrict the transactional touchpoints [2]. Globally, airport authorities and airline operators are continuously driving a contactless travel experience by eliminating passenger touchpoints using contactless IoT-enabled technologies [69]. Wearable IoT devices (IoT smart thermometer, IoT-based smart glasses, etc.) help in reducing interactions between passengers and airport/airline staff considerably. Robots linked with IoT devices can enable touchless biometrics identification by facial image processing to provide document free travel [46]. 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. Helsinki airport uses IoT-enabled location-based services to avoid contacts.[2]

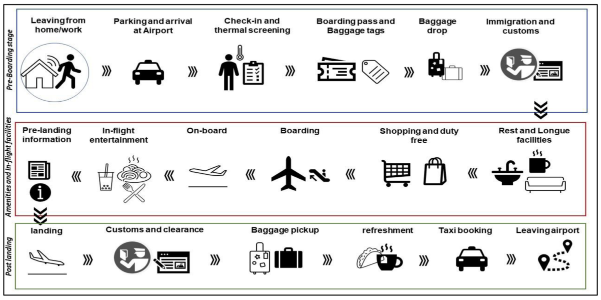
6) IC6: IoT-Enabled Health Monitoring and Alerting: IoT-enabled technologies are being accepted in the healthcare industry due to their wide range of capabilities which include tracking, identification and validation, data collection and authentication [5]. IoT-based architecture and technology solutions can support robust monitoring and controlling with multitasking capabilities of detection, diagnosis, and remote monitoring of patients while in quarantine, remote treatment, and postrecovery tracking, etc. [63]. For example, IoT wearable wristbands, given to new arrival passengers and connected to the healthcare administrative database, have been implemented at Hong Kong International airport [70]. It tracks the new arrivals at the airport during the quarantine time of 14 days with the geofencing facility. Similarly, an IoT-powered contact-tracing mobile application is one of the most followed interventions to map patient/travelers' contact information at the airport. It enables early alert in case of any contagion to nearby healthcare service centers.

7) IC7: IoT-Controlled Traffic Management System: IoT controlled traffic management systems can reduce queueing length and waiting for time [53] 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 applications [54] with the installation of a large number of sensors [71]. 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 checks [58]. The data gathered by tracking sensors are converted into speed and direction of queue movement, the number of passengers in each line, and approximate wait time; and displayed on the monitor to keep the passengers informed to avoid clustering.

8) IC8: IoT for Airport Crowd Management System: According to the work [72], crowded enclosed spaces are accompanied by 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.

IoT based crowd management system functionally works in three phases. First, the sensors collect the crowd data, then connected middleware analyzes the data and notify the administrator with crowd pattern for appropriate action, and finally

[2][Online]. Available: https://internetofbusiness.com/will-transform-airport-experience-passengers/



(a)

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		✓	✓		✓			✓		✓		✓

(b)

Fig. 2. (a) Stages of passengers' journey at an airport. (b) Potential areas for IoT implementation.

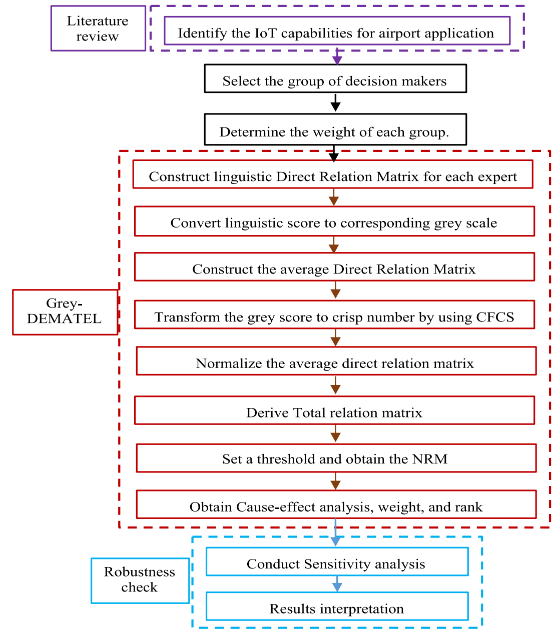


Fig. 3. Proposed Grey-DEMATEL framework.

interface layer performs executable action at the traveler/user end for crowd management [49]. This system guides the air travelers/passengers with important crowd related information, such as the flow of passengers, availability of noncrowd spaces, and crowd concentration pattern, based on real-time sensor data at the airport [51]. 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 Fig. 2(a) with potential areas of IoT implementation in Fig. 2(b).

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 postpandemic revival of the industry, which largely remains unattended in the empirical literature. First, it is crucial to examine the "mutual interaction" across IoT capabilities because discarding one feature can increase or decrease the impact of another capability [73]. A thorough analysis of the interactions between IoT capabilities can offer crucial information about how one IoT capability affects others and how that same capability is affected by others. Second, a grey-based methodology is used to address the problem of intrinsic intangibility and ambiguity of expression by exact numerical values [74].

III. Methodology and Analysis

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 the post-pandemic rebound of the airline industry through airport operation (see Fig. 3). In the first phase, the relevant IoT capabilities are identified through an extensive literature review supported by case studies of airports utilizing the relevant capabilities. The study's second phase analyzes the intricate linkages between the IoT capabilities using a grey-based DEMATEL approach, as shown in Fig. 3.

A. *Grey-DEMATEL Technique*

The DEMATEL method was proposed by the Geneva Research Centre of the Battelle Memorial Institute [75]. DEMATEL is a tool for analyzing the structural interrelationship between decision criteria in terms of a cause-and-effect diagram and network relation map (NRM). Due to its inherent advantage over other modern multicriterion decision-making (MCDM) methods like the analytical hierarchy process, interpretive structural modeling, and analytic network process [76], DEMATEL has gained popularity across a number of management disciplines, including risk management [77], SC complexity [78], frugal innovation [79], The DM's judgement of how much one decision criterion or factor influences another is used as an input by DEMATEL. However, it has been noticed that a DM is frequently unable to describe the impact or score as accurate numbers for evaluating decision attributes due to the real-world uncertainty of the situation and/or the restricted availability of the expertise domain knowledge [80]. In order to address this challenge, the grey system theory is integrated with DEMATEL to resolve uncertainty issues relating to discrete data and partial availability of information. Due to incomplete knowledge of IoT capabilities and disagreements in opinions among the many groups of DMs, including international travelers and airport facilities managers, the current dilemma is mostly ambiguous. The goal of the grey-DEMATEL model is to produce useful findings without materially affecting the result's quality.

TABLE II
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	Number of interviews	Total duration(in minutes)
Group 1	International travelers	DM 1	Business traveler, 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 Behavior	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

Second, it can produce acceptable results with a considerably smaller dataset [81]. It is worth mentioning that the current study considers fewer distinct decision criteria (eight IoT capabilities), which may create difficulty in assessing their interplay. Alternately, when the number of decision criteria increases, fuzzy numbers' usage is deemed more appropriate in an uncertain and ambiguous scenario [82]. Though fuzzy numbers can deal with uncertain data, the benefit of grey systems theory over the fuzzy approach is that it does not require any complex fuzzy membership function [79]. Hence, the computational tractability is improved to a large extent without compromising with the accuracy of results [74]. Unlike membership functions in fuzzy sets, a grey number is expressed by an interval of lower and upper bounds [83]. Since grey set theory approach uses original form of the data in terms of numerical intervals, the results obtained are more relevant in practice [84]. Due to these crucial benefits, Grey-DEMATEL has been used to propose a decision-making framework in the current research problem. The proposed framework can convert the cause and effects relationship among the considered IoT capabilities into a structural network model. This helps in depicting the contextual relationship between IoT capabilities, additionally with a quantitative indication of the strength of influence, which further aids in policy-making decisions.

The detailed mathematical equations of steps involved in adopting the Grey-DEMATEL technique can be found in the Appendix (A1).

B. 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 DMs on the subject, the questionnaire and content were 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 participating academic (DM9, DM 10, DM11) and industry experts (DM5 to DM8) is presented in Table II and acted as decision-making participants in the Grey-DEMATEL methods.

1) Selection of Decision-Makers: Since the airport operation involves multiple stakeholders of the airline industry, it is imperative to include various stakeholders' perspectives from the context of traveler, business, economic, and public policy [85]. A multistakeholder involvement can be an effective way of implementing sustainable tourism practices [86] and innovation for tourism development [87]. Extending the same, DMs are purposively selected from the following four involved groups:

1) frequent airline travelers (consumers) (Group 1);
2) airport facility managers (Group 2);
3) industry experts and policymakers (Group 3);
4) academic researchers (Group 4) through convenience sampling method.

We emphasized the adequate participation of DM from each group to ensure a composite outlook on the research objective. To capture a deeper perspective on the topic, DM with more than 10 years of relevant experience are selected in each group. The experience of DM 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) (see Table II).

2) Data Collection: The DMs, in this case, four groups represented by international travelers, airport facility managers, industry experts and policymakers, and academic researchers, were intimated using multiple channels, including email addresses from professional websites, firm website pages, and a wide professional networking platforms. We proposed anonymity of the DM 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

1) meeting in person at the airport;
2) online meeting platforms;
3) telephonic discussion;
4) industrial and promotional events;
5) discussions during conferences and seminars on the related industry.

To increase the response rate, further efforts were made using phone calls and email reminders. The in-person meetings were conducted at five Indian international airports located in New Delhi, Mumbai, Hyderabad, Bangalore, and Kolkata and offices in those cities.

Out of the total contacted 36 participants (international travelers: 12, airport facility managers: 8, industry experts and policymakers: 9, and academic researchers: 7), only 14 (international travelers: 4, airport facility managers: 4, industry experts and policymakers: 3, and academic researchers: 3) volunteered to take part in the study, bringing the acceptance rate for participation to close to 39%. Reasons cited for declining the participation are largely individual discretion, lack of interest, and nonavailability of time. The brief profile of participating DMs with corresponding groups is shown in Table II.

3) Data Acquisition: First, the participating experts/DM have explained the background of identified IoT capabilities (see Table I). Enabling the airport operation in restoring travelers' confidence 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 DMs who agreed to participate in the interview are requested to finish the pair-wise comparison based on the relative importance of the 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) (see Table V). Consequently, a pairwise direct relation matrix (8 X 8) for identified 8 IoT capabilities using linguistic terms is obtained for each of 14 participating DMs.

4) Data Conversion: The linguistic data collected in a pairwise comparison format from all the 14 DMs are transformed to a numerical scale by corresponding grey equivalent. This process results in finding 14 matrices (8 X 8) for IoT capabilities (IC1 to IC8) for each of the 14 participants (see Table II). First of all, the average direct-relation matrices are calculated across all four categories (i.e., international travelers, airport facility managers, industry experts and policymakers, and academic researchers). All respondents belonging to a particular group are considered homogeneous, and hence assigned equal weight. In a group decision-making environment, the aggregation of all direct-relation matrices is attained by the arithmetic mean of expert responses. For instance, to compute the average direct-relation matrix for the group of international travelers, equal weight (= 0.25) is given to each participant (DM1 to DM4) (see Table II) in that category. Similarly, to calculate the average direct-relation matrix for the group of industry experts and policymakers, equal weights (= 0.33) are given individually to three participating experts levelled as DM 9, DM10, and DM11. The crisp version of the aggregated direct-relation matrix is presented in Table VI. Applying mathematical operations as suggested in the Appendix, we obtain the aggregated normalized-relation matrix (see Table VII). After that, each represented group is allocated an equal weight ($w = 0.25$) to construct the aggregated total-relation matrix (see Table III) incorporating all four groups.

TABLE III
AGGREGATED TOTAL RELATIONSHIP MATRIX (ALPHA = 0.421)

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8
IC1	0.307	0.413	0.584	0.504	0.509	0.412	0.442	0.3563
IC2	0.446	0.314	0.586	0.557	0.568	0.395	0.446	0.5023
IC3	0.362	0.291	0.367	0.469	0.414	0.384	0.266	0.3877
IC4	0.259	0.218	0.328	0.257	0.330	0.283	0.298	0.3034
IC5	0.333	0.403	0.595	0.474	0.383	0.426	0.384	0.391
IC6	0.463	0.405	0.615	0.543	0.567	0.349	0.403	0.473
IC7	0.374	0.319	0.532	0.530	0.529	0.422	0.300	0.4705
IC8	0.439	0.435	0.648	0.525	0.575	0.429	0.431	0.3879

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 ($a = 0.421$) are important in developing an NRM. The a-cut total-relation matrix (aggregated level) with corresponding values of elements is shown in Table VIII (see Appendix). 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 travelers is shown in Fig. 4(a). Unidirectional arrow suggests the one-way directional causality while the bidirectional arrow indicates two-way influential relation among barriers. Likewise, prominence–causal diagraphs of IoT capabilities for the other three groups of participants constituted by airport facility managers, industry experts and policymakers, and academic researchers, respectively, are developed [see Fig. 4(b)–(d)] based on corresponding $D+R$ and $D–R$ scores.

The aggregated prominence–causal digraph representing all four groups is shown in Fig. 5. At the aggregated level, the NRM of the IoT capabilities is displayed in Fig. 6. NRM at an individual group of DM is presented in the Appendix (see Fig. 9).

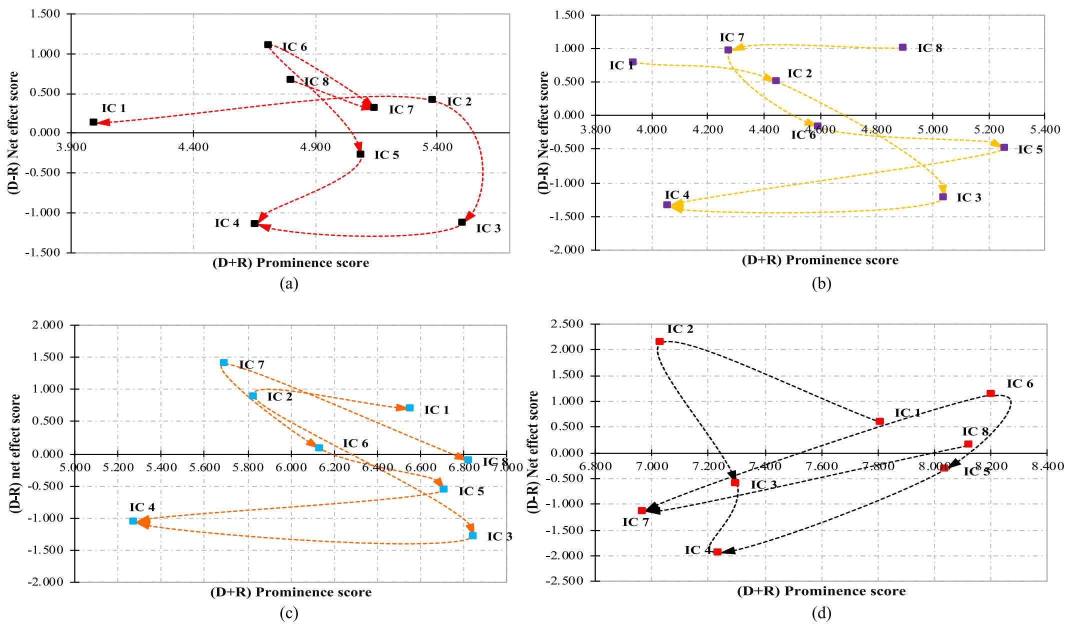


Fig. 4. Prominence and net-effect scores for different groups. (a) Group 1—international travelers. (b) Group 2—airport facility managers. (c) Group 3—industry experts and policy makers. (d) Group 4—academic researchers.

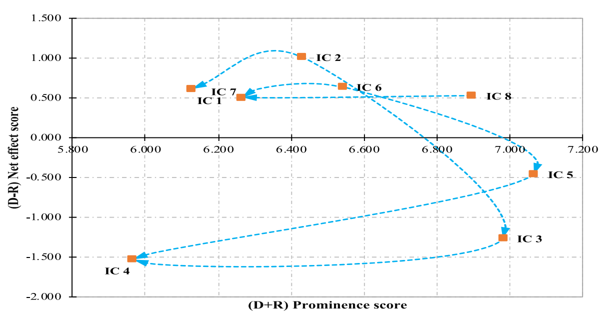


Fig. 5. Aggregated cause and effect diagram of IoT capabilities.

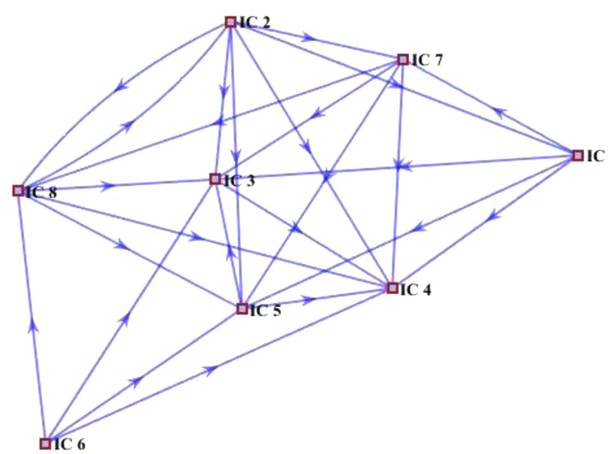


Fig. 6. Network relationship map (NRM) of IoT capabilities.

IV. Results and Discussion

A. Explanation of Preliminary Results

From the prominence–causal ($D{+}R$ versus $D{-}R$ score) relationship of IoT capabilities at an aggregated level (see Fig. 5) involving four categories of DMs, it is evident that capabilities IC1, IC2, IC6, IC7, and IC8 form 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. Furthermore, 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 traveler confidence (IC3), contactless travel (IC5), and airport crowd management system (IC8) the three most prominent capabilities playing important role in developing the overall structure of IoT capabilities. Based on the priority of IoT capabilities, it can be inferred that travelers focus largely on near-term usefulness initially. This finding corroborates with modified TAM [88].

The prominence–causal relationship among IoT capabilities for the four groups of DMs levelled as Groups 1, 2, 3, and 4 is graphically presented in Fig. 4(a)–(d), respectively. Notably, IoT capabilities in Boosting travelers' confidence (IC3), environment management systems inside airports and aircraft (IC4), and contactless travel (IC5), are the common three affected capabilities across all four groups. Likewise, IoT capabilities in driving IoT-based customization at airports/airlines for value-added service (IC1) and smart monitoring systems for hygiene management (IC2) are two capabilities serving as causal antecedents as identified by all groups. It is worthwhile to mention that two IoT capabilities in contactless travel

TABLE IV
GROUP-WISE PROMINENCE AND NET CAUSE/EFFECT VALUES FOR THE IOT CAPABILITIES

	Group 1 (International travelers)					Group 2 (airport facility managers)					Group 3 (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**
IC1	4.00	0.11	Cause	4.00	8	3.94	0.78	Cause	4.01	8	6.55	0.68	Cause	6.59	4	7.81	0.59	Cause	7.83	4
IC2	5.38	0.40	Cause	5.40	2	4.45	0.49	Cause	4.47	5	5.83	0.88	Cause	5.89	6	7.03	2.14	Cause	7.35	6
IC3	5.50	-1.14	Effect	5.62	1	5.04	-1.22	Effect	5.18	2	6.85	-1.28	Effect	6.96	1	7.30	-0.61	Effect	7.32	7
IC4	4.66	-1.14	Effect	4.80	7	4.06	-1.35	Effect	4.28	7	5.28	-1.07	Effect	5.38	8	7.23	-1.93	Effect	7.49	5
IC5	5.09	-0.28	Effect	5.09	4	5.26	-0.49	Effect	5.28	1	6.71	-0.57	Effect	6.74	3	8.04	-0.31	Effect	8.04	3
IC6	4.71	1.09	Cause	4.84	6	4.59	-0.18	Effect	4.60	4	6.13	0.08	Cause	6.13	5	8.20	1.11	Cause	8.28	1
IC7	5.15	0.30	Cause	5.16	3	4.28	0.96	Cause	4.38	6	5.69	1.38	Cause	5.86	7	6.97	-1.13	Effect	7.06	8
IC8	4.80	0.65	Cause	4.85	5	4.90	1.00	Cause	5.00	3	6.83	-0.12	Effect	6.82	2	8.12	0.14	Cause	8.12	2

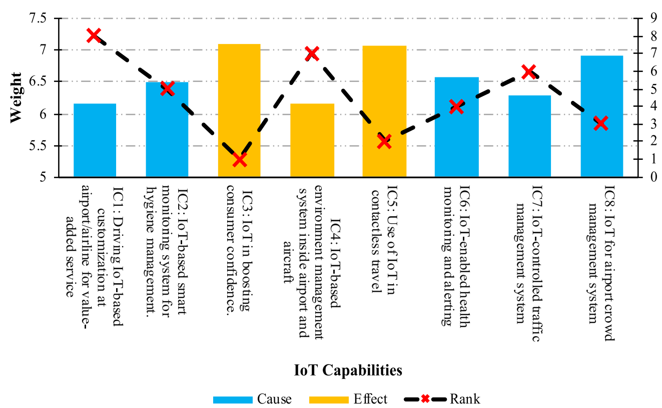


Fig. 7. Aggregated weights and ranks of IoT capabilities.

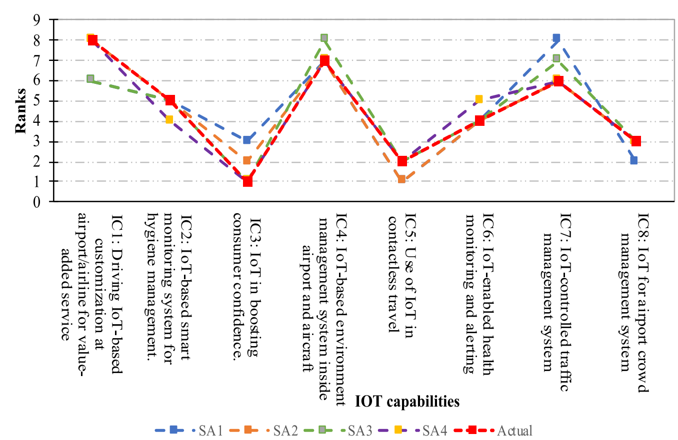


Fig. 8. Sensitivity analysis.

(IC5) and airport crowd management system (IC8) are regarded to possess higher prominence as evaluated by groups 2, 3, and 4.

B. Ranking of IoT Capabilities

IoT capabilities are ranked based on their relative prominence as assigned by an individual group of DMs. The rank is calculated using *D*+*R* and *D*–*R* scores as per (A15) and (A16) (see Appendix). Group-wise prominence and net cause/effect values for the IoT capabilities (with corresponding weight, and rank) are shown in Table IV. The weight and ranking of IoT capabilities at an aggregated level are graphically presented in Fig. 7 and is provided in the Appendix (see Table VIII). 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 indicates the variation in the relative importance of capabilities when viewed from a different group's perspective. The adoption priority of IoT capabilities might differ given the various demographic characteristics of DMs' group.

C. Sensitivity Analysis (SA)

The MCDM technique tends to rely on the subjective judgment of the DMs based on their 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 [89]. SA is performed by assigning a 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 DMs on the overall outcome in ranks of IoT capabilities. In our research, participating DMs are clustered in four groups. In the first run of sensitivity analysis (SA1), we assign a weight of 0.5 to group 1 about the international travelers to verify its impact, with a weight of 0.1666 to the remaining groups (groups 2, 3, and 4). With this weight adjustment, the change in rank of IoT capabilities is observed. Similarly, in the subsequent settings for sensitivity analysis leveled as SA2, SA3, and SA4, the weight of groups 2, 3, and 4, respectively, is increased to 0.5 with the corresponding adjustment of weights for the other groups (see Fig. 8).

The considerable consistency observed in the ranks of IoT capabilities is graphically shown in Fig. 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 the Appendix (see Table V). The stability in the cause–effect relationship and consistency in relative ranking among IoT capabilities render soundness to the research model and results.

D. Discussion

1) IoT in Boosting Travelers' Confidence: According to our research, the use of IoT in boosting travelers' confidence (IC3) is recognized to be one of the most prominent capabilities as regarded by multiple decision-making groups [see Fig. 4(a)–(d)]. This capability is often dependent on various other causal capabilities related to health monitoring, hygiene management, and value-added services, among others. Given its significance in the overall context, multiple IoT based capabilities should be made in restoring confidence among passengers/travelers/consumers in air travel starting with the airport. This research outcome is in accordance with the survey conducted by IATA, [49] involving passengers across 11 countries around the globe, which highlighted the growing need for bringing back the travelers' confidence in air travel which is a fundamental driver for the airline industry.

The impact of the pandemic has resulted in several behavioral changes among travelers driven by psychological and social risk perception [90]. Therefore, with support from TPB, the use of IoT in boosting travelers' confidence might result in reshaping the behavioral intention and attitude toward air travel. During our discussion with an expert on airport systems associated with a leading airline, an 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, and hospitality services should work cohesively in helping the travelers coming back to the airport. Technology can certainly enable this transition."

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 DMs. This can potentially contain the spread of the virus by lowering the transactional touchpoints during travel and reducing the risk of community spread [45]. This finding corroborates the global acceptance of IoT-powered devices by airport authorities and airline operators using contactless IoT-enabled technologies [69]. 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 this direction will be welcome. It will also enhance travelers' confidence in air travel. Airports also can play a vital role in implementing IoT-based services towards that."

3) Application of IoT in Causal Capabilities: Analysis of causal IoT capabilities at the individual group level [see Fig. 4(a)–(d)] 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 act as an enabler in generating affected capabilities (IC3, IC4, IC5). The causation arcs directing causal to effect IoT capabilities (see Fig. 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).

V. Research Implications

This research contributes to the ongoing discourse in proposing IoT-enabled forward-looking response strategies for the revival of the airline industry [91]. The current study unpacks the IoT capabilities that can be extended for the airline industry in restoring travelers' confidence during the ongoing pandemic, which largely remains unattended in the empirical literature [92]. First, this study contributes toward exploring IoT capabilities at multiple airport services to facilitate the change in travelers' behavior and attitude owing to behavioral restrictions during the pandemic. To that extent, the research outcome furthers the application of advanced information technologies to enable touchless air travel [93]. Second, our research identifies the possible areas of IoT application in building customer trust while pandemic-driven travel restrictions are still in place at varying levels. 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 implications.

A. Theoretical Implications

The critical research objective we wanted to examine is to explore the possibilities of applying IoT-enabled capabilities in airport services to regain travelers' confidence in the airline industry starting 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. With changing travelers' behavior in a postpandemic new-normal scenario, there is a growing need to revisit the adoption of technologies to enable the travel industry. Hence, we applied the combined theoretical lens of TAM and TPB to explicate the adoption of IoT capabilities with changing behavioral intention. This investigation provides a novel academic contribution by combining TAM and TBP perspectives. With this, we overcome the limited predictive capacity of TAM in singularity, which lacks social integration [94]. The unified theoretical approach (TAM and TPB) offers a sufficiently enhanced explanation of the travelers' intention on IoT capabilities compared to any individual theory (TAM or TPB). This observation aligns with Gao et al. [18]. The including multiple decision-making groups are likely to provide comprehensiveness in deciding the NRM. In addition, the robustness of the result as validated by sensitivity analysis, proves the soundness of the theoretical framework.

First, the technological acceptance of IoT capabilities is studied, considering travelers' ease and usefulness toward new technology. The selection of the top three most prominent IoT capabilities (IC3, IC5, and IC8) indicates the travelers' preference to focus on capabilities with perceived near-term usefulness. Hence, our findings agree with the postulates of modified TAM [88]. We have established the causal–effect relationship and level of importance among the IoT capabilities. NRM provides a theoretical ground for inter-relationship study among the IoT capabilities while studying from the traveler's perspective. Therefore, applying the TAM framework offers academic support in bundling multiple IoT capabilities following travelers' potential acceptance. Thus, our work expands TAM from a formal acceptance of technology framework to a multicapability technology acceptance model.

Second, our study expands the TPB application in identifying the IoT capabilities from travelers' behavioral and attitudinal preferences. Furthermore, in one of the rarest attempts, foundational tenets of TBP are used to study the inter-relationship among the IoT capabilities. The successful acceptance of causal IoT capabilities may eventually result in the adoption of affected IoT capabilities. We find this observation in adherence to the extension of TPB, where one behavior can drive another [95]. Therefore, this can provide a starting point for analyzing the ease of acceptance of IoT capabilities based on TPB. The prospective usefulness of IoT-enabled solutions can encourage travelers' confidence, which is likely to determine the attitude and behavioral intention of travelers toward the adoption of the same [83]. Also, our research design complements the TPB theory as we considered multigroup DMs based on "proximal determinants" [96]. Thus, we broaden the scope of TBP from conventional behavioral study to more composite settings involving demographic characteristics such as human attitudes, consumers' health, safety and wellbeing.

B. Managerial Implications

By investigating the importance of IoT capabilities in reestablishing travelers' 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 affected capabilities generated from the former. The study can guide companies in prioritizing and developing 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 airport authorities in implementing the measures to enable speedier recovery [97].

While airports can plan to develop IoT capabilities, they can also focus on implementing IoT capabilities high on perceived near-term usefulness. Thus, priority should be given to adopting these capabilities (IC3, IC5, IC8). Airport authorities might consider bundling IoT capabilities depending on the causal–prominence relationship among them. Further, the adoption priority of IoT capabilities might differ, given the different demographic characteristics of DMs. Hence, implementing IoT capabilities needs a balanced approach considering the perspectives of multiple stakeholders (referred to as groups of DMs). Based on travelers' behavioral patterns, as emphasized in TPB, customized airport management services can be designed in alignment with frequent practices [57]. The findings (see Section V-D) have shed light on several capabilities beneficial for the airline industry. Accordingly, we highlighted the potential areas for boosting travelers' confidence.

From a policy standpoint, this framework can be successfully applied in equipping international airports with IoT capabilities as preferred by multiple groups. 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 personalize on-board services. Consequently, IoT capabilities might empower the airline industry to effectively balance various processes and resources in driving operational excellence.

VI. 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 behavioral intention for accessing airport services. Second, the findings of the study are based on responses from a limited number of DMs 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' behavioral intention toward 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 the acceptance of these capabilities is beyond the scope of this research. Hence, future studies can explicate the factors which can have a resulting impact on customer acceptance. Besides, the application of IoT capabilities in conjunction with artificial intelligence, machine learning, and robotic process automation can be an interesting area to explore in the revival of consumer sentiment in airport operations [93]. This framework can also be extended for service industries sharing similar sector dynamics.

Appendix

The mathematical steps of grey-DEMATEL is taken from the following source, and could not be provided here for the space restriction.

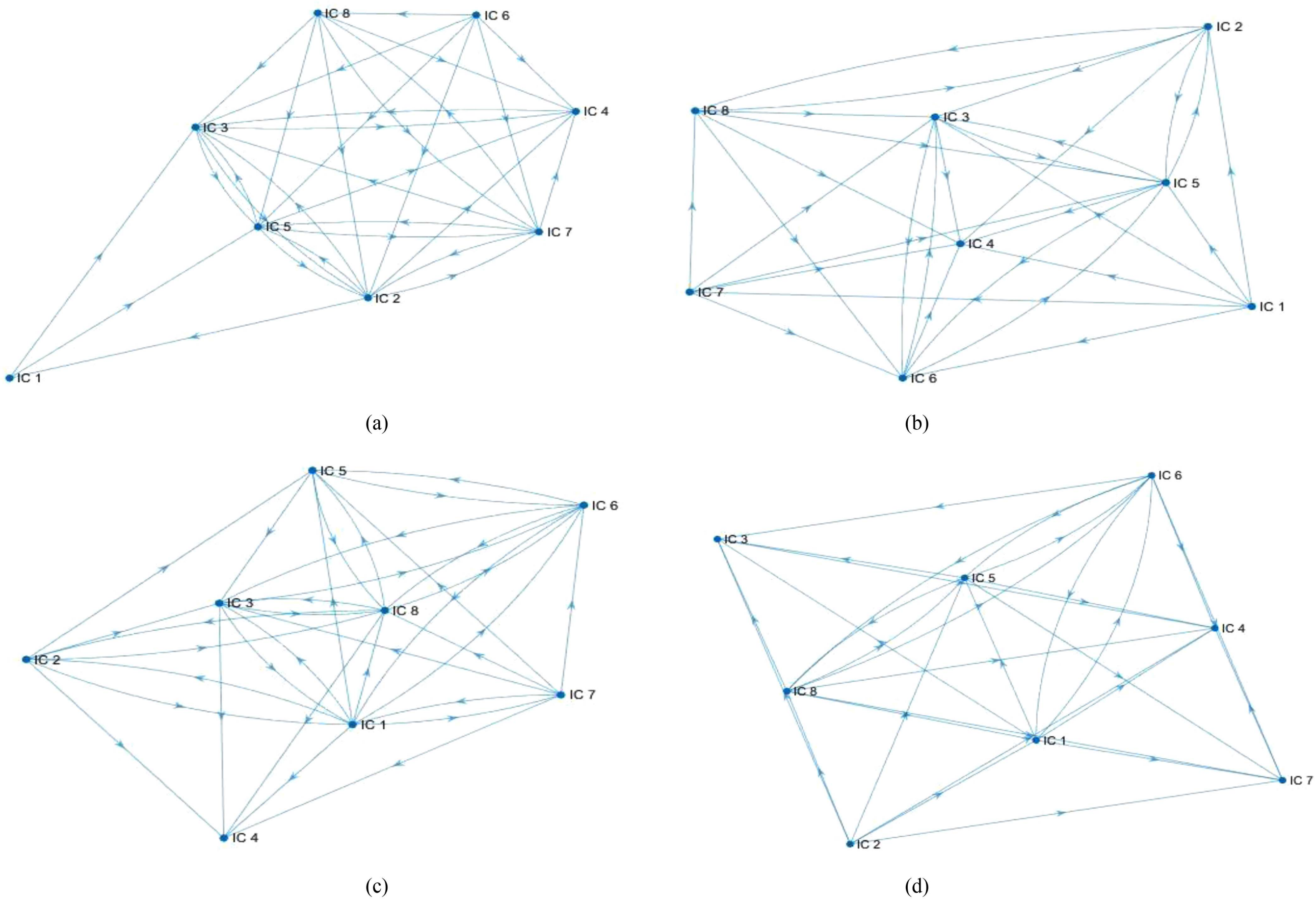


Fig. 9. Network relation maps. (a) NRM of group 1 (international travelers). (b) NRM of group 2 (industry experts and policy makers). (c) NRM of group 3 (industry experts and policy makers). (d) NRM of group 4 (academic researchers).

TABLE V
LINGUISTIC AND GREY NUMBER REPRESENTATION

Linguistic terms	Normal values	Grey scale
No influence (N)	0	[0, 0]
Very low influence (VL)	1	[0, 0.25]
Low influence (L)	2	[0.25, 0.5]
High influence (H)	3	[0.5, 0.75]
Very high influence (VH)	4	[0.75, 1]

TABLE VI
DIRECT RELATION MATRIX (AGGREGATED GROUP LEVEL)

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8
IC1	0.0000	0.6875	0.8000	0.5125	0.5750	0.3750	0.7344	0.0375
IC2	0.6198	0.0000	0.5750	0.6688	0.7250	0.2188	0.5813	0.7344
IC3	0.5417	0.2188	0.0000	0.7438	0.4250	0.6094	0.0125	0.5813
IC4	0.3073	0.1406	0.2000	0.0000	0.3500	0.3750	0.5063	0.4281
IC5	0.1458	0.6875	0.9500	0.4375	0.0000	0.6094	0.5063	0.2781
IC6	0.5417	0.4531	0.7250	0.5875	0.7250	0.0000	0.3531	0.5813
IC7	0.3802	0.1406	0.5000	0.7438	0.7250	0.5313	0.0000	0.7344
IC8	0.4583	0.6094	0.8750	0.4375	0.7250	0.3750	0.5063	0.0938

TABLE VII
NORMALIZED RELATION MATRIX (AGGREGATED GROUP LEVEL)

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8
IC1	0.0000	0.1486	0.1730	0.1108	0.1243	0.0811	0.1588	0.0081
IC2	0.1340	0.0000	0.1243	0.1446	0.1568	0.0473	0.1257	0.1588
IC3	0.1171	0.0473	0.0000	0.1608	0.0919	0.1318	0.0027	0.1257
IC4	0.0664	0.0304	0.0432	0.0000	0.0757	0.0811	0.1095	0.0926
IC5	0.0315	0.1486	0.2054	0.0946	0.0000	0.1318	0.1095	0.0601
IC6	0.1171	0.0980	0.1568	0.1270	0.1568	0.0000	0.0764	0.1257
IC7	0.0822	0.0304	0.1081	0.1608	0.1568	0.1149	0.0000	0.1588
IC8	0.0991	0.1318	0.1892	0.0946	0.1568	0.0811	0.1095	0.0000

TABLE VIII
α-CUT TOTAL RELATION MATRIX (AGGREGATED GROUP LEVEL)
[AT $\alpha = 0.421$]

	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8
IC1	0.0000	0.0000	0.5587	0.4822	0.4864	0.0000	0.4253	0.0000
IC2	0.4215	0.0000	0.5681	0.5413	0.5517	0.0000	0.4330	0.4807
IC3	0.0000	0.0000	0.0000	0.4559	0.0000	0.0000	0.0000	0.0000
IC4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IC5	0.0000	0.0000	0.5787	0.4610	0.0000	0.0000	0.0000	0.0000
IC6	0.0000	0.0000	0.5796	0.5130	0.5363	0.0000	0.0000	0.4417
IC7	0.0000	0.0000	0.5142	0.5154	0.5137	0.0000	0.0000	0.4501
IC8	0.0000	0.0000	0.6097	0.4936	0.5412	0.0000	0.0000	0.0000

ACKNOWLEDGMENT

The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Pushpendu Chand is currently working toward the Ph.D. degree in Vinod Gupta School of Management, Indian Institute of Technology Kharagpur, Kharagpur, India.

He has published his research works in *International Journal of Operations and Production Management, Journal of Purchasing and Supply Management, Journal of Cleaner Production*, and many International conferences. His research interests include supply chain complexity and supply chain performance management.

Pradeep Kumar Tarei is currently working toward the Ph.D. degree in the Indian Institute of Technology Kharagpur, Kharagpur, India.

He is an Assistant Professor in the area of Operations and Supply Chain at Management with the Indian Institute of Management Jammu, Jammu, India. His research interests include *smart mobility, social issues in supply chain*, and *decision-making under risk and uncertainty*. He has published his research works in *Computers and Industrial Engineering, Journal of Purchasing and Supply Management, Journal of Cleaner Production,* and many more reputed journals.

Rajan Kumar Gangadhari received the M.Tech. degree in industrial engineering and management from JNTU, Hyderabad, India, in 2016. He is currently working toward the Ph.D. degree in the National Institute of Industrial Engineering Mumbai, Mumbai, India.

He is a faculty member in the area of Operations and IT with ICFAI Business School Hyderabad, Hyderabad, India. He has four years of experience in process safety management. His research interests include accident and hazard management using ML and AI based techniques. He has published his research works in *Journal of Cleaner Production, Process Safety Progress* and many more reputed journals.

Patrick Mikalef received the B.Sc. degree in informatics from Ionian University, in 2008, the M.Sc. degree in business informatics from Utrecht University, in 2010, and the Ph.D. degree in IT strategy from Ionian University, in 2016.

He is a Professor in Data Science and Information Systems with the Department of Computer Science, Norwegian University of Science and Technology, Trondheim, Norway. He has been a Marie Skłodowska-Curie post-doctoral research fellow working on the research project "Competitive Advantage for the Data-driven Enterprise" (CADENT). His research interests include on strategic use of information systems and IT-business value in turbulent environments. He has published work in international conferences and peer-reviewed journals including the *Journal of Business Research*, *British Journal of Management, Information and Management, Industrial Management & Data Systems*, and *Information Systems and e-Business Management.*