

# Technology Connectivity for Aviation Supply Chain Sustainability: A Conceptual Model

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## Abstract

With the recent development of technology or known as Industrial Revolution 4.0, numerous articles published over the years with emphasizing on the needs to investigate the moving role of technology in every type of business organization and industry. The central question is what are the technology is connected to the success and sustainability of any organization. The aim of this paper has threefold: first to discuss the evolution of technology in general; second to propose the technology connectivity model with focusing on the eleven pillars of technology discussed in the literature, and third to deliberate future research works in technology connectivity in supply chain. The discussion of this study is grounded on single sector namely aviation industry as it has been recognized as a driving factor to improve aviation player's efficiency such as reducing cost and improved operations. The proposed conceptual model and list of hypotheses are developed through literature review works on technology connectivity in aviation supply chain. This study underpins theory of technology adoption (TA) and technology acceptance model (TAM) in analyzing the connectivity between supply chain member acceptance and use of technology with eleven pillars of technology. This study could be served as a blueprint for further discussion and a basis for empirical research in future.

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## 1. Introduction

Technology is critical in supply chain as it reshaping the connectivity of every channel member in supply chain networks and improved performance to achieve sustainability. A new generation of technology in digital era has streamlined the supply chain management and helpsto improve efficiency.

As highlighted by Chou et al (2004), effective and efficient supply chain activity leads to reduce wastage

and lower the distribution cost through seamless cooperation between channel members. Recently, Ellram and Murfield (2019) stress that technology is becoming the leading issue discuss in supply chain management and it is acknowledged as a cyclic process in the supply chain networks. Globally, technology has been regarded as a core in economic development in many countries since fifty (50) years ago (Burmaoglu et al, 2019). Abdul Rahman (2012) states that technology is a main element

in supply chain transition from physical distribution era in 1950s. It is acknowledged that the key evolution from physical distribution (1950s) to logistics management (1970s) and supply chain management (1990s) is derived from technology which subsequently has connected all channel members in supply chain. The process, methods and system used in business firm are example of technology that lead to successful business operation and achieve sustainability. All these party involved in supply chain is tied with information that is being shared by all channel members.

Technology encompass eleven pillars namely simulation and augmented reality, horizontal and vertical integration, industrial internet of things, cybersecurity, artificial intelligence, block chain, cloud, additive manufacturing, big data analysis and autonomous robot. However, these eleven technology pillars may applicable or not applicable in certain industries. Eventhough literature has suggested that technology leads to numerous benefits and increased performance and efficiency; however, not every technology pillar will have an impact in any organization. Practitioners or industry needs to identify the key technology pillars that related to their operation and manage the complexity (Rahman et al., 2019). To meet this challenge, this conceptual study chose aviation industry as a central case for discussion. Aviation industry is wide and consists of several players such as airline, airport, ground handler, cargo, caterer, manufacturers and maintenance, repair and overhaul (MROs).

Aviation industry is known as high technology adopters especially for airlines business and not many scholars have discussed the technology development in the aviation sector. To address this issue, this research aims to conceptualize the use of eleven pillars of technology in the aviation based on its characteristic. Therefore, we define our research questions and objective is as below:

- a. Research Question: What is the technology emergence in aviation industry?
- b. Research Objective: To determine the facets of technology emergence in aviation industry

By answering this question via a literature review, we aim to propose a conceptual model to see the significance association and describe its aspect for aviation business strategy for aviation organization sustainability, as well as technology policy development. The study is outline within the range of aviation spectrum ranging from general aviation, cargo, airline, airport, ground handler, manufacturer and MROs. The organization of the paper is as follows. Since the focus of this research is on technology in aviation, brief discussion on aviation sector will be discussed. Next, the technology definition and the eleven pillars of technology in supply chain will be explained in the later subsection, followed by the development of the model and hypotheses. The next section will discuss on the both theory of technology

adoption (TA) and technology acceptance model (TAM). The theoretical and managerial contribution, as well as future research direction for future scholars will also be presented.

## 2. Literature Review

### Aviation Sector and Technology Development

Aviation industry is a key provider for global economic development as it supports the tourism, manufacturers and logistics industry worldwide (IATA, 2019; Rahman 2017a; Rahman 2017b). At present, the aviation industry supports \$USD 2.7 trillion of the world's gross domestic GDP. As mentioned by ICAO (2010, p.68), technology plays significant role for airline players. As highlighted in ICAO report earlier in 2010, current aircraft was designed for more than 15% improvement in fuel burn than comparable aircraft of a decade ago. This new technology driven aircraft has resulted to lower emission (40%) and achieve environmental sustainability. Aviation industry has wide spectrum and ranging from general aviation, cargo, airline, airport, manufacturing, MROs and ground handler. Different spectrum may focus on different type of technology. For example, fuel efficient technology in the airline sector is one of the critical area. This is because fuel represent 30% of the airline operating cost. As such, fuel efficiency technology is really significant in the aviation. Unlike ground vehicle, they do not need fuel efficient technology as they can always refuel when the tank is almost empty. It is acknowledged that in each new development of aircraft, it has double digit fuel efficiency improvement.

Another issue with regards technology and aviation sector is about aircraft design and Global positioning system (GPS) for tracking purpose. In fact, at the airport, the security checking, flight airport management and planning, as well as flight information display (FID) are among the examples of technology use in aviation. As explained in recent article by Sivarajah et al (2019), technology used and digital transformation allow for active user engagement gather competitive intelligence to facilitate business sustainability activities among the business players.

### The notion of technology and supply chain management

To gain clearer understanding on the concept of technology and supply chain need further detail explanation on the terms. In general, supply chain refer to the network that link the downstream and upstream of channel members consisting of supplier, manufacturer, wholesaler, retailer, dealer, business customer, consumer as well as the agents or any third party such as third party logistics provider or information technology (IT) agents. Supply chain connectivity can be defined as the process that integrates several members in the logistics and supply chain network to achieve better performance and communication (Abdul Rahman et al., 2014; Gunasekaran et al, 2017). The use of technology in

supply chain will enable the supply chain to adapt according to market trends in terms of strategies, product and services, and others. On the other hand, technology is a popular term that refers to activity or process, methods and system used in business firm. In principal, it is refer to the use of scientific knowledge, method, process,

devices or system. Technology is changing fast and since the technology is relate to the social network, it should be discussed how the technology is beneficial to the users. Table 1 below explain the eleven pillars of technology discuss in this study.

Table 1: Eleven pillars of technology in supply chain management

Technology Pillars	Descriptions	References
Augmented reality	Richly used in engineering, navigation, training and simulation. Refer to a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view.	Safi et al 2019
Simulation	simulations by developing new models related to the air traffic controller's decisions, a simple traffic situation	Cokorilo 2013
Internet of things (IOT)	IOT refer to connectivity of a system. For example, interrelated communication network, interrelated digital machines and computer devices	Xia et al 2012
Horizontal and vertical integration	Horizontal and vertical integration happens in many organization and industries including aviation.	Crujssen et al (2007)
Cybersecurity	Is an effort to protect technology devices such as communication system, computer, electronic system from the cyber threat. Cyberattack cause significant delay across supply chain activities such as shipments and deliveries, investments, logistics coordination, production, schedules etc	Simon and Omar, 2019
Artificial intelligence	Artificial intelligence technology could improve human decision making process and lead to productivity and analyse data intelligently.	Hokey, 2010
Block chain	Block chain technology consist of four characteristics namely decentralized, trust less, collective maintenance and reliable database.	Yang et al 2019
Cloud computing	It is refer to data centres that is available to many users at the internet. It is related to data storage management. For instance, drop box and google drive.	Qing et al 2013
Additive manufacturing	Additive manufacturing (AM), also known as three-dimensional (3D) printing is a promising component of the digitisation of manufacturing and is the process of layered printing to build up a 3D object	Wagner and Walton (2016)
Big Data	Big data refer to the large amount of data, with extreme size of data, unstructured, diversity and complexity.	Li et al 2019
Autonomous robot	Autonomous robots can be defined as robotic system with more deliberate function such as robust functionalities	Ingrand and Gallab (2017)

Source: Drawn by the authors

### Augmented Reality (AR)

Technology known as augmented reality is a prevalent technology that extensively used in a field of education, manufacturing, logistics, architecture, entertainment as well as aviation. According to Macchiarrella et al (2015), the main objective of augmented reality technology is to increase human performance and interaction with the real world through computer-generated information that is properly aligned and integrated with scenes of the real

world. In fact, these superimpose view which is computer generated image being adapted by practitioners

to meet both organizational and individual training needs. The interactive content in augmented reality technology put the individual in relaxed and comfortable condition for training needs. In fact, from the aviation perspective, AR technology is also used in training activity. With that, we posit our first hypothesis as below:

*H1: Augmented reality technology positively affects aviation supply chain sustainability*

### Simulation

Simulation is a program that is developed to approximate imitation of the operation of a process in any activity in

organization. From supply chain management perspective, simulation helps the supply chain channel members to improve their decision making process. As highlighted by Oliveira et al (2016), modelling and hybrid simulation are both used to improved supply chain performance. In fact, modelling and simulation also regularly used managing decision making process, as well as in a selection process for supplier or provider. Simulation can assist supply chain managers to analyse various environment and appropriate solutions for the supplier or provider (Holweg and Bicheno, 2002). With that, the next research hypothesis is developed as follow:

*H2: Simulation technology strongly affects aviation supply chain sustainability.*

### **Internet of Things (IOT)**

Internet of things or known as IOT is the current development of technology that affects supply chain coordination and performance. It refers to a network that connect any item through the internet or system in achieving exchange of information, tracking and traceability, monitoring, improved communication and management through RFID (radio frequency identification). Yan et al (2017) refer IOT as a wireless technology that provide data transmission over a network without requiring human-to-human or human-to-computer interaction. With that, this research establishes the third hypothesis as below:

*H3: Internet of things (IOT) positively affects Aviation supply chain sustainability*

### **Horizontal and vertical integration**

Horizontal and vertical integration is considered as environmental impacts of market structure among the supply chain members. The nature of supply chain management is being influenced by the horizontal and vertical coordination. A horizontal and vertical integration are the main strategies used by businesses or organization in a supply chain activity to increase their competitive advantage. This is connected to the communication network among the supply chain member. As highlighted by Cruijssen et al (2007), reverse engineering, arrangement of subcontracting, passing the technology from one cycle to another is also an example of horizontal and vertical integration. Hence, the next hypothesis is created as below:

*H4: Horizontal and vertical integration are strongly associates with aviation supply chain sustainability.*

### **Cybersecurity**

Cybersecurity is another issue that affect the aviation supply chain sustainability. The tendency of firms within the supply chain network to be affected by cyber threat is considered as difficult challenge to supply chains. Boyson (2014) define cybersecurity as the body of combined technologies, process and practices that are put in place to protect data and networks from attacks, damage or unauthorized access. As reported in McAfee Center for

Strategic and International Studies (2014), cybercrime case has been increasing from year to year and give negative impact to the world economy with annual costs of about 445 billion USD. The interconnected and interdependence among the channel members in the supply chain network are identified to be vulnerable for the system to be disrupted (Chopra and Khanna, 2015; Simon and Omar 2019). As such the following hypotheses are posited as below:

*H5: Cybersecurity positively affects the aviation supply chain sustainability in the aviation sector.*

### **Artificial Intelligence (AI)**

The aim of AI in supply chain is to design computer system that can copy human behavioural patterns in decision making and problem solving process. This study intends to see how AI is connected in the aviation supply chain activity with the use of computers for reasoning, recognizing patterns, learning certain behaviours from experience and retain the knowledge. Earlier study by Min (2010) stress that AI has established since 1970s. In supply chain management activity, it always requires rapid and adaptive decision making process as supply chain is wide and has a huge and multidimensional data sources across the supply chain network. As suggested by Baryannis et al (2019), these unique characteristics of supply chain managements are very suit to the application of AI technique in problem solving and decision making. In fact, AI is widely recognized as a decision aid tool in supply chain management with sharing some real time information with supply chain members. Sharing real time information is acknowledged as a better way to manage information and leverage for better decision making process among the supply chain professional. As emphasised by recent study Baryannis et al (2019) and Min (2010), since AI technology has not been fully utilised in the area of SCM, therefore this study aims to evaluate AI technology connectivity in the aviation sector. With that, the following research hypotheses is developed.

*H6: Artificial intelligence (AI) technology has positive association with aviation supply chain sustainability*

### **Block Chain**

Block chain refer to distributed data storage technology with point to point trans mission and encryption algorithm. "Block chains can be generally understood as an Excel table without central management, which has limited functional permissions, such as "add", "query", "modify", "delete". The table also stores different contents for different tasks" (Yuan et al 2019, p.4). The application of block chain technology in aviation supply chain is still dearth. In general, block chain technology starts in banking sector and has moved to many industries. It is acknowledged that block chain technology could save lot of intermediary cost by means of decentralized distributed structure and solve data tracking

problem. The main facet of block chain technology is decentralization, with basic protocol of global credit based on cryptographic algorithm. As mentioned by Yang et al (2019) recently, block chain technology could effectively improve any transportation efficiency including airline efficiency. Block chain could increase the transparency of the operation and management process in transportation industry. It helps the any transaction to be more credible as its characteristics is decentralised, traceability and trustworthy. With that, the following research hypothesis is developed as below:

*H7: Block chain technology has positive association with aviation supply chain sustainability*

### Cloud Computing

Cloud computing is widely used in many industries including aviation. It is a popular trend among supply chain network that refer to data storage and computing power that manage and process data. Cloud computing provide value advantage with regards to stability of the data, as well as flexibility of the data for certain use. As highlighted by Jede and Teuteberg (2015), cloud computing study has been increased and proliferates. For instance, in the aviation sector, cloud computing is mainly used in MROs and the airline. By utilizing and referring to the data from cloud computing, any repairs for the aircraft needed could be seen in real time. In fact, by using cloud computing also, the airlines could receive its flight location and details information about the flying aircraft such as speed and other information. With that, cloud computing is regarded as one of the key technology that could lead to business sustainability for other aviation players such as cargo, airport, manufacturers, caterers and others. Hence, the next hypothesis is posited as below:

*H8: Cloud computing is positively affect the aviation supply chain sustainability*

### Additive Manufacturing

Additive manufacturing technology helps the supply chain member especially in manufacturing in two main things namely increase value of goods produce via 3d printing and reduced cost. It is used by multiple industry including automotive, construction, machinery, electronic, medical and also aerospace. For instance, in 2014, the history was made whereby an electric car was printed by Local Motors company. That is the first electric car produced by this additive manufacturing or 3D printing technology which took about 44 hours

(Laliberte, 2014). At present, the technology is expand in the aviation sector. As mentioned by Durach et al (2017), by using this technology, the production process become very fast and reduced cost. Hence, the next research hypothesis is developed as follow:

*H9: Additive manufacturing positively affects the aviation supply chain sustainability*

### Big Data

Big data is connected to the improvement of business process and decision making process in management and operational issue. Big data also links to data analytics that links to the rich information of one observable issue that guide managers for effective decision making process. Earlier study by Gunasekaran et al (2017) and George et al (2014) has proved that there is a strong relationship between big data technology with firm performance. It creates value in every process of data collection, data mining, data processing, and data analysis and data execution. In fact, this technology also brings significant advantage to supply chain channel members as it uses large dataset as additional information for business making decision. This research posits the next hypothesis as below:

*H10: Big data positively associates with aviation supply chain sustainability*

### Autonomous Robot

Autonomous robot technology refers to the provision of labor in a diverse open environment which could perform a variety of tasks and interaction to fulfil their organizational objective. As mentioned by Ingrand and Ghallab (2017), autonomous robots facing a diversity of environments, a variety of tasks and a range of interaction with organization environment. In the aviation sector, autonomous robot technology can be referring to unmanned aircraft, or also known as autopilot technology. Pilotless drone aircraft is an example of autonomous robot in the aviation sector. In this study, we want to determine whether autonomous robot leads to aviation supply chain sustainability. Therefore, the next hypothesis is developed as below:

*H11: Autonomous robot is positively affects aviation supply chain sustainability*

Below table 2 list down the eleven hypotheses developed in this study that explains technology in the aviation sector for achieving sustainability. While Figure 1 shows the conceptual model developed in this study.

Table 2: List of hypotheses developed in this study

Technology Dimension/ Pillars	Hypotheses
Augmented reality	H1: Augmented reality technology positively affects aviation supply chain sustainability
Simulation	H2: Simulation technology strongly affects aviation supply chain sustainability
Internet of things	H3: Internet of things (IOT) positively affects Aviation supply chain sustainability

(IOT)	
Horizontal and vertical integration	H4: Horizontal and vertical integration are strongly associates with aviation supply chain sustainability
Cybersecurity	H5: Cybersecurity positively affects the aviation supply chain sustainability in the aviation sector
Artificial intelligence (AI)	H6: Artificial intelligence (AI) technology has positive association with aviation supply chain sustainability
Block chain	H7: Block chain technology has positive association with aviation supply chain sustainability
Cloud computing	H8: Cloud computing is positively affect the aviation supply chain sustainability
Additive manufacturing	H9: Additive manufacturing positively affects the aviation supply chain sustainability
Big Data	H10: Big data positively associates with aviation supply chain sustainability
Autonomous robot	H11: Autonomous robot is positively affects aviation supply chain sustainability

Source: Developed by the researchers

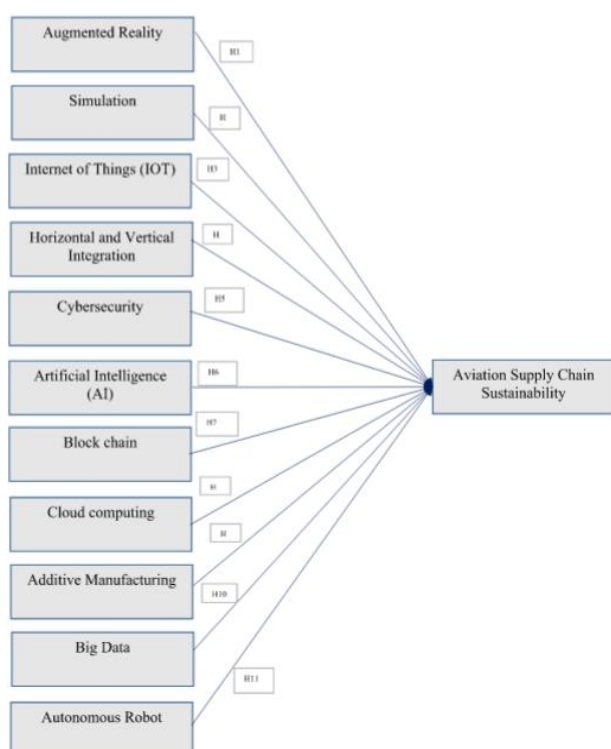


Figure 1: Conceptual Model on Technology Connectivity for Aviation Supply Chain Sustainability

Source: Drawn by the authors

### 3. Theoretical Lenses on Technology Study: Theory of Adoption Technology and Theory of Technology Acceptance Model (TAM)

Technology advancement in the aviation and other sector such as in medical, transportation, architecture, automotive, construction, manufacturing and others have revolutionized the business process and communication system across the value chain. Essentially, studies on technology adoption focus on the exploration of technology used in the organization. It was firstly introduced by Khasawneh et al (2008). While theory of acceptance model or known as (TAM) was introduced by Davis in year 1986. Theory of adoption technology shed

light on the individual choice and decision making in accepting or rejecting towards new invention or innovation including technology. This is contrast with what propose by diffusion technology that explain how innovation or technology is spread through a population. The adoption in this theory reflects the behavioural adoption of technology among people (Straub, 2017). On the other hand, a TAM highlight the determinant towards the behavioural of accepting technology in the organization. This theory has widely recognized and has been cited extensively in a previous study related to use of information technology or IT in the organization. Among the main variables discussed in this study are attitudes towards using the system and perceived usefulness of the system (Nasri and Charfeddine, 2012).

### 4. Conclusion

This study aims to proposed technology connectivity model for aviation supply chain sustainability. Eleven hypotheses have been developed with regards to technology connectivity in the aviation supply chain. Future research can thus conduct and empirical studies on technology in the same field as well as in the area of coordinating supply chain performance in a wider context. This research also contributes to the practitioners by giving the larger view on technology to structure the use of technology in their organization with specific aim and specific aviation spectrum.

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