Journal of Information Technology Case and Application Research

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/utca20

Actualizing the affordances of seaport smart container terminal system in a developing country

Emmanuel Owusu-Oware, John Effah, Ibrahim Osman Adam & Fred Amankwah-Sarfo

JOURNAL OF INFORMATION TECHNOLOGY CASE AND APPLICATION RESEARCH
https://doi.org/10.1080/15228053.2023.2250238

RESEARCH CASE ARTICLE

Actualizing the affordances of seaport smart container terminal system in a developing country

Emmanuel Owusu-Oware [a], John Effah [b], Ibrahim Osman Adam [c], and Fred Amankwah-Sarfo [d]

[a]Department of Information Technology Studies, University of Professional Studies, Accra, Ghana; [b]Department of Operations and Management Information Systems, University of Ghana, Legon, Ghana; [c]Department of Accounting, University of Development Studies, Tamale, Ghana; [d]Department of Information Technology and Systems, Ghana Communication Technology University, Tesano, Ghana

ABSTRACT
Transportation by sea routes and seaport container terminals are critical infrastructure that facilitates global trade. Thus, the emerging information systems research on smart container systems is essential. However, these studies lack empirical insights, and there is little on developing country contexts. To address these knowledge gaps, this study employs qualitative interpretive case study approach and technology affordance and constraint theory to investigate how Ghana's port authority replaced a predominantly paper-based container handling system with smart systems, as well as the consequences of doing so. The study's findings show that technology affordances are actualized in a developing country seaport smart container system based on management's perception of the system and the port's situational context. The study's findings show significant improvements over the manual paper processes, along with constraints including stakeholder digital unpreparedness, limited data storage capacity, unreliable internet and power supply disruptions, and equipment breakdowns. The findings have implications for research, practice, and policy.

Introduction

This study examines a developing country's replacement of its predominantly paper-based seaport container handling system with smart technologies. Sea transportation and seaport container terminals are important infrastructures that facilitate global trade. Intercontinental sea route container transportation accounts for about 90% of global trade (Jiang et al., 2018). As part of sea route transportation of goods, container terminals at seaports provide the infrastructure for loading and unloading cargo containers from ships, storing containers temporarily, and facilitating customs clearance (Kim & Hong, 2010; Sarkar & Shankar, 2021). Containers are steel boxes that enable easy and fast handling of sea freight (Steenken

CONTACT Emmanuel Owusu-Oware emmanuel.owusu-oware@upsamail.edu.gh Department of Information Technology Studies, University of Professional Studies, Accra, Ghana

et al., 2004). Therefore, the effective and efficient operation of seaport container terminal is critical for global trade and transactions (Sarkar & Shankar, 2021).

Effective seaport container terminal services are desired because of the need to lower shipment times and enhance productivity of port operations. Such desired outcomes cannot be achieved without information and communication technologies (ICTs) (Kim & Hong, 2010; Sarkar & Shankar, 2021; Steenken et al., 2004). Smart systems are advanced ICTs that can be used to transform container terminal operations and services. A smart system typically affords real-time data collection to enable intelligent actions to be performed and improve services, individual well-being, and economic development (Chen & Chan, 2022; Hildebrandt, 2020; Neuhofer et al., 2015). Thus, leading seaports such as Rotterdam and Antwerp have adopted smart systems to deliver goods quickly to their destinations by enhancing container traffic within a logistics network (Cimino et al., 2017; Heilig & Voß, 2017).

Information systems (IS) research on smart systems exists. However, the literature is predominantly on smart cities, smart manufacturing, and smart homes (Papagiannidis & Marikyan, 2020). While studies on smart seaport container terminals also exist (Cimino et al., 2017; Hameed, 2016; Kim & Hong, 2010; Sarkar & Shankar, 2021) there is little research in developing country contexts where ICT infrastructure issues remain prevalent. Moreover, the extant literature on smart seaports is mainly conceptual and less empirical. To bridge these knowledge gaps, this study examined the case of a developing country's smart container terminal system, which was deployed to replace a manual and inefficient paper-based system.

Therefore, the research questions guiding this study are: 1) how is a smart container system implemented and used in a developing country seaport? and 2) What are the consequences of using a smart container system in a developing country seaport? To answer these research questions, this study employed a qualitative interpretive case study approach (Klein & Myers, 1999; Walsham, 1995, 2006), and technology affordance and constraint theory (Majchrzak & Markus, 2012; Majchrzak et al., 2013) to examine the case of Ghana, a developing country in Africa, regarding the implementation and use of a smart container system at the Tema port, the larger of the country's two seaports.

The remaining part of the study continues as follows. The next section provides background literature on smart seaport container handling. This is followed by the theoretical foundation for this study, which is technology affordance and constraint theory. Thereafter, the research setting, and the study's methodology are presented, followed by the findings. In the ensuing section, the findings in relation to the research question and literature are discussed. The final section concludes the paper by summarizing the findings and presenting the implications for research, practice, and policy, as well as suggestions for future research.

Background literature

Seaport container terminal services

Seaport container terminal services are delivered through a complicated logistics system involving container handling activities using quay cranes, vehicles, and yard cranes (Kim & Hong, 2010). A seaport container terminal consists of two main areas: the quayside, which is located by the seaside and is used for unloading and loading containers onto or off ships, and the landside, where containers are transferred between trucks, trains, and the terminal. Containers are stored at temporary storage areas called stacks, thus enabling the separation of quayside and landside operations (Steenken et al., 2004).

Key factors contributing to effective and efficient container handling services include reducing the duration a containership stays at a seaport terminal and minimizing transshipment cost (Steenken et al., 2004). These success factors depend on available berths for ships, container stacks, extent of congestion at the port, and overall loading and unloading time (Sarkar & Shankar, 2021; Vis & De Koster, 2003).

Smart systems

Smart systems have evolved with the rapid development of ICTs and the "connected world," characterized by pervasive embeddedness (Papagiannidis & Marikyan, 2020). The term "smart" is commonly used to describe innovative technologies that allow devices to actively monitor and alert individuals in-charge to take appropriate action (Papagiannidis & Marikyan, 2020; Smith, 2005). Hildebrandt (2020) notes that the key aspect of a truly smart system is the intelligent nature of the response compared to a rigidly predetermined one.

By design, smart systems enable efficient information management for smart services which involve real-time data collection, intelligent data analysis, networked and creative IT systems and platforms (Yang et al., 2021). Typically, smart systems automate object identification and access control. An example is using a smart mobile application to automatically recognize students' attendance in class through their university ID cards (Alghamdi, 2019). Compared to traditional versions, smart systems transform business processes into an integrated chain of value-adding activities, reduce costs for all parties, facilitate collaboration among parties, and supply chain performance prediction (Cimino et al., 2017).

Smart systems are a convergence of multiple technologies, ranging from wireless communications to the Internet and from embedded to sensing systems (Cimino et al., 2017). Generally, the ICTs that characterize smart systems are sensors, networks, and middleware software (Romero et al., 2020). Commonly known sensors include radio frequency identification (RFID) devices and optical character recognition (OCR) systems. These sensors automatically collect information on an object in real-time. The real-time information may be a change in the object's environment, condition, or operating history. The middleware software then processes and interprets the collected information, draws inferences, and performs self-control and self-adjustment on related components (Hildebrandt, 2020; Jiang et al., 2018).

Smart systems for seaport container terminal

To enhance container terminal productivity, port management have adopted smart system infrastructures (Cimino et al., 2017). Container terminal productivity requires intense and timely communications with external parties. The parties include shipping lines agents, freight forwarders, truck and rail companies, customs, and police (Steenken et al., 2004). Because many actors are involved, information sharing is critical for seaport container terminal services (Sarkar & Shankar, 2021). Thus, every change in container status is communicated among the parties (Steenken et al., 2004).

The IS literature has identified smart systems applications in port logistics management (Cimino et al., 2017; Kim & Hong, 2010; Sarkar & Shankar, 2021; Steenken et al., 2004). Mainly, these systems include global positioning systems (GPS), RFID devices, OCRs, wireless networks, real-time locating systems (RTLS) and middleware software. These systems are deployed as sensor nodes embedded in containers and vehicles to collect data and track their positions and movements in real- time within the terminal. The effect is remote monitoring of cargo with less human effort (Cimino et al., 2017). The large amounts of data generated from these sensors are stored centrally in cloud storage (Jiang et al., 2018). Smart systems for port logistics handling are also used as access control to authorize who and what enters the port (Cimino et al., 2017). Thus, smart container handling systems contribute to the improvement of port security and the efficient management of cargo at terminals, leading to optimized operations in seaports. However, these systems expose the port to cyberattacks (Lezzi et al., 2018; Sarkar & Shankar, 2021).

Thus far, our knowledge of smart container systems has been mainly conceptual or based on models and simulations (Cimino et al., 2017; Kim & Hong, 2010; Sarkar & Shankar, 2021). While these studies have enriched the smart systems literature, there are less empirical insights into how smart container handling systems are implemented and used in real-life situations and the consequent effects. Moreover, knowledge of smart container terminal systems in a developing country context is sparse. This study, therefore, fills these knowledge gaps by examining the case of Ghana's Tema port on how container handling services were transformed from paper-based to smart system processes.

Theoretical foundation: technology affordance and constraint theory

The theoretical foundation for this study is technology affordance and constraint theory (TACT) (Majchrzak & Markus, 2012; Majchrzak et al., 2013). The theory is derived from the concept of affordance introduced by Gibson (1977), an ecological psychologist, who used it to explain how animals perceive what their physical surroundings enable them to do. Gibson defined *affordance* as the action possibilities that an object affords an actor to achieve a goal (Gibson, 1977). In relation to information systems, technology affordance is used to understand organizational outcomes resulting from interactions between a user (actor), technology (material features) and the context (i.e., the situated nature of use) (Evans et al., 2017; Markus & Silver, 2008).

The main concepts of TACT are actor, technology, technology affordance, affordance perception and affordance actualization. These are depicted in Figure 1.

Actor is an individual, group, or organization that takes part in the development or use of an information system (Drevin & Dalcher, 2011). Technology refers to ICTs that actors engage with in order to generate information system outputs (Hammond, 2010; Markus & Silver, 2008; Sun et al., 2019). Technology affordance describes the action possibilities a specific technology affords a goal-oriented actor (Majchrzak & Markus, 2012). Technology affordance is regarded as an emergent property that arises from

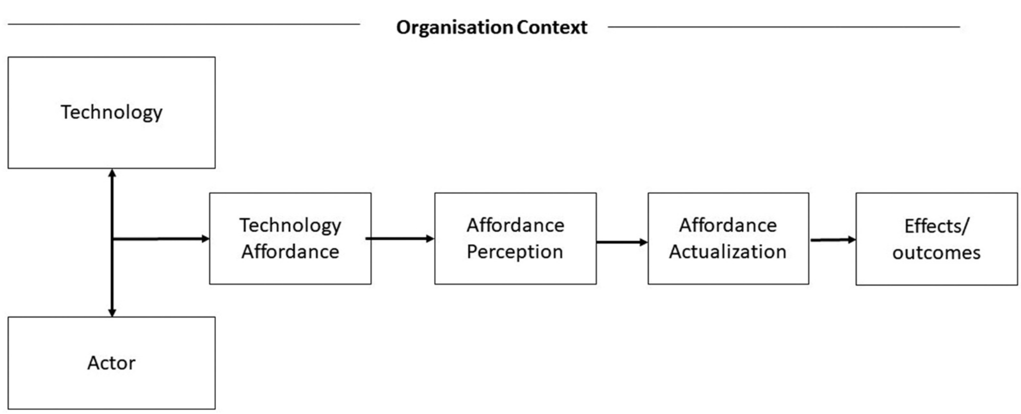

Figure 1. Technology affordance and actualization process [adapted from (Majchrzak & Markus, 2012; Majchrzak et al., 2013)].

the interactions between ICTs and actors, rather than being solely attributed to either of them individually (Majchrzak & Markus, 2012; Wang et al., 2018). As depicted in Figure 1, technology affordance (i.e., action possibilities) is shaped by ICTs and actor interactions and the organizational context. Organizational context refers to actor's historical and socio-institutional settings (Pozzi et al., 2014; Zheng & Yu, 2016).

Affordance perception is actor's perception of a technological artifact given the intended goals. Such perception is shaped by the technology features and actor's organizational context (Leidner et al., 2018). Affordance actualization denotes actions taken by an actor to realize the affordances that contribute to achievement of organizational goals and outcomes (Volkoff & Strong, 2017). The actions are the goal-oriented activities that an actor undertakes to transform the action potentials into outcomes (Liu & Hung, 2019). The actions involve deploying and using IT artifacts to achieve organizational goals and outcomes (Burton-Jones & Volkoff, 2017; Strong et al., 2014). Like perception, goal-oriented actions are shaped by ICT artifacts and organizational context (Du, 2019). Effects is the long-term consequences of actualizing the technology affordances (Dini et al., 2016; Strong et al., 2014). A major principle of affordances is that they can be both enabling and constraining. Enablers and constraints, as applied to technology affordances, are factors that occasion or hinder realization of action possibilities to achieve goals (Effah et al., 2020; Wang et al., 2018). Thus, affordance perception and actualization can either be enabled or constrained by the technology, actor, and organizational context.

The theory has been applied in IS studies in areas including social media (Dini & Saebo, 2016; Strong et al., 2014), mobile payment (Pal et al., 2018), digital work (Ens et al., 2018), self-service technology (Liu & Hung, 2019), and blockchain technology (Du et. al., 2019). This paper applies the technology affordance and constraints perspective to understand how smart systems are implemented for container handling at a developing country seaport and what the consequences are. The theory was chosen to answer the research questions by exploring the interactions between actors and smart system affordances within the situated context of container handling at a seaport.

Research setting and methodology

Research setting

The Tema port is the larger of the two seaports in Ghana. The port is administered by the Ghana Ports and Harbors Authority (GPHA). Located on the east coast of Ghana, the port is considered the leading port and gateway to West Africa because it serves the landlocked countries in the West Africa sub-region, namely Mali, Burkina Faso, and Niger. On average, the port receives 1,650 vessel calls annually from various parts of the world, including Europe, Asia, the North and South Americas, and Australia. The port spans a land area of about 3.9 million square meters.

Over a period of 11 years, from 2008 to 2019, through a public-private partnership (PPP) arrangement, the port's digitalization project, named e-project, was pursued to transform the port's operations. As a result, the port's systems and services were significantly enhanced with ICTs. This study focuses on the port's smart containerized cargo handling system, a sub-project. The implementation of the smart container system started in 2015 with procurement processes, installations in 2017, and completion in 2019.

The port provides container handling facilities via dedicated terminals, built, managed, and operated by a private company. The terminal consists of two berths and a quay length of 575 meters, with facilities including: 3 ship-to-shore gantries, 4-yard gantries, 2 mobile cranes, reach stackers, 272 reefer plug points, and a six-lane electronic gate complex. In 2021, an additional 400 m of berth and 16 gantry cranes were inaugurated to enhance port efficiency and security.

The port has the infrastructure for multipurpose vessels and dedicated container terminals. Major services offered by the port include vessel handling and marine services, stevedoring, shore handling, and conservancy services.

Methodology

This study's methodology is qualitative interpretive case study (Klein & Myers, 1999; Walsham, 1995, 2006). Qualitative research seeks in-depth understanding of a phenomenon involving humans and their social interpretations, experiences, and actions (Creswell, 2014). The underlying interpretive research paradigm of the study is based on subjective ontology, which regards reality as the subjective and intersubjective perspectives formed by everyday human interactions (Orlikowski & Baroudi, 1991; Schwartz-Shea & Yanow, 2013). This means that the research phenomenon under study and the knowledge output are socially constructed rather than objectively given (Myers, 2013).

A qualitative case study affords deep insights into the phenomenon being investigated (Xie et al., 2020). Moreover, a case study method draws on multiple data sources to understand a complex phenomenon within its natural and unique setting (Ridder et al., 2009). Given the purpose and research questions of the study, the qualitative interpretive case study methodology was therefore found to be appropriate to gain deeper understanding of seaport container handling system based on the interactions of actors and smart systems and their effects.

Data collection

Data collection occurred over six months, from September 2020 to February 2021. In line with the interpretive case study tradition, qualitative data was collected from multiple sources with interviews as the primary source and complemented with field observations, websites, and documentary materials. Nineteen participants were interviewed. The participants were selected through purposive sampling (Creswell, 2014; Patton, 2002). With the assistance of the port manager, the participants were selected based on their role, knowledge of the port operations and involvement with the conception and implementation of the port's smart systems. Table 1 shows a summary of the nineteen participants interviewed. Generic positions have been used for anonymity reasons.

As shown in Table 1, the port employees were: port operations – manager (1), harbor master (1) crane operator (1); stevedore (1); officers at container department (2); port security (1); information systems professionals – manager and officers (3). Stakeholders were – customs officers (3), shipping line agents (2), clearing agents (2), and truck drivers (2).

The participants were interviewed using a semi-structured interview guide (Myers, 2013). They narrated their experiences with the traditional paper-based processes, how the smart systems were introduced at the port, and the results. The interview guide questions used for the interviews are included in the appendix section. On average, the interview sessions lasted between 50 minutes and an hour. The interview sessions were audio recorded with the permission of interviewees. Note-taking complemented the audio recordings. We subsequently transcribed the interview sessions. Follow-ups by e-mail and phone calls were made for additional data or clarifications.

Table 1. Interview participants.

Interview Participants	Number
1. Port operations	
• Manager	1
• Harbor master	1
• Crane operator	1
2. Stevedore	1
3. Container department officers	2
4. Port security	1
5. Information systems professionals	
• Manager	1
• IT Officers	2
6. Stakeholders	
• Custom officers	3
• Shipping line agents	2
• Clearing agents	2
• Truck drivers	2
Total	19

Data analysis

Data analysis was theory-driven (Walsham, 2006). The analysis involved reading through the data sources severally and iteratively using TACT concepts and principles as the themes. The collected qualitative data (i.e., the interview scripts, field notes and documents) were analyzed by finding instances of the theoretical concepts of TACT, that is, technology affordance, affordance perception, and affordance actualization. For example, here is part of the port's IT manager's description of the ICTs to be implemented for the container handling process coded as an instance of technology affordance perception:

> ... instead of a physical gate, it was planned to implement a smart gate system that will automatically verify entries and exits without human intervention ...

Thus, the study's theory was used as a "sensitizing" device (Klein & Myers, 1999) and not as a testing instrument.

Each author performed the analysis independently, and we met at scheduled times to present and discuss the findings. Disagreements were resolved either by contacting participants again or by gathering further information from documented sources. In some cases our different perspectives were maintained in line with the multiple interpretation principle of interpretive studies (Klein & Myers, 1999). The multiple interpretation perspectives of the authors enriched the study's findings, which are presented in the next section.

Findings

This section applies the concepts of TACT to present the study's findings. The findings are summarized in Figure 2. The figure shows the interaction of the actor, the smart container system, and the organizational context. In the figure, actor refers to the port management, project implementation team (PIT), and users (i.e., port employees, import and export agents). The smart container system refers to the ICTs that were deployed and used to transform the port's operations and services. The context is the traditional manual paper-based container handling processes, its challenges, actor, and the goals of the port authority. The context shaped the perception and actualization of the smart system affordances. The outcome is a smart container system and its effects. The detailed findings on the interplay of these situational elements in the implementation and use of a smart container system are presented in the subsections that follow.

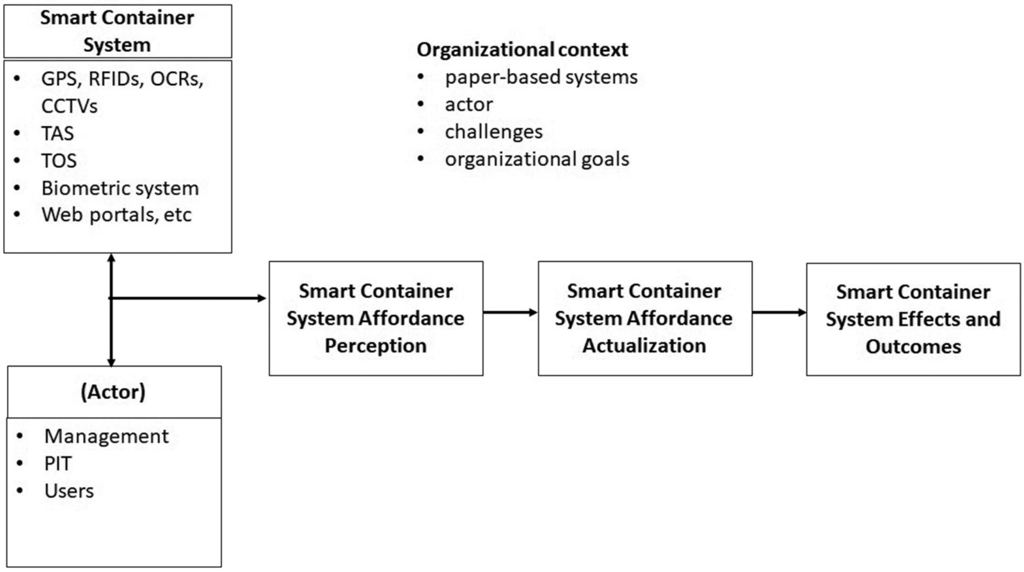

Figure 2. Actualization of seaport smart container system affordances.

Smart container system affordance perception

The port management and the PIT perceived smart container system affordances as opportunity to deliver services that comply with international port facility standards. This perception was formed based on several factors: the difficulties encountered with the predominantly paper-based container handling processes at the port, the insights gained from visiting ports in Rotterdam and Antwerp, where smart systems were in place, and the project team's defined requirements for acquiring and implementing the smart container system.

The port manager gave insights into the traditional container handling processes before the introduction of the smart systems. According to the port manager, the container handling process at the port can be divided into three subprocesses: 1) pre-arrival and arrival of a containership; 2) the unloading/loading of containers; and 3) the pickup and drop-off of containers. The pre-arrival process began before the arrival of ships, when a shipping line's agent sent a manifest by facsimile to the container allocation department. The fax showed the vessel's number, country of origin, arrival date, consignee, number of containers to be unloaded and other details such as tonnage and content. A container allocation officer explained:

> After submitting the manifest, the shipping line agent requested a berthing space by filling out forms with the particulars of the vessel. . . . the shipping line agents provided the information on paper forms and took them to the harbor master's outlet . . .

The harbor master checked berthing space availability and a convenient time slot for the vessel, taking into consideration the type and size of the vessel and the cargo to be unloaded. A berthing meeting was held with stakeholders to validate the information and agree on a date and time to berth the vessel. After that, the container allocation office printed copies of the vessel's unloading details and physically sent them to the terminal and crane operators. The approval to berth assigned a berth place, quay cranes, and operator allocations. The arrival process followed when the ship berthed, and the container details were physically verified.

With the unloading process, quay crane operators removed the imported containers from the ship's hold. The unloaded containers were then transported by truck to the stacks for temporary storage. The containers remained in the stacks until they were transported outside the port by outbound trucks after passing through physical security checks at the port gate. Loading of containers onto a berthing ship followed the reverse process.

The port manager recounted the challenges at the port before introducing the smart container system.

> The port operations had several challenges . . . long waits in clearing cargos, congestion at the port, false declarations . . . So we were losing millions of cedis annually.

According to the port master, the paper-based processes caused delays and long dwell times (i.e., the number of days a cargo remains within the port), with container vessels queuing for about a month. Under the manual era, security personnel checked entries into and exits from the port. The manual security checks not only caused delays and traffic congestion but also allowed unauthorized persons to gain access to the port. One custom officer commented on the inefficiency of the container handling services.

> The process was so cumbersome, creating long dwell times of cargos at the port . . . these delays attracted penalties for consignments that remain beyond the "grace period."

An IT officer described the nature of the paper-based processes and their effects:

> Paper records dominated the processes . . . . filling forms, making photocopies, retyping, and printing documents . . . making entries into notebooks . . . manually validating information. . .all these created delays and room for malpractices. So, we were incurring high transaction costs.

Thus, in seeking to replace the paper-based container handling processes with a smart system, the port management, with input from the project implementation team (PIT), perceived the replacement system as one that would significantly reduce the delays and inconveniences to customers, reduce the high transaction costs, eliminate avenues for malpractice, and ultimately attain the international port standards needed to attract vessels and increase revenue.

The IT manager's description of the ICTs to be implemented reflected the port's perception of smart system affordances.

> . . . our visits to modern ports abroad helped a lot . . . so instead of a physical gate, it was planned to implement access control systems that will automatically verify entries and exits without human intervention . . . For the loading and discharge of container cargos we thought of quay cranes with sensors that will automatically identify containers . . . .

Table 2 summarizes management perception of smart container handling system affordances as gathered from the interview participants.

Table 2 depicts positive perceptions of the affordances of the smart container system affordances. However, these favorable perceptions of the port management were constrained by past experiences of unreliable internet and electrical power. This constrained perception led to the choice of a local data storage instead of cloud-based storage for the smart container system. The IT manager explained.

> We chose to host the data collected from the smart systems on a local storage system because a cloud storage depends on reliable internet service . . . But here at the port we have been experiencing disruptions in internet service . . . so if the internet is off and we were using cloud storage, we will not be able to use the smart system . . .

The IT manager also recalled the unstable power supply situation in the recent past. Between 2015 and 2016, the country experienced long periods of intermittent and unpredictable power outages commonly called "dumsor." These infrastructure factors influenced the port management's perception of reliable intranet infrastructure as a necessity for the smart container handling system. However, the persistent power supply outages and management's choice of

Table 2. Port management's perception of smart container handling system affordances.

Container handling process	Affordance Perception
Container pre-arrival and arrival	**Smart identification and information management** (1) Online submission and approval of berthing requests (2) Autonomous and real-time identification/verification of berthing ships and containers (3) Autonomous and real-time data capture into a central database (4) Data analytics and reporting
Container unloading and loading	**Smart identification and information management** (1) Autonomous capture and update of container information details as containers are unloaded and loaded. (2) Data analytics and reporting
Container pickup and drop-off	**Smart access control** • Autonomous identification and verification of drivers, trucks, and containers for entering and exiting the port.**Smart identification and information management** • Autonomous tracking of container status in real-time regarding movements and position at the port terminal • Data analytics and reporting
Work orders	**Smart workflow** • Automatic work order generation and alerts • Status update of work on containers

a local storage system constrained the smart system's use (see subsection on the effects of the smart container system). The perception of other actors, such as importers and clearing agents, constrained the actualization of the affordances of the smart container system in the form of resistance to the project (see subsection on the effects of the smart container system).

Overall, the port management believed that the smart container system offered the best opportunity to replace the inefficient paper-based information system, prevent revenue leakages, and attain international port standards. The next section presents the actualization of the affordances of the smart container handling system through the port's e-Project.

Smart container system affordance actualization: project implementation

The port management, with the support of the government, launched an e-project to digitalize the entire port process. The government was supportive and approved the counterpart funds for the public-private partnership (PPP) project. The smart container system was a sub-project. Smart container system affordance actualization involved deploying smart technologies to replace the traditional process. In 2019, through the e-Port project, smart systems were deployed into the operations of the port and integrated with the port's enterprise system. According to the IT manager, a project implementation team (PIT) was constituted by the port management to oversee the implementation of the smart systems. The PIT was made up of internal representatives from departments of IT, operations, finance, audit, marketing, and corporate affairs. The external representatives included a private partner of the PPP, shipping lines, customs, stevedoring companies, and clearing agents. A series of meetings were held to plan and implement the project. Following the meetings on planning and requirements determination, the team came up with a blueprint of the container processes and the roll-out plan. The blueprint and the requirements reflected the perceived affordances of the smart system outlined in Table 2.

The IT manager described the various components of the smart system for the container handling processes.

> We engaged solution providers to implement the different aspects of the smart container system. Each provider had their expertise. So, one looked at the data collection sensors, another catered for the terminal operating system, yet another took up the web portals . . .

The smart container system technologies that were actualized through project implementation in line with perceived affordances are summarized in Table 3.

As shown in Table 3 (see also Figure 1), the smart systems that were actualized for the port's container handling processes comprise sensor technologies, i.e., GPS, RFIDs, OCRs, and CCTVs as well as biometric fingerprint

Table 3. Actualized smart container system technologies in line with perceived affordances.

Affordance Perception	Affordance Actualization (Technologies implemented)
Smart access control • Autonomous identification and verification of drivers, trucks, and containers for entering/exiting the port	• Smart gates embedded with RFIDs, OCRs and CCTVs • Biometric fingerprint system • Web applications and backend systems: Truck Appointment System (TAS) and Terminal Operating system (TOS).
Smart identification and information management • Autonomous capture and update of container information details as containers are unloaded and loaded • Autonomous tracking of container status in real-time regarding movements and position at the port terminal	• GPS, RFIDs, CCTV, mobile devices, OCRs, • Middleware software – Truck appointment system (TAS) and Terminal (Operating system (TOS). • Email/Electric Data Interchange (EDI)
Smart workflow • Automatic work order generation and alerts • Status update of work on containers	• Mobile devices, Truck appointment system and Terminal (TAS) and Terminal Operating system (TOS).

system and middleware software, mainly, TAS (truck appointment system), and TOS (terminal operating system). The middleware software are web portals that integrate the sensor systems. The findings on how these smart system affordances were actualized for container handling are presented in the subsequent section.

Actualization of the smart container system affordances through the e-project was constrained. According to the port manager, apart from procurement delays, there was resistance from importers and clearing agents. An importer recalled her anxiety about the project during a stakeholder meeting.

> There are just too many failed digitization projects... so we didn't believe this one will work . . . instead it will create further problems for us . . . today the computer is down . . . tomorrow it is up.

Others resisted the project because of the new demands on them, namely learning how to use the system, having the required mobile devices equipped with GPS and RFID, and purchasing internet data units. According to a port officer, some stakeholders resisted the project because they wanted to maintain the status quo, which allowed them to engage in malpractices. Thus, as part of actualizing the smart container system affordances, the port management engaged stakeholders in meetings and training sessions. While these actions helped gain stakeholders' cooperation, some continued to resist. However, the port authority's resolve and the government's support enabled the project to be completed, albeit three more years later than was originally planned. The delay was caused mainly by cumbersome procurement processes and delay in government releasing funds. Thus, the project implementation, which started in 2015, was completed in 2019.

Smart container system affordance actualization: use of system

The smart container system affordances perceived by the port management were actualized into use for the three container handling processes of pre-arrival/arrival, unloading/loading, and pickup/drop-off. Starting with the pre-arrival/arrival processes, the shipping line, while at sea, sends manifest information by e-mail to the port authority, the local importer agent, and customs. The manifest information is also automatically uploaded to a web portal linked to the TOS. The TOS is the central database for the smart systems. The e-manifest information includes the consignee's name and address, the date of arrival, the estimated time of arrival, the vessel details, the number of containers to be unloaded, and the type of cargo. The information includes the berthing and draft specifications for the ship, the crane outreach, and the air draft. Stevedores and terminal operators access the container vessel information online and automatically allocate berths to the vessel without printing. Depending on the availability of a berth, a containership before its arrival will be assigned a berth or must wait until a berth becomes available.

On arrival at the allocated port's berth, the port's OCR cameras placed at vantage points automatically scan and verify the ship's details. Crane operators using mobile devices scan and verify the information indicated on the container. All scanned information are automatically saved to the TOS. The TOS stores information about container handling activities at the terminal and allows access from anywhere at any time by authorized stakeholders, as well as data analytics and reporting.

The smart quay cranes facilitate unloading containers from the ship's hold. These cranes are embedded with OCR cameras, which automatically recognize the number of containers and their details by scanning the information affixed to them. The scanned OCR information includes the container ID, ISO code, seal presence, International Maritime Dangerous Goods (IMDG) label, and door direction. This information is sent instantly to the TOS. The crane operator also scans information about the containers using mobile devices, which are instantly sent to the TOS. The automatic identification is done as the crane lifts the containers onto yard trucks, which transport them to the terminal stacks for temporary storage.

Container pickup begins when a freight forwarder accesses the port's TAS, an online portal for scheduling container pickups from the port. Through the TAS, the port restricts access to the port terminal to only authorized freight forwarders who need to pick up or drop off containers at the port. Describing the features and functionalities of the TAS, the IT manager said the TAS is fully integrated with the TOS. The IT manager explained further:

> Through the TAS, customers have access to dashboards showing their personal information and available containers. The TAS portal is accessible anytime from anywhere by registered customers. The TAS communicates in real-time with the centralized terminal

> operating system (TOS) to retrieve and validate all data. So compared to the manual process there are no waiting times.

After an appointment request is approved through the TAS, the registered truck and driver are authorized to enter the port terminal. Smart gates installed at the entry and exit terminal points automate secured access to the port. The smart gates are equipped with CCTV cameras and RFID, enabling autonomous access control without human intervention, as was the case with traditional manual security checks. Drivers are authenticated at the port terminal entry gate using their assigned biometric ID cards and fingerprint readers at the gate. The driver's truck is also verified using an RFID tag on the truck's windshield. The RFID tag is a unique tamper-proof identification sticker on the truck's windshield. A terminal officer explained the significance of the smart validation as part of the container handling process at the port:

> We wanted to ensure visitors and customers to the terminal are automatically allowed without human intervention. In this way, facilities and cargos are kept much safer and in compliance with the international shipping and port facility security (ISPS) code.

After a driver and truck are validated and admitted into the terminal, their movement through the various locations in the port is automatically tracked using CCTV, OCR, and RFID as the process for picking up or dropping off containers progresses. Each container is originally tagged with RFID from the point of loading by the shipping lines. A container's movement and status data are captured through an embedded RFID tag and saved to the TOS. On the other hand, the embedded CCTV camera provides visual monitoring footage of the truck and container's movements. The data captured from the OCR and RFID are compared with the booking information in the TOS. For containers arriving at the port to be exported, the TOS will retrieve the booking information (i.e., container number, IMO classification, etc.) to be compared with the OCR scanned information at the gate. The terminal operations manager described container movement process as follows:

> As containers are transported from one area to another, the RFID sends data in real time to port authorities and shipping lines. Sharing data electronically facilitates imported cargo flow and saves time and money by eliminating redundant data entry.

Automated workflows are initiated and run alongside the container handling processes. Such workflows allow terminal workers to be alerted on their mobile devices to perform their work at scheduled times. For containers arriving at the port to be exported, an automated workflow is initiated as the truck enters through the terminal gates toward the destination at the container yard. The TOS will retrieve the booking information and then compare with the OCR information. An officer at the container terminal gave some insights into the automated tracking process.

> All data is captured and verified in real time as the truck enters to drive through the yard, a routing slip is printed at the portal, indicating which destination in the yard the truck is supposed to go. By the time the truck reaches the destination point in the yard all data is processed.

Truck drivers use mobile devices equipped with GPS and RFID to receive and transmit information on scheduled pick-up and delivery on their phones. As a truck driver heads toward the yard, a gantry operator automatically receives a work order on their mobile device, through the TOS. On arrival at the destination, the truck is served. The driver proceeds to the out-gate after the container has been unloaded or loaded onto the truck, where an OCR automatically verifies the truck condition. The actualization of the affordances of the smart system in use had its constraints. These constraints and their effects are presented together with the improvements gained in the next subsection.

Effects of the seaport smart container system

The smart container system significantly improved container handling processes at the port, though with some drawbacks. The beneficial effects were mainly reduction in manual data capture, reduction in delays, autonomous and semi-autonomous data capture, ready access to information by stakeholders for timely decision-making, and transparency of the container handling processes among stakeholders. The overall effect was improved container handling services that met international port standards.

The pre-arrival and arrival paper-based processes were replaced with e-Manifest and an online portal. This replacement allowed real-time sharing of berthing request information among stakeholders and online approvals for shipping berths. The result was efficient and timely processing of berthing requests.

With container unloading/loading processes, the associated physical inspection and validation of container information and manual entries of container details were replaced with smart information management and tracking using GPS, RFIDs, OCRs, and mobile devices, all linked to the TOS. As a result, information was instantly available for container handling processes.

The manual information system that supported picking and dropping off containers for import and export was also transformed with smart systems comprising TAS, TOS, smart gates, RFIDs, and biometric systems. The result was that drivers and trucks were automatically verified at the port gate without human intervention. Further, the smart systems ensure transparency and reduce errors and malpractices by tracking the movement of drivers and trucks through the port terminal in real-time. One terminal officer noted:

> The real time monitoring provides added transparency and visibility as every cargo movement is sensed and monitored. This is fundamental to having a situational awareness of what is going on at the port.

Thus, with increased data transparency, incentives for corruption and fraud were curbed, according to the port officials. With the smart container system, importers are assured of paying the appropriate charges. Charges and duties are automatically calculated, which gives a high level of trust in paying appropriate fees on goods and cargo clearance. "The system is now open and unbiased to all consignees," a freight forwarder remarked. Reduced traffic congestion is another outcome of smart container handling. Containers arriving at and leaving the terminals increased traffic jams with the former traditional paper-based system. A senior terminal officer commented on the beneficial impact of the TAS:

> Real-time information is shared with drivers and transport companies, so they can see the real traffic conditions at the container terminals at any given time.

As a result, importers can now submit clearance requests online. All interested parties receive the submitted documents in real time, invoices are generated, payments are made, and truck entry permits are granted online. An importer shared her delight:

> The frustrations and delays that we experienced have been drastically reduced. We no longer submit hard copies of shipping line delivery orders and customs release to the terminal for confirmation.

The introduction of the smart container system at the port vessel reduced queuing time from 30 days to 5–10 days. An officer at the container department also indicated that with the smart system, the number of people who directly handled containers has been reduced from about 20 to 5 people. However, the smart container system was not without challenges in its use.

The officers interviewed shared their experiences with the challenges associated with using the smart system, including interruptions in electricity and internet connectivity, exposure to cyber security threats, and limited storage capacity. These challenges affected the availability and smooth running of the smart container system. One IT officer narrated the challenges with the Internet and occasional power outages and equipment breakdowns:

> Power and internet disruptions affect the smooth running of the system despite having standby generators and service level agreements. We encounter equipment breakdown due to salty conditions at the port environment… We have had to revert to the manual system on few occasions due to long periods of power outages and equipment breakdown. But now things are much better with further investments in the IT infrastructure.

Online access exposed the port's smart systems to cyberattacks. "From our firewall logs, we see cyberattack attempts," according to an IT officer. The mitigation of cyberattacks and unreliable electricity and internet challenges caused the port authorities to spend more on maintaining the port's smart systems.

One major challenge was the limited storage capacity for the massive amounts of data collected through the sensor systems. These compelled the port authority to delete data to make way for new ones, thus losing historical data. This effect was because of the decision by the port to use the local area storage system instead of cloud storage. According to the IT manager, the choice of local storage over the cloud was that the sensor network within the port should work even if the internet service goes down.

Overall, the smart container system brought about significant improvements in container handling services at the Tema port. Ultimately, the port authority was able to achieve the international port standards using the smart systems.

Discussion of findings

The study's findings in relation to the research questions stated in the introduction section and the literature are discussed in this section. In line with the two research questions, we discuss the findings under two subsections. The first subsection discusses how a smart container system is implemented and used in a developing country seaport, while the second subsection examines the Effects and outcomes.

Smart container system implementation and use

The study's findings show that a developing country seaport smart container system is implemented and used in accordance with the main actor's perception of the system affordances and their actualization within the port's situational context. In this study, the smart container system affordance perception of the main actor (i.e., the port management and the PIT) was shaped by the situational context of the port. The port's situational context was an inefficient and ineffective paper-based container handling system that frustrated customers, created revenue leakages, and fell short of international port standards. Given this situational context, combined with knowledge of smart container systems gained through visits to modern ports, the port management perceived the smart container system affordances as capabilities that will enable automatic access control, identification, information management, work schedule, and updates as detailed in the study's findings.

In terms of project implementation, this study's findings show that actualizing smart container system affordances in a developing country's context involves sub-processes. These sub-processes include gaining government support, employing a PPP arrangement, constituting a broad-based stakeholder PIT, engaging smart solution providers, and implementing the smart system per the perceived affordances of the main actor. As the study shows, the replacement of the paper-based container handling processes involved deploying three functional smart container subsystems comprising: 1) *smart access control*, which involved smart gates (embedded with RFIDs and OCRs), a biometric fingerprint system, and middleware software (i.e., TAS and TOS); 2) *smart identification and information management* using GPS, RFIDs, CCTV, OCRs, EDI, and middleware software; and 3) *smart workflow* using mobile devices, TOS, and TAS. This study's findings on the smart container system components are consistent with the literature discussions on smart container system technologies (Cimino et al., 2017; Kim & Hong, 2010; Sarkar & Shankar, 2021; Steenken et al., 2004). However, the study's findings on how seaport smart container system components get implemented in a developing country context are new.

Also, findings from this study show that ICT project implementations that actualize smart container system affordances can be constrained by stakeholder resistance and procurement delays. In this study, these constraining factors prolonged the completion date by three more years. While these findings on project implementation are new in the smart container system literature, they are not in the developing country IS literature on project implementations (e.g. Effah & Debrah, 2018; Larkotey et al., 2021; McGrath & Maiye, 2010). Also in the IS literature on developing country project implementations, the need to engage all stakeholders has been amply highlighted (Masiero, 2016; e.g.; Nkohkwo & Islam, 2013; Owusu-Oware et al., 2017). In this study, the port authority engaged the stakeholders in orientation and training sessions, in addition to having their representatives on the PIT. This helped to bring on board the stakeholders, though some stakeholders continued to resist the project.

In terms of use, the study's findings show that smart container system affordances are actualized for autonomous access control, identification, information management and workflow in accordance with the port's management's perceived affordances. The actualization of these affordances into use enables real-time data capture, monitoring and responses that are independent of humans. For instance, in this study, smart quay cranes equipped with OCRs and RFIDs autonomously verify containers as they are unloaded from the ship's hold. These findings on affordances concur with the literature regarding smart systems acting independently of human monitoring, controlling and optimizing activities (Paukstadt et al., 2019; Porter & Heppelmann, 2015). Additionally, in this study, beyond the autonomous smart data capture, mobile devices used by terminal operators complemented data capture of container information.

The study's findings also show that using smart systems to handle container processes can replace or reduce the number of human beings. This finding corroborates existing literature on smart systems replacing human beings in performing activities (Baheti & Gill, 2011; Martin et al., 2019; Porter & Heppelmann, 2015). In this study, smart gates embedded with OCRs and RFIDs were used to replace the physical inspection of trucks. In the manual inspection system, human beings physically opened and closed gates. This created delays and congestion at the gates.

We found similarities between smart port container handling and smart hotel platforms, which track customers' stays at hotels. Smart hotel services involve automatic data collection and tracking of customers' prior arrival, stay, and post-stay on one centralized platform (Neuhofer et al., 2015). This is similar to seaport container lifecycle. While a smart hotel platform enables customer information to be collected, accessed, and retrieved by a hotel to personalize services, this study's findings show that a smart container platform tracks and controls container handling from pre-arrival to exit from a port terminal and vice versa. Thus, as observed by research in other domains such as tourism, a smart container system fulfills the requirement for consistent information collection at all stages (Buhalis & Law, 2008; Neuhofer et al., 2015).

The study's findings show constraining factors with the deployment and use of the smart container system at the Tema Port. We discuss next these constraints in addition to the beneficial effects of using a smart container system in place of a paper-based one.

Smart container system effects and outcomes

Starting with the beneficial effects, this study's findings show that a developing country's seaport's use of smart container systems can bring about significant improvements. In this study, the findings show improvements included reduced dwell times, timely decision-making, transparency, cost savings, and ultimately compliance with international standards. These beneficial effects result from real-time data capture and processing regarding containers' arrival at the seaport, containers' metadata, contents, positions, and movements within the port terminal, and access to container information by stakeholders. For instance, in this study, labor for unloading/loading containers reduced from about 20 to 5. This finding aligns with the understanding that smart systems are beneficial, as they mitigate delays and high operational costs associated with manual equivalent systems (Alghamdi, 2019; Cimino et al., 2017). This study's findings also show the beneficial effect of timely access to information by stakeholders involved in port container handling processes (Sarkar & Shankar, 2021).

Specifically, for the allocation of berths for containerships, the study's findings show timely and efficient processing of allocation requests when online systems such as e-Manifests and portals are used as part of the smart container system. Optimized berth allocation is important taking into consideration containers already stacked in the terminal yard (Steenken et al., 2004). For loading and unloading containers, the findings show that RFIDs and OCRs automate information updates of container states into a central database to enable instant access to information by stakeholders. The timely information updates of container states facilitate transparency in container handling charges, taxes to be paid, and service delivery. For picking up and dropping off containers, the findings show smart container system affordances contribute to reducing congestion at the port by providing real-time updates of container status at the terminal. In this study, the implemented smart container system that provides real-time information updates to help reduce congestion at the port comprise middleware software (TAS and TOS), smart gates, sensors (RFID and OCRs) and biometric identification systems. This study's findings confirm research on use of OCRs and RFIDs for automatic identification of containers, trucks, and cargo and the consequent result of reducing congestion at ports (Heilig & Voß, 2017; Heilig et al., 2017).

The study's findings also show constraints in the actualization of smart container system affordances in relation to project implementation and use. For project implementation, the constraints included stakeholders' resistance. In this study, some stakeholders resisted the project because of their digital unpreparedness and lack of trust in the workability of the new smart system. Other stakeholders were perceived to be resisting the project because of their interest in maintaining the manual system, which was prone to malpractice.

The study's findings also show that seaport smart container systems in a developing country can be constrained by equipment breakdown, unstable electricity and internet availability, limited data storage capacity and device breakdowns. In this study, these challenges occasioned reverting to the manual container handling processes. These findings have not been discussed in the literature. For instance the promotion of big data availability for analytics and reporting has been noted in the extant literature on smart service systems (Maglio & Lim, 2016; Medina-Borja, 2015). However, in this study, the port authority periodically deletes data to make room for updates from the container handling processes because of the limited local storage capability, which was adopted for the smart systems. In the literature, cloud-based storage has been identified as the storage option for smart container systems (Cimino et al., 2017). However, in this study, the port authority did not opt for cloud-based storage because of internet instability challenges. Cloud-based storage depends on a stable internet connection.

Another finding on constraints in using the smart container system was exposure to cyberattacks. As the study's findings show, the threats of cyberattacks on the deployed smart systems led to further enhancements of the port's cybersecurity infrastructure. Cybersecurity has been identified as a challenge in extant literature (Williams et al., 2008). Due to their interconnections and dependency on ICTs and the Internet, ports are increasingly vulnerable to cyber-attacks.

The study's findings on digital preparedness and the necessity to train employees and external stakeholders such as clearing agents have been acknowledged in the literature. In this study, not only digital illiteracy but also some stakeholders lacked access devices and thus were not digitally prepared to use the smart systems. According to Sarkar and Shankar (2021), the absence of adequate training and domain expertise can serve as a hindrance to deploying and using smart systems. In this study, domain experts were engaged, and training of external stakeholders undertaken.

Conclusion

This study used the case of Ghana's biggest seaport to understand how a smart system is implemented and used for seaport container terminal services and the consequences in a developing country context. The findings show implementation wise, that actualizing a developing country smart container system involves decision choices of main actors, informed by their perception of smart container system affordances, employing a PPP arrangement, constituting a broad-based stakeholder PIT, and engaging smart solution providers. In terms of use, the findings show smart systems enable a developing country's seaport to meet international port standards by using them for autonomous access control, identification, information management, and workflow. However, the study's findings show that using smart systems for port container handling processes in a developing country context can be constrained by stakeholder digital unpreparedness, equipment breakdown, unstable electrical power and the Internet, and limited data storage capacity.

The study findings have implications for research, practice, and policy. For research, this study extends current understanding of smart systems, specifically to developing country smart seaport container terminals, by providing empirical insights into their implementation and use. Using TACT, the study provides understanding of smart container systems in terms of technology affordance perception and actualization.

For practice and policy, this study provides rich insights into the implementation and use of smart container systems in a developing country context. The insights show the need for practitioners and policy makers to consider the environment and stakeholders involved. For instance, the study's findings show that in a developing country context, smart system affordances can be constrained by perceptions of failed systems in the past, which can lead to stakeholder resistance and choices that may not be optimal.

This study is limited by a single case study in one developing country and the use of the TACT perspective. This implies other factors or perspectives may have been blanked out as a result these limitations. However, the study findings can be generalized to similar settings in line with interpretive research. Future research can explore other developing countries to establish similarities and differences. Along the same lines, future research could also investigate the phenomenon using other perspectives such as boundary object theory, supply chain and ICT4D (information and communication technology for development).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

No funding was received for conducting this study.

Notes on contributors

Emmanuel Owusu-Oware is a senior lecturer at the University of Professional Studies, Accra. He holds a PhD in Information Systems from the University of Ghana, MBA in Management Information Systems from the University of Ghana, and Vrije Universitéit Brussels, and BSc in Electrical and Electronic Engineering (Telecommunications Major) from Kwame University of Science and Technology. His research interests are in digital innovations in organizations, with particular interest in public-sector biometric systems. He is also an information systems practitioner with many years of experience in IT management and consulting.

John Effah is an Associate Professor of Information Systems at the University of Ghana. His research interests span areas of digital innovation in business, government, and society as well as biometric systems in developing countries. John holds a PhD in information systems from the University of Salford in Manchester, UK and MBA MIS and BSc in Business Administration (Accounting Option) with First Class honor's both from University of Ghana. John serves on the editorial boards of Electronic Journal of Information Systems in Developing Countries and African Journal of Information Systems as a Deputy Editor-in-Chief.

Ibrahim Osman Adam is an associate professor of management information systems and holds a PhD in Information Systems from the University of Ghana Business School. He holds a double master's degree; an MSc in Development Management from the London School of Economics and Political Science (LSE) (UK) and an MSc in Applied Informatics from the Henley Business School, University of Reading (UK). His research interests are in digital technologies in business and society and Information and Communication Technology for Development (ICT4D) value chain areas, specifically e-commerce, e-government, social media, and other digital transformations.

Fred Amankwah-Sarfo **is** a lecturer in Information Systems at the Ghana Communication Technology University, an adjunct lecturer at the Ghana Institute of Public Management and

Public Administration. His research interests include organizational information systems, smart systems, digital transformation and ICT project management and port systems in developing countries. He holds a PhD in information systems, an MBA in MIS, and a BSc in Business Administration from the University of Ghana. Fred was the Business Development Manager at the Ghana India Kofi Annan Center of Excellence in ICT. He is an ICT consultant for public and private institutions.

ORCID

Emmanuel Owusu-Oware http://orcid.org/0000-0001-6119-0790

References

Alghamdi, S. (2019). Monitoring student attendance using a smart system at Taif University. *International Journal of Computer Science & Information Technology*, *11*(1), 107–115. https://doi.org/10.5121/ijcsit.2019.11108

Baheti, R., & Gill, H. (2011). Cyber-physical systems. In Tariq Samad, & Anuradha Annaswamy (Eds). *The Impact of Control Technology* (1st ed., pp. 161–166). IEEE Control Systems Society. https://www.ieeecss.org/impact-control-technology-1st-edition.

Buhalis, D., & Law, R. (2008). Progress in information technology and tourism management. 20 years on and 10 years after the internet. The state of etourism research. *Tourism Management*, *23*(3), 207–222. https://doi.org/10.1016/S0261-5177(01)00085-1

Burton-Jones, A., & Volkoff, O. (2017). How can we develop contextualized theories of effective use? A demonstration in the context of community-care electronic health records. *Information Systems Research*, *28*(3), 468–489. https://doi.org/10.1287/isre.2017.0702

Chen, Z., & Chan, I. C. C. (2022). Smart cities and quality of life: A quantitative analysis of citizens' support for smart city development. *Information Technology & People*, https://doi.org/10.1108/ITP-07-2021-0577

Cimino, M. G. C. A., Palumbo, F., Vaglini, G., Ferro, E., Celandroni, N., & La Rosa, D. (2017). Evaluating the impact of smart technologies on harbor's logistics via BPMN modeling and simulation. *Information Technology and Management*, *18*(3), 223–239. https://doi.org/10.1007/s10799-016-0266-4

Creswell, J. (2014). Qualitative, quantitative, and mixed methods approaches. In Vicki Knight, Jessica Young, Kalie Kosielak, & Megan Markinich (Eds.), *Research design* (4th ed., pp. 1–265. Sage Publications.

Dini, A. A., & Saebo, O. (2016). The current state of social media research for eParticipation in developing countries: A literature review. In *Proceedings of the 49th Hawaii International Conference on System Sciences (HICSS-49)*, Koloa, HI, USA (pp. 2698–2707). IEEE.

Dini, A. A., Wahid, F., & Sæbo, Ø. (2016). Affordances and constraints of social media use in eParticipation: Perspectives from Indonesian politicians. In *20th Pacific Asia Conference on Information Systems (PACIS 2016)* (pp. 1–14). http://www.pacis2016.org/abstract/ALL/523.pdf

Drevin, L., & Dalcher, D. (2011). Using antenarrative approaches to investigate the perceptions of information systems' actors regarding failure and success. *Information Systems Development*, 207–217.

Du, W. D., Pan, S. L., Leidner, D. E., & Ying, W. (2019). Affordances, experimentation and actualization of FinTech: A blockchain implementation study. *Journal of Strategic Information Systems*, *28*(1), 50–65. https://doi.org/10.1016/j.jsis.2018.10.002

Effah, J., Amankwah-Sarfo, F., & Boateng, R. (2020). Affordances and constraints processes of smart service systems: Insights from the case of seaport security in Ghana. *International Journal of Information Management*, *58*(2021), 102204. https://doi.org/10.1016/j.ijinfomgt.2020.102204

Effah, J., & Debrah, E. (2018). Biometric technology for voter identification: The experience in Ghana. *The Information Society*, *34*(2), 104–113. https://doi.org/10.1080/01972243.2017.1414720

Ens, N., Stein, M. K., & Jensen, T. B. (2018). Decent digital work: Technology affordances and constraints. *International Conference on Information Systems 2018, ICIS 2018*, San Francisco, USA (pp. 1–9).

Evans, S. K., Pearce, K. E., Vitak, J., & Treem, J. W. (2017). Explicating affordances: A conceptual framework for understanding affordances in Communication research. *Journal of Computer-Mediated Communication*, *22*(1), 35–52. https://doi.org/10.1111/jcc4.12180

Gibson, J. (1977). A theory of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting and knowing: toward an ecological psychology* (pp. 67–82). Lawrence Erlbaum Associates, Inc.

Hameed, T. (2016). Impact of big data analytics on individuals and the South Korean big data analytics market. *Journal of Information Technology Case & Application Research*, *18*(3), 130–140. https://doi.org/10.1080/15228053.2016.1220201

Hammond, M. (2010). What is an affordance and can it help us understand the use of ICT in education? *Education and Information Technologies*, *15*(3), 205–217. https://doi.org/10.1007/s10639-009-9106-z

Heilig, L., Lalla-Ruiz, E., & Voß, S. (2017). Digital transformation in maritime ports: Analysis and a game theoretic framework. *NETNOMICS: Economic Research and Electronic Networking*, *18*(2–3), 227–254. https://doi.org/10.1007/s11066-017-9122-x

Heilig, L., & Voß, S. (2017). Information systems in seaports: A categorization and overview. *Information Technology and Management*, *18*(3), 179–201. https://doi.org/10.1007/s10799-016-0269-1

Hildebrandt, M. (2020). Smart technologies. *Internet Policy Review*, *9*(4), 1–16. https://doi.org/10.14763/2020.4.1531

Jiang, J., Peng, G., & Xing, F. (2018). Socio-technical challenges of smart fleet equipment management systems in the Maritime Industry. *International Conference on Distributed, Ambient, and Pervasive Interactions*, Tashkent, Uzbekistan (pp. 242–252).

Kim, K. H., & Hong, B. H. (2010). Maritime logistics and applications of information technologies. *The 40th International Conference on Computers & Indutrial Engineering*, Awaji, Japan (pp. 1–6).

Klein, H. K., & Myers, M. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, *23*(1), 67–94. https://doi.org/10.2307/249410

Larkotey, W. O., Effah, J., & Boateng, R. (2021). Government workspace digitalization and socioeconomic development outcomes in Ghana. *The African Journal of Information Systems*, *13*(4), 454–475. https://digitalcommons.kennesaw.edu/ajis/vol13/iss4/2

Leidner, D. E., Gonzalez, E., & Koch, H. (2018). An affordance perspective of enterprise social media and organizational socialization. *Journal of Strategic Information Systems*, *27*(2), 117–138. https://doi.org/10.1016/j.jsis.2018.03.003

Lezzi, M., Lazoi, M., & Corallo, A. (2018). Cybersecurity for Industry 4.0 in the current literature: A reference framework. *Computers in Industry*, *103*, 97–110. https://doi.org/10.1016/j.compind.2018.09.004

Liu, C., & Hung, K. (2019). Understanding self-service technology in hotels in China: Technology affordances and constraints. In J. Pesonen & J. Neidhard (Eds.), *Information* *and communication technologies in tourism 2019* (pp. 225–236). Springer International Publishing. https://doi.org/10.1007/978-3-030-05940-8_18

Maglio, P., & Lim, C.-H. (2016). Big data and smart service systems. *Journal of Innovation Management*, *4*(1), 11–21. https://doi.org/10.24840/2183-0606_004.001_0003

Majchrzak, A., Faraj, S., Kane, G. C., & Azad, B. (2013). The contradictory influence of social media affordances on online communal knowledge sharing. *Journal of Computer-Mediated Communication*, *19*(1), 38–55. https://doi.org/10.1111/jcc4.12030

Majchrzak, A., & Markus, M. L. (2012). Technology affordances and constraints in management information systems. In E. Kessler (Ed.), *Encyclopedia of management theory* (pp. 833–834). Sage Publications. http://ssrn.com/abstract=2192196

Markus, M. L., & Silver, M. S. (2008). A foundation for the study of IT effects: A new look at DeSanctis and Poole's concepts of structural features and spirit. *Journal of the Association for Information Systems*, *9*(10), 609–632. https://doi.org/10.17705/1jais.00176

Martin, D., Hirt, R., & Kühl, N. (2019). Service systems, smart service systems and cyber-physical systems — What ' s the difference? Towards a unified terminology. *14th International Conference on Wirtschaftsinformatik*, 17–31.

Masiero, S. (2016). The origins of failure: Seeking the causes of design-reality gaps. *Information Technology for Development*, *22*(3), 487–502. https://doi.org/10.1080/02681102.2016.1143346

McGrath, K., & Maiye, A. (2010). The role of institutions in ICT innovation: Learning from interventions in a Nigerian e-government initiative. *Information Technology for Development*, *16*(4), 260–278. https://doi.org/10.1080/02681102.2010.498408

Medina-Borja, A. (2015). Smart things as service providers: A call for convergence of disciplines to build a research agenda for the service systems of the future. *Service Science*, *7*(1), ii–v. https://doi.org/10.1287/serv.2014.0090

Myers, M. (2013). *Qualitative research in business and management*. Sage.

Neuhofer, B., Buhalis, D., & Ladkin, A. (2015). Smart technologies for personalized experiences: A case study in the hospitality domain. *Electronic Markets*, *25*(3), 243–254. https://doi.org/10.1007/s12525-015-0182-1

Nkohkwo, Q. N., & Islam, M. S. (2013). Challenges to the successful implementation of e-government initiatives in sub-saharan Africa: A literature review. *Electronic Journal of E-Government*, *11*(1), 252–266. https://academic-publishing.org/index.php/ejeg/article/view/585

Orlikowski, W., & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research*, *2*(1), 1–28. https://doi.org/10.1287/isre.2.1.1

Owusu-Oware, E., Effah, J., & Boateng, R. (2017). Institutional enablers and constraints of national biometric identification implementation in developing countries: The case of Ghana. *AMCIS 2017 Proceedings*, Boston, USA.

Pal, A., Herath, T., De, R., & Rao, H. R. (2018). An investigation of affordances and constraints for continued usage of mobile payment technology. *Proceedings Annual Workshop of the AIS Special Interest Group for ICT in Global Development*, San Francisco, USA (pp. 13).

Papagiannidis, S., & Marikyan, D. (2020). Smart offices: A productivity and well-being perspective. *International Journal of Information Management*, *51*, 102027. https://doi.org/10.1016/j.ijinfomgt.2019.10.012

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. SAGE Publications.

Paukstadt, U., Eicker, S., & Eicker, S. (2019). Understanding services in the era of the internet of things: A smart service taxanomy. *27th European Conference on Information Systems*, Stockholm & Uppsala, Sweden, June 8-14, 2019.

Porter, M. E., & Heppelmann, J. E. (2015, October). How smart, connected products are transforming companies. *Harvard Business Review*, *93*(10), 96–114. https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies

Pozzi, G., Pigni, F., & Vitari, C. (2014). Affordance theory in the is discipline: A review and synthesis of the literature. *AMCIS 2014 Proceedings, 2014*, Savannah, United States.

Ridder, H. G., Hoon, C., & McCandless, A. (2009). The theoretical contribution of case study research to the field of strategy and management. *Research Methodology in Strategy & Management*, *5*, 137–175. https://doi.org/10.1108/S1479-8387(2009)0000005007

Romero, M., Guédria, W., Panetto, H., & Barafort, B. (2020). Towards a characterisation of smart systems: A systematic literature review. *Computers in Industry*, *120*, 103224. https://doi.org/10.1016/j.compind.2020.103224

Sarkar, B. D., & Shankar, R. (2021). Understanding the barriers of port logistics for effective operation in the Industry 4.0 era: Data-driven decision making. *International Journal of Information Management Data Insights*, *1*(2), 100031. https://doi.org/10.1016/j.jjimei.2021.100031

Schwartz-Shea, P., & Yanow, D. (2013). *Interpretive research design: Concepts and processes*. Routledge.

Smith, A. D. (2005). Exploring radio frequency identification technology and its impact on business systems. *Information Management & Computer Security*, *13*(1), 16–28. https://doi.org/10.1108/09685220510582647

Steenken, D., Voß, S., & Stahlbock, R. (2004). Container terminal operation and operations research-a classification and literature review. *OR Spectrum*, *26*(1), 3–49. https://doi.org/10.1007/s00291-003-0157-z

Strong, D. M., Johnson, S. A., Tulu, B., Trudel, J., Volkoff, O., Pelletier, L. R., Bar-On, I., & Garber, L. (2014). A theory of organization-EHR affordance actualization. *Journal of the Association for Information Systems*, *15*(2), 53–85. https://doi.org/10.17705/1jais.00353

Sun, Y., Zhou, X., Jeyaraj, A., Shang, R. A., & Hu, F. (2019). The impact of enterprise social media platforms on knowledge sharing: An affordance lens perspective. *Journal of Enterprise Information Management*, *32*(2), 233–250. https://doi.org/10.1108/JEIM-10-2018-0232

Vis, I. F., & De Koster, R. (2003). Transshipment of containers at a container terminal: An overview. *European Journal of Operational Research*, *147*(1), 1–16. https://doi.org/10.1016/S0377-2217(02)00293-X

Volkoff, O., & Strong, D. M. (2017). Affordance theory and how to use it in is research. *The Routledge Companion to Management Information Systems*, 232–246. https://doi.org/10.4324/9781315619361-18

Walsham, G. (1995). Interpretive case studies in is research: Nature and method. *European Journal of Information Systems*, *4*(2), 74–81. https://doi.org/10.1057/ejis.1995.9

Walsham, G. (2006). Doing interpretive research. *European Journal of Information Systems*, *15*(3), 320–330. https://doi.org/10.1057/palgrave.ejis.3000589

Wang, H., Wang, J., & Tang, Q. (2018). A review of Application of affordance theory in information systems. *Journal of Service Science & Management*, *11*(1), 56–70. https://doi.org/10.4236/jssm.2018.111006

Williams, P., Basker, S., & Ward, N. (2008). E-navigation and the case for eLoran. *The Journal of Navigation*, *61*(3), 473–484. https://doi.org/10.1017/S0373463308004748

Xie, W., Mehta, N., & Palvia, P. (2020). Value co-creation dimensions and challenges in EHR systems. *Journal of Information Technology Case and Application Research*, *22*(3), 188–215. https://doi.org/10.1080/15228053.2020.1832647

Yang, Y. C., Ying, H., Jin, Y., Cheng, H. K., & Liang, T. P. (2021). Special issue editorial: Information systems research in the age of smart services. *Journal of the Association for Information Systems*, *22*(3), 10. https://doi.org/10.17705/1jais.00673

Zheng, Y., & Yu, A. (2016). Affordances of social media in collective action: The case of free lunch for children in China. *Information Systems Journal*, *26*(3), 289–313. https://doi.org/10.1111/isj.12096

Appendix – Interview Guide

In line with interpretive studies, an interview guide was used to conduct the semi-structured interview of participants. The guide was used to direct the conversations while leaving room for participants to bring up other topics and issues. In this appendix, we present there main question themes in the interview guide.

Traditional system:

Paper-based container handling system

(1) Describe the paper-based container handling system in loading and unloading containers to and from the port?
(2) What were the challenges with the manual system and how did they affect the port's container handling process?

smart container handling system

a) Conception and implementation

(1) Describe how smart systems were introduced into the container handling processes at the port. Who were involved and what were their roles?
(2) What are the technology components of the smart container system that have been implemented at the port?
(3) What challenges were encountered in the conception and implementation of the smart container system?

b) Use of the system

(1) Describe the smart container handling system in loading and unloading containers to and from the ship.
(2) What are the challenges with the use of the smart container handling system?

Effects and outcomes

(1) How did the deployment and use of the smart container handling system achieve the desired goals for which it was implemented?
(2) What are the gains (or benefits) and bottlenecks in using smart systems for container handling at the port?
(3) What were the consequences after deploying the smart container system at the port?
(4) What might have contributed to those consequences?