Analysis of Airport BIM Implementation through Multi-Party Perspectives in Construction Technology Ecosystem: A Construction Innovation Framework Approach

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Abstract

Airports encompass highly complex and fragmented building and business systems that inaugurate high value interactions between people, places, and things. Value creation is a recurring issue in airport projects. Accordingly, as a highly important economic engine, life cycle management of airport projects through design-build-operate stages requires innovative approaches to meet ever-evolving needs of end-users. Building Information Modeling (BIM) can be considered as a key process innovation that can tackle the aforementioned issues while enhancing connectivity between different construction technology solutions. In this study, a construction innovation framework is employed to analyze airport BIM implementation processes of different parties, including the client, general contractor, consultant, and technology vendor. This framework enables the analysis of BIM implementation process based on various components such as drivers, inputs, enablers, barriers, benefits, and impacts. Multi-party perspective approach is adopted to explore these components for a large size U.S. airport project. It is found that the primary driver for BIM implementation is fast realization of quantifiable value- such as fewer safety issues provided by less rework on site- by the Owner. Major enablers are perceived as simplifying BIM processes and BIM tools interfaces according to project individuals' competencies and realizing potential synergies between different platforms and construction management processes; whereas rapid change of BIM tools and platforms, and significant resistance of upstream project personnel are regarded as major barriers. Based on the findings, determining BIM requirements and scope while avoiding ambiguity for each party enables continuous value creation throughout BIM implementation processes in an airport project. This study helps in understanding how BIM diffuses within an airport project context by articulating the dynamic relationships between key people, technology, and processes.

Keywords: Airport building information modeling (BIM) implementation, Construction innovation, Construction technology landscape, Connectivity, Multi-party collaboration

1. Introduction

In today's developing world, aging infrastructure falls short of addressing the hyper-evolving demands of the society. Modernizing and expanding infrastructure becomes increasingly important. Annual infrastructure investment needs for transport (road, rail, ports, and airports) continues to rise through 2030 to keep up with projected GDP growth; and it is estimated that an additional annual $2.5 trillion is needed in infrastructure investment through 2030 (MGI, 2013). Airports -forming one of the most important economic engines- play a crucial role within the infrastructure and urban development industry as hosting high value interactions between people, places, and things. They encapsulate various types of infrastructure, building and business systems. However, Airports Council International (ACI) World Key Performance Indicators (KPIs) (2019) reports that two-thirds of world airports are lossmaking (Airports Council International (ACI) World, 2019). To increase infrastructure productivity, the delivery of projects -starting from the selection to building, and operation- should be streamlined by proven innovative practices (MGI, 2013).

Building Information Modeling (BIM) is increasingly employed as one of the most promising digital, innovative processes for transportation infrastructure projects, providing a more efficient management of network of assets in terms of scope, cost, time, quality, and resources from construction to operation (Bradley, Li, Lark, & Dunn, 2016; Costin, Adibfar, Hu, & Chen, 2018; Fortin, Bloomfield, Mahaz, & Alfaqih, 2018). According to Smart Market Report by Dodge Data & Analytics, the adoption levels of BIM use in transportation infrastructure is increasing; and 62% of the firms doing aviation projects have a higher level of BIM implementation in the majority of their projects compared to the ones having roads, bridges, rail/mass transit or tunnel projects in their portfolios. It is also reported that BIM use has been more than doubled in the US, UK, France, and Germany since 2015; and there is as a consistent trend that the designers are early adopters, and contractors are experiencing comparatively higher rate in BIM implementation despite having owner requests for BIM for roughly 35% of their projects (Petrullo et al., 2017). Increasing adoption of BIM implementation by firms with different roles focusing on aviation projects also implies the introduction of various other technology ecosystem use cases along with BIM to the airport projects. These use cases can be incorporated with the BIM implementation processes within the relevant project phases. The essential ones in which BIM technologies and processes create synergies in airport projects can be listed as 3-D modeling, lean construction, process simulation, value engineering, document management, project scheduling, design simulation (Koseoglu & Nurtan-Gunes, 2018; McCuen & Pittenger, 2016).

Moreover, connectivity between the aforementioned construction technologies and along the project supply chain network is crucial as it requires a certain level of collaboration between project parties. Because every party brings its own practices, sustaining a certain level of information flow throughout the supply chain network of the project is critical. In essence, it is important for every project participant to understand that the collaborative process within the BIM-enabled project leads to higher efficiency (Lu, Zhang, & Rowlinson, 2013). This notion becomes more complicated for airport projects as they typically have large scopes, long time periods between planning to completion; and they involve a wide variety of stakeholders (Sentence, 2013). Efficient deployment of airport BIM implementation can target challenges associated with seamless data handover between project parties and phases that occur due to siloed nature of airport projects. However, it is essential to understand the interactions both within a range of stakeholders, and between stakeholders and technology uses (Harty, 2005). Accordingly, the major objective of this study is to provide a solid understanding in how airport BIM processes can facilitate the delivery of a project by delineating the multi-party perspectives within a construction technology ecosystem.

1.1. BIM as an Innovation Process in Construction

BIM was an accepted acronym for a range of descriptions such as Virtual Design & Construction (VDC), integrated Project Models, or Building Product Models, but its single use and definition were standardized for Architecture, Engineering, and Construction (AEC) industry to holistically address planning, design, delivery, and operational processes within the building lifecycle (Dominik Holzer, 2016). Since then, BIM has been widely recognized as one of the disruptive digital innovations in the AEC sector. To explore BIM adoption's evolvement and diffusion as a construction innovation at the firm level and project level, several models, frameworks, and approaches have been suggested in the literature. It is discussed that considering the inter-organizational contexts of construction industry, BIM is an innovation that extends beyond a confined circle of application and has an inter-organizational level of effect in a project (Harty, 2005; Riitta & Hirvensalo, 2008; Shibeika & Harty, 2015). However, most of the literature has investigated construction innovation processes at the firm level, and the project level studies generally focus solely on building project case studies to analyze BIM implementation processes, lacking clear differentiation of multi-party perspectives.

BIM use facilitates the delivery of a project by enhancing the connectivity between parties and construction technology ecosystem use cases. In this study, interacting components of an innovation framework developed by Ozorhon (2013) are utilized to systematically analyze BIM implementation technology and processes from an innovation diffusion process approach in a complex large-scale project setting. The adopted framework is demonstrated in Figure 1.

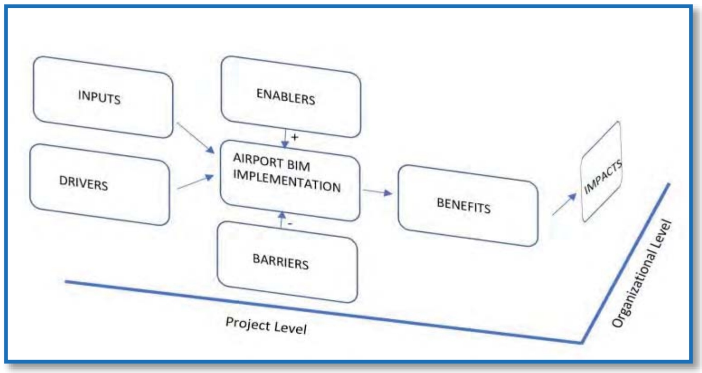

Figure 1: Framework for the Innovation Process of Airport BIM Implementation (adopted from (Ozorhon, 2013)*)*

In this framework, drivers represent main motivations for BIM implementation, and inputs represent resources utilized during the implementation process. The rate of innovation is influenced by barriers and enablers. Barriers are the primary factors that hinder BIM implementation. Enablers act as the factors that are used to overcome the barriers. The outcomes of the BIM implementation are represented by benefits which are realized at the project level. Wider outcomes are defined by impacts that are observed at the organizational or firm level in the long run. According to this framework, it is assumed that project-level benefits trigger the impacts realized at the organizational level. These components are examined in a complex large-scale airport case study to depict a clear picture of how Airport BIM implementation diffuses within a project environment from multi-party perspectives.

2. Material and Methods

This research uses a qualitative methodology, in which an explanatory case-study approach is followed via semi-structured interviews for data collection. Explanatory case studies focus on specific cases in which the theory, and its potential can be examined with the logic of replication to produce generalizations (Scapens, 1990). Also, to make conceptual generalizations from the local context of the case study to other settings, systematic collection of data from interviews, observation and documentation reviews are carried out (Seale, 1999). In this study, the fifth busiest U.S. large hub (a commercial airport classification having a minimum number of annual passenger boardings of 1 million (FAA, 2018)), Denver International Airport (DEN), is used as a case study. DEN is the largest airport in the US with 6 runways, spanning 136 km^2, and handling 61.4 million passengers annually (Dugdale, 2018). Also, DEN has been selected as the best among the 20 largest U.S. airports according to the first WSJ Airport Rankings (McCartney, 2018). The case study investigates BIM-enabled project delivery and life cycle management of DEN via focusing on DEN’s completed expansion project of Hotel and Transit Center Program, containing a commuter rail transit center and a 519-room hotel, and current digital facilities and asset management practices. This case is chosen strategically to address the problem statement and to provide an in-depth analysis by answering questions of “how” and “why” (Yin, 1994) from multi-party perspectives. With an understanding of the existence of different stakeholders and different perspectives, semi-structured interviews are carried out with four different parties representing the Owner, General Contractor, Supplier (technology/software vendor), and Consultant as the owner’s representative. The roles of the interviewees are provided in detail in Table 1. Each participant oversees the airport BIM implementation process within their respective organizations. As such, yielded data encompass insights on upstream to downstream activities within organizations. Semi-structured interview questions are provided in Table 2.

Furthermore, thematic analysis is used to identify patterns and themes in the qualitative data collected. Thematic analysis begins at the stage of data collection, data entry and continues throughout data coding and interpretation (Evans & Lewis, 2017). In this study, themes are determined as the components of an innovation framework, which are drivers, inputs, enablers, barriers, benefits, and impacts. The qualitative data collected via each interview question is coded with the associated themes (See Table 2). A qualitative data analysis computer software package, NVivo, is used to code the collected data to provide an in-depth case analysis by developing links between the themes and the original data coming from interviewees' answers. Themes are represented as nodes in the NVivo interface and interviewee's responses are imported as cases to the NVivo project. The coding patterns are analyzed for each case by calculating the coding percentages for each theme.

Table 1: Interviewees' Roles and Organizations

Interviewee	Role	Organization
Digital Facilities and Infrastructure (DFI) Program Manager	- Building up the DFI Program including BIM, VDC and integrations with GIS and Asset Management - Implementing the rollout of a bidirectional connection between airport BIM models and the airport asset management program - Developing workflows that improved the warranty management program by integrating it with other newly deployed platforms to create additional synergies	Owner
Senior Integrated Construction Manager	- Manage projects/teams from pre-construction through occupancy by utilizing VDC - Implementing training programs on VDC uses - Leading the integrated delivery process in pre-construction - Assisting in creation of company-wide VDC standards, and streamlining the BIM execution plan - Benchmarking emerging technologies including laser scanning	General Contractor
Principal Sales Consultant	- Offering insights and hands-on experience of innovative construction technologies - Providing pre-sales activity up to the executive level, consulting and professional services with Software as a Service (SaaS) platform, and connected BIM	Supplier (Technology Vendor)
Global Aviation Business Line Senior BIM Program Manager	- Working with owners, designers, and contractors in developing BIM processes for airport owners under all types of project delivery methods - Guiding clients in setting expectations and integrating BIM processes for comprehensive program development for integrated maintenance and management activities	Consultant

Table 2: Interview Questions with Coded Themes

Interview Questions	Theme
How do you customize an Airport BIM implementation strategy for your airport project?	Drivers, Inputs, Enablers
Could you describe how your BIM strategy addresses potential needs of the major project parties?	Drivers, Enablers
Could you describe the bottlenecks in BIM data flow between parties and/or phases of the project?	Barriers
Could you tell us your expectations for Airport BIM implementation outcomes in this project?	Benefits, Impacts
What are the current demands in BIM implementation processes considering current state of the art in the infrastructure sector?	Barriers, Drivers, Enablers
Could you tell us how you utilize BIM data?	Enablers, Benefits, Impacts

3. Results

The qualitative data collected through semi-structured interviews is systematically analyzed according to the data protocol (themes) demonstrated in Table 2 in the previous section. The coding summary, presenting the percentage of coding provided for each theme (component) by each party, is given in Figure 2.

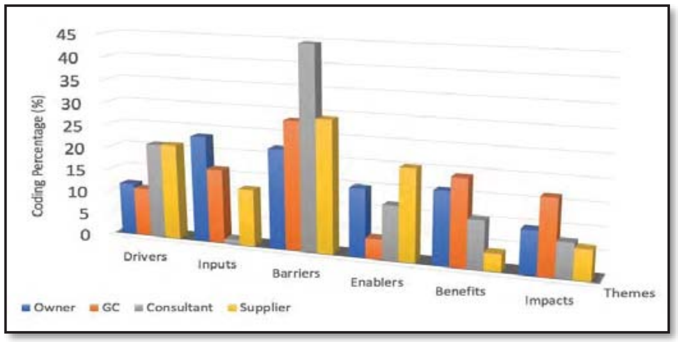

Figure 2: Coding Percentages of Themes from Multi-Party Perspectives

It is seen that 'Barriers' is the most coded component, and the rich-feedback for the barriers in airport BIM implementation shows that parties need to focus on enhancing their enablers or providing new enablers to support innovation in their projects. The Consultant has the highest coding percentage for barriers, and it is aligned with his responsibility requiring high awareness of potential challenges on the long-run to strategize optimum BIM implementation for such a large-scale project. On the other hand, the Consultant has the least input for 'Inputs' while the Owner has the highest coding percentage. This is because the Consultant sees the "big picture", but the Owner both finances and uses the BIM resources hands-on. Thus, the Consultant gives more insights on 'Drivers' as he triggers and observes BIM implementation process for different projects. However, for 'Enablers', it is the Supplier who has the highest coding percentage. Because the enablers are mainly represented by extended use of BIM technologies for better data management and utilization, the Supplier could give richer insights. Besides, more homogeneous distribution of the percentage coverage of the coding for the Owner indicates his centrality in the ecosystem as having similar levels of experience in each component. Furthermore, the Supplier has the least coverage for 'Benefits' as his project-level observation is more limited than the other parties. On the other hand, the GC realizes the benefits and impacts significantly. This highlights the higher level of BIM implementation in the design & engineering and construction phases compared to the operations and maintenance in airport projects, and also, how the GC leverages the BIM experience in the organizational level by transferring the generated knowledge to other projects.

Further analysis on each component is provided in the following sections.

3.1 Drivers

Drivers represent the main motivations for airport BIM implementation. Given the case study features, a large-scale airport project delivery requires an innovative, and more digital approach centralizing the Owner requirements (Keskin, Ozorhon, & Koseoglu, 2018). There are also common factors that drive every party to contribute to the BIM processes. Safety, eliminating cost over-runs, reducing waste, reducing time, increasing quality, effective interface management, easy management and access to the project documentation, facilitated communication and decision making, government mandates, Owner/client requirements are major drivers for parties throughout the life cycle of the project. These common drivers can also be applicable to various type of projects.

However, in the case study, from the Owner's perspective, the most prominent driver is having a record model on cloud to have certain bidirectional connectivity of the airport BIM model and the airport's asset management program for sustaining operational efficiency of the airport. This driver is also significantly emphasized by the Consultant, as it was stated that saving time via leveraging the common data environment in the operations phase, which corresponds to the 70%-90% of the total ownership cost (TOC), is more important. As the Owner side sees the value of BIM use by fast quantification achieved by the pilot projects in the construction phase, the Owner directs and obliges other parties towards BIM delivery guided by the Owner's BIM execution plan, standards, and matrices. Thus, Owner's engagement becomes one of the key drivers for other parties. Accordingly, General Contractor (GC) reported having a record model with a total of 50000 assets on cloud leading to enhanced connectivity with concurrent engineering & design and construction as a driver. Continuous realizations of value by the Owner and GC representatives increase the demand for use of BIM tools and processes. Furthermore, Owner's support also provides an optimum environment for the Supplier to set up the tools and consult the project parties for better use and integration of the tools. As such, the Supplier is driven to push the Owner to a more digitized project environment by offering integration of IoT and smart sensors to track real-time project efficiency with detection of use times of the tools, and enhanced safety on site.

It can be stated that Owner's dedicated BIM team and centralizing Owner's operational requirements are the major drivers that motivate all parties.

3.2 Inputs

Inputs are the resources utilized during the airport BIM implementation process. BIM processes can be described as the utilization of BIM tools, which are categorized as either authoring or analysis tools, and approaches to improve project phases of planning, design, construction, facility management and operations (McCuen & Pittenger, 2016). Not only BIM tools, but also other resources such as emerging technologies that can potentially be integrated with the BIM processes can be considered as inputs. BIM software, database technologies, geographic information system (GIS), complimentary technologies belong to the technology field of the BIM activity (Succar, 2009). The use of technology field is guided by the standards, execution plans, and strategies used in the project.

The Supplier, as the technology/software vendor, gave clear insights on the current state-of-practice in terms of the BIM tools used and how they sustain the information flow between parties. As the variety of BIM tools increases, platform solutions are mostly preferred by the Owners. Informative dashboards showing the number of assigned issues, clashes, documents are useful to track performance throughout the upstream to downstream activities. Not only BIM tools, but also IoT and smart sensor technologies were suggested by the Supplier as a next step in utilizing platform solutions. The Owner side, as managing and controlling the BIM delivery, reported various BIM tools including Revit, AutoCAD Civil 3D, Navisworks, BIM 360, Esri ArcGIS, Bluebeam, and IBM Maximo that correspond to the whole project life cycle. The Owner provided BIM design standards including Revit families, project coordinates, shared global coordinates, scripts to automate the BIM processes, and digital facilities and infrastructure matrix showing the required design model level of detail (LOD) at each package deliverable (LOD 100 to LOD 300). The Owner also has a strategy of mobile BIM including an inspection team of 62 inspectors and 220 mobile tablets on site for quality assurance and quality control (QA/QC) purposes. To avoid interoperability and other data exchange problems, GC also uses same authoring tools, but additionally GC tracks performance on site by using Synchro, Oracle Aconex, and Point Layout. Furthermore, the Consultant provides the BIM strategy, which is optimized according to the project resources and scale, overseeing all parties' BIM delivery responsibilities. As a common ground, it was reported that Internet of Things (IoT) and smart sensor technology can facilitate risk management by providing a more effective control on site.

Overall, each party brings in various tools and approaches to the project ecosystem to execute their own BIM scope. However, these tools and approaches should be complimentary and supportive to execute a single integrated digital platform for the project.

3.3 Barriers

Barriers are the primary factors that hinder airport BIM implementation. Lack of financial resources, lack of clear benefits, unsupportive organizational culture, lack of experienced BIM professionals, lack of awareness, lack of governmental support, and level of project complexity can be listed as major barriers of BIM implementation (Keskin et.al., 2018). These barriers can evolve overtime and can show discrepancies among different project phases and different parties. Thus, BIM adopters should determine and prioritize the most vital ones for their project considering their BIM scope at the time.

In this case study, barriers reported are mostly related to the BIM data handover and cultural barriers. Due to the collaborative nature of BIM, one party's incompetency in BIM affects other parties' practices significantly. Accordingly, lack of alignment and/or integration of complimentary practices such as GIS and BIM are some of the major challenges for the Owner. Lack of technology readiness and lack of software vendor support and/or involvement are common barriers for BIM data-handover reported by the Owner and GC. According to the Supplier, the major challenge is the siloed nature of airport projects, featuring 15 different data silos on average. Converging data spaces of each party, and highly expanded communication networks requiring approval of project documents by different parties block seamless data handover. The Supplier also stated that budget constraints and lack of technology readiness mainly hinder the BIM implementation process. These factors also hinder the involvement of the Supplier according to the Owner and GC.

Furthermore, the limited number of resources in terms of team members and BIM tools is another barrier reported by both the Consultant and the Owner. Lack of support from the governing bodies at the state and municipal levels restricts the resources for the digital facilities team to pursue competitive BIM applications such as BIM-enabled facility management (FM). A budget-based approach for asset management is preferred instead of an asset-based approach. As another common point reported by the Owner and the Consultant, the scale and complexity of the airport project, which led to a significantly large asset pool, is challenging the BIM implementation in the facility management phase. According to the Consultant, barriers for advancing BIM implementation experiences in an airport context are also more prominent because of the ever-changing retail and airline concourses. This situation makes the required updates in the BIM model significantly more challenging in the FM phase.

Even for a well strategized BIM implementation plan for design & engineering and construction phases, pushing data to FM phase is still not seamless, and requires a gap analysis considering the operational specifics of the airport.

3.4. Enablers

Enablers act as factors that are used to overcome the barriers. The key constructs of enablers of BIM implementation can be given as strategic initiatives, change management, cultural readiness, learning orientation, knowledge capability, organizational structure, and process management (Abbasnejad, Nepal, & Drogemuller, 2016). Methods and strategies developed to overcome barriers also show certain variation among different parties due to the power of authority and resources they possess.

Taking strategic initiatives to generate key control mechanisms and incentives is a key enabler for the Owner. According to the Owner, BIM is not 'visible' to all parties such as technicians on site because the main idea is to facilitate the project delivery by BIM, where applicable. If BIM use confuses parties by disrupting their work efficiencies, there is no value in enforcing BIM. Thus, BIM is not introduced to certain downstream parties who would have significantly steep BIM learning curves with no realizable contribution to their scope of work. Similarly, for parties that need to implement BIM, aligning their BIM learning curves is a major enabler for the Owner. Centralizing BIM management on behalf of the Owner is another enabler that enhances all parties' speed in BIM delivery, and asset management capabilities of the airport in the FM phase. Additionally, as the Owner manages all BIM processes, optimizing time spent on improving integration and exploring new technology is also a crucial enabler for the Owner. The Consultant's key strategy that acts as an enabler is dissolving the boundaries between project phases by implementing an integrated project delivery mindset. A similar strategy is also grasped by the Supplier as he reported that the design of BIM platforms that provide clear deadlines for every issue visible to all upstream and downstream parties is a key enabler. The Supplier also perceives real-time continuous monitoring on site as another enabler, which can mostly provide benefits to the Owner.

Moreover, both the Owner and the General Contractor perceive certain application programming interfaces (APIs) as enablers for their airport BIM implementation processes. APIs enabling real time notifications for changes in projects, files, and folders, and interacting with 3D models in a web browser with no additional software needed are considered as enablers that can defer the problems with heavy airport models and expanded, siloed communication networks within the project. They can also be beneficial throughout the whole project life cycle.

3.5 Benefits

Benefits represent BIM implementation outcomes realized at the project level. BIM benefits can be presented as the way it creates synergies between other construction technology ecosystems' uses by providing an optimum base platform to utilize metadata for various project management purposes. Multidimensional capacity of BIM in performing project management practices brings clear benefits, such as organizing project schedule and budget, better coordination with the design team, optimizing the Owner's experience and satisfaction, increased profit margin, better control of the subcontractors, project closeout with facility information rich models (Bryde, Broquetas, & Volm, 2013).

Similarly, in the case study, utilizing BIM data efficiently for key project management practices within construction technology ecosystem for different phases of the project to extract actionable insights is the common benefit for all parties. The benefit of increased connectivity between project resources is expressed as direct relation between 3D modeling, design management, document management, quality control, and enterprise geospatial information services (eGIS) by both the Owner and the GC. On top of the listed construction technology uses, GC also benefits from BIM in project scheduling, quality control, progress tracking via performance dashboards, as-built model generation, cost control and concurrent engineering & design. The Consultant, Supplier, and Owner were more focused on the enhanced operational capacity by hosting a record model, which can guide the operator in asset management practices. The Supplier paid attention to how virtually navigating the airport model can increase wayfinding efficiency for end-users. Besides, because the Consultant oversees and guides the Owner for better customization of their BIM strategy, the Consultant is also mostly concerned with translating the BIM practices into faster delivery of the project with coordinated project timelines to make such a busy airport sustain its operational capacity for its passengers.

3.6. Impacts

Impacts are wider outcomes which are observed at the organizational or firm level in the long term. Knowledge gained as project-level benefits can be reusable and transferrable to create impacts at the organizational level. Organizations can experience improvements by benefiting from such impacts.

Airports are both building and business systems, and the impacts discussed by the multi-party perspectives focus mostly on business outcomes enhanced by airport BIM implementation for the whole project life cycle. As a common sense, to realize impacts in such a complex operational ecosystem, BIM should be implemented continuously by the support of all parties. According to the Consultant, developing a competitive edge for the airport is one of the key impacts because airports are not just competing for more passengers and being airline hubs, but also for reputation, which is highly linked to the best technology implementation. In a more detailed sense, according to the GC and the Owner, transferring the digital platform to the operations phase leads to positive impacts due to improvements in airport operations metrics, such as special airport systems service time, security checkpoints wait time, and baggage delivery wait time. All of these metrics affect the business performance of an airport. The Supplier highlighted that the collaboration power can be projected to the producer – customer – consumer chain by the knowledge generated during project delivery.

4. Conclusion

The competitive landscape of the infrastructure and urban development sector requires more innovative and digitally transformative solutions that unleash significant opportunities by connecting people, technology, and space starting from the very beginning of the project. As construction technology solutions become more connected, interactions of project stakeholders also increase along the supply chain network. These interactions and their influence are more prominent in large-scale complex project settings like airports. This study contributes to the body of knowledge and practice by presenting a high level and scalable novel approach to analyze BIM implementation for airport projects from multi-party perspectives through a real-life case study. This paper also provides a systematic understanding for how each party can have an impact on the level of BIM implementation diffusion by their own perspectives in a complex airport project.

Based on the research findings, the major barrier to airport BIM implementation is the highly-siloed airport systems coupled with existence of a technology-averse team, hindering the data handover processes. The major enabler is more transparent BIM platforms used with an integrated project delivery mindset. It is also seen that the perceived impacts of successful BIM implementation for an airport project are of concern to a significant number of parties as they hold significant business value. Accordingly, it can be recommended for all project parties to have BIM implementation roadmaps defining the expected business outcomes. In addition, all factors (from multi-party perspectives) determined for each component in the innovation framework should be assessed together as they are highly interdependent. Not only data transfer, but also data utilization, by connecting the project resources and project management practices in a construction ecosystem, is crucial for leveraging airport BIM implementation for a successful project delivery.

It should be noted that the findings presented in this study are reflecting conditions observed in a specific project. Caution should be exercised while extrapolating these findings to other projects. Further studies might consider the analysis of other airport projects, as well as other types of construction projects to enable comparison of BIM implementation process in different settings. Besides, additional projects may be analyzed in different countries and comparative studies may be produced to observe the similarities and differences regarding the country-specific factors.

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