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"Internet of Things" (IOT)-Enabled Product Monitoring: Insights from Socio-Technical Systems Theory, Affordances Theory, and Structurational Model of Technology

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ABSTRACT

This qualitative research features case studies of two firms, SteadyServ, a beer inventory management technology solution firm, and Kuehne + Nagel, a global logistics firms offering specialized pharmaceutical goods storage and delivery services. Both firms are using "Internet of Things" (IOT)-enabled sensor solutions in product monitoring. Three theoretical frameworks are applied in the attempt to understand the IT solution deployment experiences of both firms: socio-technical systems theory, affordances theory, and structurational model of technology.

KEYWORDS: Internet of Things (IOT), radio frequency identification (RFID), socio-technical systems theory, affordances theory, and structurational model of technology (Orlikowski), logistics, supply chain management

INTRODUCTION

This research paper featuring two case studies of the firms, SteadyServ, a beer technology solution firm, and Kuehne + Nagel (K+N), a global logistics firm, highlights the use of sensors for "Internet of Things" (IOT) applications, both involving product monitoring. This study also uses these three theoretical frameworks for understanding the information systems implementation experiences of these two firms: socio-technical systems theory, affordances theory, and Orlikowski's structurational model of technology.

Iansiti and Lakhani (2014) articulate the innovative business possibilities enabled by the "Internet of Things" (IOT) or the pervasive deployment of wireless sensors for realizing digitization and connectivity to previously analog tasks, processes, and machine and service operations. In their paper, they focus on how General Electric (GE) has transformed itself from merely manufacturing physical and analog products for business/home appliances, airplane engines for the aviation industry, energy generation infrastructure, lighting, mining, healthcare, transportation, and many more industries, to being a firm that offers services founded on value creation derived from capture, storage, distribution, and analysis of digital data involving various forms of information technology supporting IOT. For instance, GE has a wind farm deal with the global energy giant E.ON. wherein GE offers data analytics services using E.ON.'s extensive operational data to run simulations that suggest solutions for meeting energy demand fluctuations. In the past, GE used to sell physical machines like turbines and related equipment to firms such as E.ON. But today, GE has changed its business model by extracting value from data analytics powered by software assets and charging for these services. GE is an extreme example in terms of a firm that has pushed IOT possibilities to its optimal boundaries. This study of SteadyServ and K+N shows how the use of sensors for product monitoring has given

both firms possibilities for offering innovative services to their clients based on data analytics capabilities.

The three theoretical frameworks were chosen because they focus on the interaction between information systems/information technology components and organization in producing the desired outcomes in deploying the specific information systems solution adopted by a firm.

The socio-technical systems theory provides a simple to use framework for analyzing how components of an organizational system (i.e., task, structure, people, and technology) work together.

The affordances theory lens allows researchers to view IT and organizations as entities that exist independently of each other. Yet, IT and organizations can be viewed by researchers as valuable in explaining organization form and function only if it is recognized that they need to be enacted together (Zammuto, 2007). So, although IT and organizations each have their own potentials and constraints, theories such as the affordance theory are needed to understand how they are woven together so that "functional" affordances could emerge. The affordance theory lens admits that a technological object has built-in functionalities, but it needs to be recognized as a "social object" as well. And, as a social object, the technological object influences organizational functioning and performance, which, in turn, cannot be viewed apart from worker expertise, jobs, business processes, and structures (Zammuto, 2007).

Orlikowski's structurational model of technology (1992) recognizes that IT is both the medium and product of human action. Organizational contexts shape human action within organizations. Human agents either reinforce or transform the institutional properties of an organization when using IT.

When taken together, these three theoretical frameworks provide potent tools for generating rich insights that can help us understand how information systems solutions are deployed in firms.

LITERATURE REVIEW

The following section highlights the key concepts, theoretical frameworks, and firm background information used in this study.

Internet of Things (IOT)

"Internet of Things" or IOT is defined as "…a worldwide information infrastructure for the information society in which physical and virtual 'things' were uniquely identified and connected over the wired or wireless internet. These physical and virtual things could include an object or smart device, such as clothes, a watch, a camera, a washer, a building, a bridge, a car, a suite, an animal or even a person…." (Yen, 2015, pp. 2-3). In a global survey of 795 firms, Tata Consultancy Services found that four out of the five firms have already deployed IOT initiatives (Tata Consultancy Services, 2015). The four major areas for IOT application are: (1) product monitoring: tracking products by embedding sensors, software, and other technologies in physical products; (2) premises monitoring: installing sensors, digital cameras, and other devices in firms' business operations sites; (3) customer monitoring: tracking wireless mobile devices carried by customers; (4) supply chain monitoring: installing sensors, digital devices, and cameras in the production and distribution facilities and other points in a firm's supply chain (Tata Consultancy Services, 2015). This study will focus mainly on product monitoring at SteadyServ and Kuehne + Nagel.

Gartner Group projects that there will be 4.9 billion connected devices by 2015, growing to 25 billion connected objects by the end of the decade (Tata Consultancy, 2015). In its global

survey of corporate IOT initiatives involving 795 executives in the sample, Tata Consultancy found out the following: (1) About 79 percent of the global firms that responded to the survey already use IOT technologies to track their customers, products, premises, and supply chains; (2) firms that offer higher-priced products will be spending more on IOT in 2015 than those offering lower-priced products; (3) mobile apps have a key role to play in tracking customers and are used by 50 percent of the firms in the sample; (4) in general, IOT adoption is higher in North American and European firms than their counterparts in Asia-Pacific and Latin America; (5) in gaining benefits from IOT, industrial manufacturers are way ahead of the 12 other major global industries represented in the sample; (6) strategic and cultural issues appear to be the biggest constraints in firms in terms of planning for IOT initiatives; and (7) firms that gained the largest revenue increases from their respective IOT initiatives had these attributes: (a) they are more likely to digitally reimagine the businesses ; (b) they were more flexible in altering their business models to suit IOT; (c) they appreciated the breakthrough potential of IOT; (d) they organized themselves to respond rapidly based on performance and customer usage data; (e) they are better at managing internal resistance to IOT internally; (f) they worked on improving the security aspects of IOT technologies they deployed; and (g) they made incremental investments in IOT, ensuring positive returns first, before pouring in larger dollar investments.

Industrial manufacturers appear to be ahead of other industries in gaining benefits from IOT according to the study findings. The following are the typical IOT applications in industrial manufacturing: (1) predictive maintenance of equipment with sensors monitoring parts exceeding thresholds and generating alerts to managers; (2) inventory/asset tracking systems between locations as they move throughout the supply chain; value-added services include tracking ambient storage and delivery conditions such as temperature, pressure, volume, etc.; (3) quality control using sensors, cameras, and lasers to analyze manufacturing processes; (4) smart grid systems for monitoring energy consumption; (5) indoor air quality systems will monitor toxic gas and oxygen levels inside chemical plants to ensure worker safety; temperature monitoring in medical and industrial refrigerators to safeguard “cold chain” temperature-sensitive product items; (6) sensors embedded in foundations of constructed structures will provide load and stress monitoring to ensure building integrity and safety, among others.

The case study method in this research project features product monitoring aspects of the services provided by SteadyServ and Kuehne + Nagel.

Socio-Technical Systems Theory

Building on Leavitt’s (1965) socio-technical model, the socio-technical systems (STS) theory as articulated by Bostrom and Heinen (1977) provides a framework for analyzing how components of an organizational system (i.e., task, structure, people, and technology) relate to an information system. Leavitt (1965) identified task, structure, people, and technology as important dimensions of organizations as work systems. The technology dimension of the Leavitt model consists of elements of an information system as an integrated set of software using information technology to transmit, process, and store information (Piccoli, 2008).

The simplicity and elegance of the STS model have been recognized and the framework has been frequently used for studying IS-enabled organizational change (Bostrom et al., 2009; Lyytinen & Newman, 2008; Pitt et al., 2011). Two subsystems constitute the overarching STS system: (1) the tasks and technologies that make up the technical subsystem transform inputs into outputs; and (2) individuals in a work unit, their relationships, reward systems, and authority and work structures make up the social subsystem. Organizational systems are usually faced with targeted goals often instigated by pressure coming from the external environment. The organization’s internal environment consisting of both the technical and social subsystems,

consequently, need to interact optimally in order to meet organizational goals adopted in response to external pressures. This STS framework has been useful in studying organizational change and in capturing the rich context of factors and interactions involved in deploying information systems in meeting organizational goals. A major missing piece in using the STS theoretical framework, though, is the articulation of how the critical structural, technological, people, and task-based dimensions interact in the process of changing the organization. Thus, this case study's analysis transitions to the use of the "affordances theory" (Gibson, 1976, 1979, 1986) and very specifically, the concept of "functional affordances" (Markus & Silver, 2008). These complementary theoretical lenses will bridge the missing gap and assist in showing how information systems relate to behavioral routines of end workers as manifested in their work practices (Leonardi, 2011) as they try to realize their action goals and values (Markus & Silver, 2008).

Affordances Theory

In understanding the deployment of information technology in organizations, the "affordances" theory has been espoused by a number of academics (Faraj & Azad, 2012; Hutchby, 2001; Leonardi & Barley, 2008; Markus & Silver, 2008; Norman, 1988; Zammuto et al., 2007).

Gibson (1997, 1979) first offered the concept of "affordance" in the field of ecological psychology and used it to define the range of possibilities and constraints for action that a material object presents to an actor.

Material properties of information systems allow "possibilities for goal-oriented action" or "functional affordances" of that form of technology (Markus & Silver, 2008). Chemero (2008) suggests, though, that affordances have to be perceived by the end user before they can be enacted or actualized. Leonardi (2011) dovetails this idea by suggesting that the end user's ability to perceive the action possibilities proffered by functional affordances depends on the relationships between the form of information system and the end user within the context in which the information system is used.

Features of different forms of information technology can be used by human agents or ignored by them, depending on the end purposes they have in mind (Stinchcombe, 1968). Thus, both intended and unintended consequences of information technology are realized through functionalities of material artifacts that "afford" those consequences.

Orlikowski's Structuration Model of Technology

This study applies Orlikowski's "Structurational Model of Technology," (Orlikowski, 1992; Orlikowski & Robey, 1991) to understand how information technology (IT) interacts with organizations. This model draws on Giddens' theory of structuration (Giddens, 1984, 1979, 1976), which proposed the concept of the "duality of structure," "…which refers to the notion that the structure or institutional properties of social systems are created by human action, and then serve to shape future human action…." (Orlikowski & Robey, 1991, p. 147). "…In Giddens' theory, structure is understood to be an abstract property of social systems. Structure is not something concrete, situated in time and space, and it lacks material characteristics. Structure cannot exist apart from the human actors who enact and interpret its dimensions. Structure has only virtual existence. Interestingly, people readily allow their actions to be constrained by these shared abstractions as social structure….The ability of organizational structures to elicit compliance and conformity in the absence of material constraints attests to the power of those socially constructed abstractions….Social structure conditions these social practices by providing the contextual rules and resources that allow human actors to make sense of their own

acts and those of other people." (Orlikowski & Robey, 1991, p. 147). Furthermore, Giddens specifies that human interactions are an amalgamation of structures of meaning, power, and moral frameworks enacted in what he calls the "modalities" of these interactions: interpretive schemes, resources, and norms.

"Interpretive schemes…form the core of mutual knowledge whereby an accountable universe of meaning is sustained through and in processes of interaction (Giddens, 1979, p. 83]. Orlikowski & Robey (1991) translate Giddens' concept of "interpretive scheme" within the realm of IT and explain that IT represents reality through a set of concepts of symbols embedded in it by which end users understand their world. Thus, IT is not only a medium for the construction of social reality, but also a means of institutionalizing certain "interpretive schemes" or stocks of knowledge within the organization by standardizing, sharing, and taking them for granted.

Resources are the media through which power is exercised by human actors because it is through these resources that humans can accomplish their objectives and thus, gain "domination" (Orlikowski & Robey, 1991). Therefore, the deployment of IT institutes a certain order of authority, dictating the way work will be performed, and also, resulting in the differential distribution of power in the organization.

Norms are understood as organizational rules that shape "legitimate" behavior. IT is a medium for installing such norms in order to control human behavior in an organization (Orlikowski & Robey, 1991).

Orlikowski incorporates the following components in her framework: first, the human agents, consisting of technology designers, end users, and decision makers; second, the material artifacts that constitute IT itself, and third, the institutional properties of organizations --- structural arrangements, business strategies, ideology, culture, control mechanisms, standard operating procedures, division of labor, expertise, communication patterns, and environmental pressures (Orlikowski, 1992; Orlikowski & Robey, 1991).

The structurational model of technology discusses four critical issues (Orlikowski & Robey, 1991). First, IT is the product of human action, which is responsible for the creation, use, and maintenance of different forms of IT. It is only through the human appropriation of IT that it is able to influence human activity. Second, technology is the medium of human action. Since different forms of IT are used by organizational workers, they mediate organizational work either by facilitating it and in some ways, also constraining it. Third, organizational contexts shape human action within organizations. Human agents are influenced by the institutional properties of their setting which provide the resources, norms, and knowledge they need to work. Furthermore, IT is created and used within certain social and historical circumstances which influence the form and features of this technology. Fourth, human agents either reinforce or transform the institutional properties of an organization when using IT. Weick (1979) characterized technology as "enacted environment" whose construction is determined by an organization's structures of signification, domination, and legitimation. Any change in these three structures indicate the "appropriation" and use of technology.

"Structure of signification" refers to the way the concepts and procedures intrinsic to the knowledge embedded in IT directs the manner in which problems are interpreted and work is conducted in the organization (Orlikowski, 1992). "Structure of domination" refers to IT's ability to control the work of organizational members once it is deployed. "Structure of legitimation" refers to the ability of IT to sanction a particular mode of conducting the work and thus, propagate a set of norms about what is considered legitimate business practice. Orlikowski also incorporates the three modalities of structuration --- interpretive schemes, resources, and norms --- in her application of the structures of signification, domination, and legitimation in the deployment of IT in an organization.

SteadyServ Firm Background

Founded in 2012 in Carmel, Indiana, USA, SteadyServ Technologies developed the SteadyServ iKeg system --- a software as a service (SaaS) based mobile software solution for inventory and order management for the beer industry (Identiv, 2014). This is a breakthrough product/service in that it provides real-time intelligence for beer retail establishments, distributors, and brewers through the use of a smartphone app that runs on IOS or Android devices and also through the use of a web-enabled SaaS portal. This solution also enables synchronization with a beer distributor's order management system to assure beer retailer customers that their inventory can always fill customer demand at any point in time.

Product Monitoring Needs of Draft Beer Industry

Efficient and effective beer management has been an elusive goal in the beer industry for a very long time. This is a major problem in an industry where craft breweries are on the rise and retailers have a wide range of beer brands to choose from to fulfill every increasing end customer expectations at retail outlets like bars, restaurants, and pubs (Intel, 2015). However, in order to offer the best beer mix in a retail outlet, managers need to know how much beer is left on hand in their beer kegs. These assets called kegs are often returned to distributors still containing left over beer, which translates to costly wastage and profit loss for retailers. Traditionally, retail managers relied on old methods like the "first in, first out" mentality to physically lifting kegs to arrive at "guesstimates" of how much beer is left over --- both have led to significant waste of money. A more effective method of tracking beer inventory is needed to alleviate this situation. A sensor-based solution appears to be just what is called for.

Kuehne + Nagel Firm Background

Kuehne + Nagel (K+N) is a based in Switzerland and is a global leader in providing business-to-business sea freight, air freight, overland, and contract logistics services in more than 100 countries (Greengard, 2015). The aerospace, automotive, industrials, high tech, oil and gas, retail, pharmaceutical, and healthcare industries are among the key industries served by K+N. In March 2011, K+N introduced the PharmaChain specialized logistics service for the pharmaceutical and health-care industries. K+N guarantees that its pharma cold chain logistics services follows the best practices guidelines of the World Health Organization (WHO) and that its entire network of facilities is GXP compliant meaning that the firm observes regulations that ensure the delivery of quality high-risk products like pharmaceutical goods and biologics. K+N handles pharma shipments in three categories of facilities: (1) pharma gateways: these have cool zones with temperature ranges of 1-8 and 15-25 degrees Celsius; (2) competence centers: have cooler facilities but do not observe stringent cool zone standards with specific temperature ranges; and (3) pharma branches: do not have special equipment; staff strictly deals with moving goods but are not allowed to physically handle or touch them (Putzger, 2012).

K+N filled a niche in the logistics services marketplace on account of a number of factors. There are multiple stakeholders involved in the shipment of temperature-sensitive pharmaceutical and biologic products. Even for a firm like K+N, delivering logistics services requires coverage of land, air, and water modes of transportation in order to cover the entire world. Traditionally, the pharmaceutical cold chain has been characterized by lack of process visibility leading to serious constraints in the logistics service providers' ability to mitigate

shipment delivery problems while the goods are in transit. Limited investment in information technology by different logistics service providers is partly to blame for this lack of visibility. Inadequate equipment performance is also notable --- with more reliable equipment/assets used in logistics found in more developed countries and thus, “breaks” in the cold chain occur in less developed countries where such assets perform less reliably.

Product Monitoring Needs of Pharmaceutical and Life Sciences Industries

Temperature-sensitive products constitute a “cold or cool chain” and the logistics operations of moving them through a physical supply chain are regulated by federal law and guidelines of regulatory agencies. Drug or biotechnical testing laboratories and manufacturers, contract manufacturers and packagers, distribution centers, wholesalers, healthcare facilities, pharmacies, etc., are the usual stakeholders who would be concerned about proper product disposition.

A successful “cold chain” supply chain is one that can deliver products to the customer in usable form. Pharmaceutical drug and biotechnology products must arrive unadulterated and with its efficacy fully intact. Organizations such as the U.S. Food and Drug Administration (U.S./FDA) and the International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH) act as regulatory arbiters and partners in ensuring the arrival of high quality and safe cold chain products.

The pharmaceutical and life sciences industries are faced with two major risks as its physical products traverse its “cold chains”: risk of adulterating the products while in transit and storage and the risk of non-compliance with federal regulations, guidelines, and standards. To date, there is no universal standard, guidance, regulator, arbiter, or document with the “final say” on what constitutes a compliant cold chain for a specific geographical area. All affected industries such as the pharmaceutical and life sciences industries currently deal with a multitude of recommendations on how to be compliant from many regulations at different levels, conferences, technical reports, and consultants --- reflecting a totally fragmented regulatory environment for these types of products. Amidst this fragmentation, however, two organizations are preeminent in mandating compliance procedures: the U.S./FDA and ICH.

RESEARCH METHOD

This study uses the case study approach and content analysis in aligning the concepts prescribed by the three theoretical frameworks to the sensor-based systems of SteadyServ and K+N. The case study is an appropriate methodology for understanding complex social phenomena especially for purposes of exploring, describing, and explaining such phenomena (Yin, 1984) and in testing the application of a conceptual framework to a real firm. Also, since there are two firms featured in this study, methodological suggestions from Eisenhardt (1989) and Yin (1984) are used for detecting cross-case patterns, i.e., detecting similarities in the application of the selected theoretical frameworks used in this study to the case facts.

The primary data used was based on the transcription of the conference presentation talk of key executives from SteadyServ and Kuehne + Nagel at the RFID Journal Live! 13th Annual

Conference and Exhibition, on April 15-17, 2015, San Diego, California, USA. The primary speakers from the firms were Steve Hershberger, CEO and Founder of SteadyServ and Terry Sell, the Pharma and Temperature Controlled Airfreight Services, North America, K+N Director. In addition, secondary data sources from academic and trade articles were content analyzed using key concepts in the model. Content analysis was applied to both primary and secondary data. The following are accepted definitions of the content analysis method:

> "Content analysis is any research technique for making inferences by systematically and objectively identifying specified characteristics within text." (Stone & Dunphy, 1966, p. 5).
> "Content analysis is a research technique for making replicable and valid inferences from data to their context." (Krippendorff, 1980, p. 21).
> "Content analysis is a research method that uses a set of procedures to make valid inferences from text." (Weber, 1990, p. 1).

In this study, the concepts used for content analysis were derived from the three theoretical frameworks. This framework forms the "context" of the content analysis method as applied to the sensor systems of SteadyServ and K+N:

> "A context is always someone's construction, the conceptual environment of a text, the situation in which it plays a role. In a content analysis, the context explains what the analyst does with the texts; it could be considered the analyst's best hypothesis for how the texts came to be, what they mean, what they can tell or do. In the course of a content analysis, the context embraces all the knowledge that the analyst applies to given texts, whether in the form of scientific theories, plausibly argued propositions, empirical evidence, grounded intuitions, or knowledge of reading habits…. The context specifies the world in which texts can be related to the analyst's research questions." (Krippendorff, 2004, p. 33).

The secondary data was analyzed within the context provided by the three theoretical, which is considered the "prior theory." "Analytical constructs operationalize what the content analyst knows about the context, specifically the network of correlations that are assumed to explain how available text are connected to the possible answers to the analyst's questions and the conditions under which these correlations could change….analytical constructs ensure that an analysis of given texts models the texts' context of use…" (Krippendorff, 2004, p. 34).

The following key conceptual elements of the content analysis method as stipulated by Krippendorff (2 0 0 4) were used in this study: (1) body of text selected for the analysis; (2) research question that needed to be addressed; (3) a context of analysis within which interpretations will be made; (4) analytical constructs that operationalize what the analyst knows about the context; and (5) inferences that will be arrived at to address the research question.

STUDY FINDINGS

The following are the study findings for the two firms applying the theoretical frameworks: socio-technical systems theory, affordances theory, and structurational model of technology.

SteadyServ Firm

The following are the findings for applying the three theoretical frameworks to SteadyServ.

Socio-Technical Systems Theory and Affordances Theory/SteadyServ

The concept of "functional affordances" allows us to analyze how end users (i.e., in this case, relevant end users would be beer brewers, distributors, retailers, and others) who subscribe to emerging action goals related to managing and controlling beer inventory within their respective establishments interpret the material properties of an IOT-enabled RFID IT infrastructure system Tables 1 and 2).

Table 1: Conceptual analysis of the functional affordance of beer volume & weight & pressure monitoring at SteadyServ

Material Properties Of Information Systems	**Use Context**		
	Structure	**People**	**Task**
-Monitoring Features: 1.An iKeg sensor is paired with an RFID tag (tells the sensor what's sitting on top of it). 2.The ikeg sensor sends keg depletion data to the cellular uplink using Verizon wireless network. 3.The cellular uplink transmits encrypted data to the SteadyServ's cloud database and inventory management software, hosted by Amazon.com Inc.'s Web Services. 4.The SteadyServ cloud database analyzes the information for client firm to view on their end users' smartphone, tablet, or pc.	-Entrepreneurial one-man start-up founded by Steve Hershberger in February 2012. -responded to a long-term problem in the beer industry of not being able to manage inventory -innovative solution: IOT-enabled RFID solution in the form of iKeg sensor paired with an RFID tag attached to beer keg -a small, tight firm with a team of 25 people, including engineers in India and a manufacturing team in China	-end user (i.e., beer brewer, pub owner/manager, bartender, or beer retailer) can receive text alerts when a beer keg needs to be replaced -leverage collected beer depletion & consumption data (end users impacted: beer brewers, distributors, retailers) (1) track real-time sales and depletions against goals (2)know the impact of competitive pressure by style, category, size, trending, etc. (3) know the impact of dates, local weather,	+ effective inventory management effect: affordances, if realized, can help beer brewers, distributors, & retailers know accurate inventory needs of their customers, & avoid beer wastage & spoilage + business intelligence effect: affordances, if realized, enable beer brewers, distributors, retailers, & workers "mine" collected beer data and apply

	+ this venture start-up raised $1.5 million, followed by a $5 million Series A round from Elevate Ventures and angel investors. The co-founders are currently in talks about the next round, which Hershberger expects to be in the $4 million to $6 million range. + CEO Hershberger also owns a successful brewery, Flat12 Bierwerks, founded in 2009.	and local events on sales (4) understand the impact of brand and product mix -plot consumption, social & scan data by market: (end users impacted: beer brewers, distributors, retailers) (1)know when, how, and where to allocate staff, marketing and promotional dollars, as well as, focus social activities (2)understand local consumption trends, optimize brands, styles, etc. + beer distributors can easily track which of their customers need additional supply and keep brewers on top of sales trends and quality control	insights for more streamlined beer inventory ordering, promotional campaigns, especially through social media means like tweets or Facebook messages + customer relationship management effect: affordances, if realized, will enable beer brewers, distributors, & retailers identify high-value customers and lengthen, widen, & deepen relationships with these customers + promotional effect: affordances, if realized, will enable beer retailers, establishment owners, & workers create promotional & marketing campaigns that immediately reach high-value individual customers and transmit the latest & most accurate "up-to-the-

			minute" updates on beer inventory on tap

The concept of "functional affordances" in this case study allows us to accomplish the following: (1) identify what relevant functional affordances there are that apply to SteadyServ, analyze how end users (i.e., in this case, relevant end users would be beer brewers, distributors, retailers, SteadyServ workers, and others); (2) understand how these end users who subscribe to emerging action goals related to managing and controlling beer inventory within their respective establishments interpret the material properties of an IOT-enabled RFID IT infrastructure system; and (3) understand the nature of the structure and tasks that end users are working with.

Table 2: Organization-iKeg Solution Affordance: beer volume & weight & pressure monitoring at SteadyServ

1) iKeg Solution Features (material properties of information systems):

1.An iKeg sensor is paired with an RFID tag (tells the sensor what's sitting on top of it).

2.The ikeg sensor sends keg depletion data to the cellular uplink using Verizon wireless network.

3.The cellular uplink transmits encrypted data to the SteadyServ's cloud database and inventory management software, hosted by Amazon.com Inc.'s Web Services.

4.The SteadyServ cloud database analyzes the information for client firm to view on their end users' smartphone, tablet, or PC.

2) Characteristics of Actors

+ Bar owners can analyze RFID beer data and apply insights to real-time beer inventory control

+ Beer distributors that purchase beer data can, in turn, use the beer data showing what retail establishments such as restaurants and bars are ordering, and consequently streamline their beer inventory as well.

+ Bar workers and managers will be able to do the following with the iKeg system smartphone app:
- manage inventory based on real-time keg data and anticipate beer demand better;
- discover profitable beer purchases based on regional trends;
-track beer shipments;
-automate social media messages to valued regular customers and inform them of beer stock levels "up to the latest minute"
-and catalog special events.

+ Bar and restaurant and other establishment owners can better manage their beer distributors with the RFID beer inventory data.

+ Bar tenders or managers respond to restore beer inventory levels after receiving text alerts or reading inventory reports on their tablets, laptops, or smartphones.

3) Example of immediate concrete outcomes from data

Steve Hershberger, CEO of SteadyServ, expressed the following: "…The consumer benefits from knowing exactly where their favorite beers are on tap, how much a specific retailer has on hand, how fresh the product is, and which is proving to be the most popular by consumption. For business users, SteadyServ's iQ analytics engine compares performance data in the market as well as integrated unstructured data, such as local weather and social media, and it provides recommendations designed to increase sales, customer loyalty, and product freshness…." (Joshua New, 2015).

Hershberger, in this talk at RFID Journal Live! 2015, shared another insight about the price of beer --- how it becomes inelastic after a period of time. This finding is particularly valuable to beer distributors who sell beer in large quantities:

"So we now have the ability to look at that data and show by product type what's going on in different markets not only today, but looking forward. What is likely to occur. What is likely the mix need to be so that if I'm BW3's I can so I can tell corporately my manager "order this, order this, order this. Raise your price here, lower your price there." Turns out the price of beer is really inelastic to a point. So when you were all out drinking your beers last night and they bring you the pint and they say "well that'll be $5.75." Who says "oh no no no, I'm only paying $5.20 for that beer"? Nobody does that. You just accept it. Would you pay $6? Would you pay $6.25? Probably. Would you pay $14? Depends on the beer. Beer prices are highly elastic to a point and then become highly inelastic. But having the ability to use RFID and IOT technologies allow us to tell with a high degree of accuracy what you need to sell. What the proper mix is. If rebel IPA from Boston beer needs to be on tap. Where it needs to be on tap. And what is it best paired with vs what is it not best paired with? Where do I get halo? Where so I get cannibalization?"

Ryan Kellerman, Director of Beverage Hospitality at A Pots & Pans Production, an Indianapolis-based restaurant management firm, said that he saved time and cut back on "over-ordering" beer at two of the six Scotty's Brewhouses that his firm manages (Boulton, 2014). Prior to using the iKeg solution, Kellerman said that they were wasting about US$2,000 worth of excess draft beer weekly. Now, using the iKeg solution, "…It's helped [Kellerman's firm] control [their] inventory levels tremendously…" so much so that the solution will be deployed in four more brewhouses overseen by his firm. (Boulton, 2014).

Bartenders of two restaurants managed by the Pendleton, Indiana-based CZH Hospitality Group have significantly reduced the amount of beer they waste from just guessing what is left over in the kegs. Carl Bruggemeier, CEO of CZH Hospitality Group, estimates that they sell about US$2,000 worth of beer monthly that would otherwise be wasted without the iKeg solution:
"I consider it paying nothing….It's costing me $70 to garner $1,600 of profits [each month]. It's a

no-brainer." (Cantor, 2014).

4) Goal-directed actions needed to actualize an affordance

-need to know how to use mobile devices
-need to respond to alerts
-need to properly interpret RFID data
-need to ask the "right" questions when performing data mining
-need to act on the insights derived from the data and relate with beer distributors effectively in ensuring desired beer inventory is never out of stock or is immediately replenished
-need to convert real-time data into appealing and timely social media alerts to customers to draw them into the brick-and-mortar establishment --- bar, restaurant, pub, etc.

5) Applicable goals and organizational context

-enable beer brewers, retailers, and distributors to monitor and manage beer inventory more efficiently

-leverage collected depletion & consumption data

+ track real-time sales and depletions against goals

+ know the impact of competitive pressure by style, category, size, trending, etc.

+ know the impact of dates, local weather, and local events on sales

+ understand the impact of brand and product mix

-plot consumption, social & scan data by market

+ know when, how, and where to allocate staff, marketing and promotional dollars, as well as, focus social activities

+ understand local consumption trends, optimize brands, styles, etc.

- (for brewers:) increase efficiencies of marketing campaigns and in-field sales staff, increasing revenue and, market share

- (for beer distributors:) increase acquisition and retention of high performing taps and high value retailers, understanding the optimum beer mix for each retailer, able to cede low value retailers and poor performing taps to competitors

- (for retailers:) increase draft beer revenue, margin and lower waste

-(for retailers:) average retailer ROI exceeds 10X annually

In addition to the basic affordances theory, this study applies the insights of Strong et al. (2014) in extending the affordances theory by articulating affordances in an organizational context and specifying the "actualization" of functional affordances. Strong et al. (2014) posit that the affordance theory has not really clarified how an affordance's potential is actualized, how

affordances operate within an organizational context, and how affordances arise as a "bundle" of interrelated affordances.

Strong et al. (2014) articulate how they extended the affordances theory by addressing the following: distinguishing between affordances as potentials for action and their actualization and developing the concept of "organizational affordances."

An "organizational affordance" is one that calls for potential collective actions of its members in the effort to achieve organizational –level immediate outcomes, which should, in turn, support organizational level goals (Strong et al., 2014). The "function" of an "organizational affordance" is expected to be the same across different individuals and different organizational levels. So, for instance, the functionality of the organizational affordance called "temperature, pressure, and volume monitoring of beer" will be the same for all kinds of end users in the roles of beer brewers, distributors, and retailers, bar tenders, restaurant waiters, etc. However, in terms of "structure" of an affordance, what is monitored (i.e., there are different types of beer in many establishments) and the specific purposes for which the beer is monitored in the different retail establishments will be different across all the SteadyServ clientele members. The manner in which the iKeg RFID solution, though, works within the context of the RFID infrastructure and the cloud service support from SteadyServ will be the same across all of the firm's clients.

IT-related affordances are defined by Markus and Silver (2008, p. 622) as "… the possibilities for goal-oriented action afforded to specified user groups by technical objects…." These IT-related affordances are also called "functional affordance" in the context of this study. Zammuto et al. (2007) has a related "take' on this and calls attention to affordances that arise from the interaction of organizational systems and different forms of information technology.

Technology is not viewed as being "static" --- rather, it evolves through time, especially when implemented and used by individuals in an organizational context and "interpret" it during its use (Orlikowski, 2000). Table 2 focuses on the key affordance featured in this case study of SteadyServ: "affordance" of monitoring the temperature, weight, and pressure of beer using RFID sensors.

The authors define actualization of affordances as "…the actions taken by actors as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcomes in support of organizational goals…." (Strong et al., 2014, p. 70). In order to move from being an "affordance potential" to being an "actualized affordance," there are certain goal-directed actions required of the relevant end users in the beer industry.

An immediate concrete outcome is a specific expected outcome from the "actualization" of an affordance. In the SteadyServ case study, examples of immediate concrete outcomes are reduction in the amount of beer wasted and reduction in the frequency of reordering imprecise amounts of beer. These concrete outcomes are viewed as useful for realizing overarching organizational goals, which in the case of SteadyServ would include better management of beer inventory and capture of more accurate beer consumption data. These immediate concrete outcomes also serve as an "intermediary" between "actualization" outcomes and a firm's organizational goals (Strong et al., 2014).

Whether or not a specific SteadyServ client achieves its desired organizational level outcomes depends on the consistency, extent, and alignment of the collective actions of the end users in that client firm that interact with the iKeg solution. Strong et al. (2014) further explain that an "affordance" is defined by a set of characteristics related to the nature of an immediate outcome. However, an organization's members may actualize a functional affordance is a variety of ways appropriate to their particular organizational setting. Thus, what we will find is that while different SteadyServ clients will be interacting with the same standardized iKeg solution embedded in an RFID IT infrastructure, what each client chooses

to “actualize” in terms of a specific immediate outcome related to having the ability to “monitor the temperature, pressure, and volume of beer” could be different. One client may be interested in monitoring beer strictly to cut down beer wastage. Another client may want to use the monitored beer data primarily for promotional purposes and use social media for informing its highly valued customers at what dates and times to come in for “Happy Hour” consumption of their favorite light beer. Yet another client may want to mine captured beer data to negotiate better beer prices with its top three beer distributors.

Apparently, SteadyServ has achieved a level of success as manifested in the reaching of desired outcomes at beer serving establishments. This is described using the concept of the “immediate concrete outcome” and the accompanying data vignettes in Table 2 illustrate how successful end users have reached certain organizational goals.

Structuration Model of Technology and SteadyServ

The following are the findings of this study concerning the implementation of the SteadyServ keg solution using the theoretical framework of the structuration model of technology by Orlikowski.

Structure of Signification

The SteadyServ iKeg system consists of the following IT infrastructural elements (SteadyServ, 2012; Swedberg, 2013)

(1) Identiv high frequency (HF) 13.56 MHz passive RFID inlay made with NXP semiconductors chip and integrated into a label made by RR Donnelley; this tag is attached to the keg’s handle;
(2) SteadyServ’s Sensor ring with a built-in RFID reader and weight sensor --- which is used as a platform on which the beer keg sits;
(3) Mobile app enabling end users to manage beer inventory levels from a smartphone; the app is available for both IOS or Android devices;
(4) SteadyServ’s gateway installed in every retail outlet like a restaurant, bar, etc. (Swedberg, 2013).

The Uplink/Gateway is a plastic box that contains radio receivers, computer hardware, computer software, and radio transmitters, which is mounted on the wall outside the beer cooler of the retailer’s (i.e., bar or restaurant) establishment. Each Uplink/Gateway box has a unique serial number embedded in its Uplink/Gateway software. The Uplink/Gateway boxes have two major functionalities: the Zigbee hardware radio receiver and software stack receives data transmissions from keg sensor/transmitters within range. This Zigbee hardware radio receiver accepts this data, organizes it, and tags the data with information unique to the Uplink/Gateway, including the unit’s unique serial number and version number. Keg sensor/transmitter data that has been organized is, then, forwarded to the code division multiple access (CDMA) cell phone gateway.

The CDMA Uplink/Gateway, on the other hand, also is a transmitter/receiver in a box containing radio hardware and software. This box could be designed by a wireless carrier partner such as Verizon Communications (in the U.S.). “This CDMA Uplink/Gateway will then join the wireless carrier’s data service by connecting the closest cellphone tower to the on-premise retailer where the Uplink/Gateway has been placed….The Uplink/Gateway relays the data from the Keg Sensor/Transmitter(s) that has been collected by the Zigbee receiver. The

CDMA Uplink/Gateway will communicate with the carrier's network to determine the longitude and latitude of the Gateway and will transmit that data, its software version number, and the data collected by the Zigbee receiver to the SaaS Software." (SteadyServ, 2012).

The beer distributor warehouse receives a number of keg sensor/transmitters, which are installed on the kegs. For instance, the sensor could be mounted at the bottom of the keg. Workers in the distributor warehouse have to make sure that the keg upon which the sensor/transmitter has been attached matches the items listed on the Order Pick List. The Order Pick List could be stored in an SaaS using an electronic data interchange (EDI) connection to the beer distributor's inventory system.

The distributor's warehouse usually uses a paper keg collar, clipped at the keg's top valve, which identifies the contents of the keg. Let's say that for one keg, the warehouse worker sees the label, "Coors Light." The keg sensor/transmitted for this particular keg will, then, transmit its serial number as KS1234 through the uplink Gateway. The computer monitor that shows data coming from the SaaS application will show that the keg sensor is associated to the stockkeeping unit (SKU) for "Coors Light," and confirms that the correct sensor has been attached to the right keg of beer. The Order Pick List will also be shown on the monitor from the SaaS software and this information can help the warehouse worker confirm that the beer keg leaving the distributor warehouse is the right one.

Kegs delivered from SteadyServ to the different retail establishment/customers have sensors/transmitters attached to them. These customers, then, store the kegs in coolers which puts the kegs within radio range of a mesh network that includes the keg sensors/transmitters and the uplink/gateway. Once inside the coolers, the sensors/transmitters of the kegs send data such as the weight parameter (0-20), the sensor/transmitter serial number, the software's version number, among other things. The uplink/gateway, which has its own serial number (e.g., #UG5678) and location longitude and latitude coordinates, collects the data from the sensors/transmitters. The carrier's CDMA cell phone data network, then, transmits this keg data collected by the uplink/gateway (which includes data from the gateway itself) to the SaaS software.

The SaaS software collects this data, which, it then stores in databases in a number of ways. The database supporting the SaaS software has been programmed to correlate the serial number of the sensor/transmitter and the stock keeping unit (SKU) that identifies a beer type and brand. An example can illustrate the way this works. Let us say serial numbers AB0000 to AB5678 are assigned the SKU 998877665544, which points to the product "Heineken" --- a particular beer type and brand. So, "Heineken" is written on the database by the SaaS software when data from sensor/transmitter serial number AB5676 is received, for instance. The same SaaS software has also been programmed to convert weight parameter into a percentage volume of the keg. So, say, using a weight scale of 0-20, a weight measurement of 10 from a specific keg would be converted by the SaaS software into 50% volume.

The location of the kegs in the different retail outlets is also collected by the uplink/gateway and the corresponding coordinates are also determined and recorded. So, for example, let's take the data from keg sensor/transmitter AB5676 with a weight parameter of 10 sent to the SaaS software by uplink/gateway UG1234. The SaaS software converts the data received from the keg of "Heineken" at 4 pm today and indicates that this keg is housed in "Rhum Corner," bar is 30 percent full.

Software with embedded intelligence manage the keg sensors/transmitters and controls the frequency of transmitting data from the sensors/transmitters to the uplink/gateway. This software could be programmed so that, for instance, data will be transmitted only if the weight of the keg changes. Work is underway so that data about the ambient temperature in the cooler and the sensor/transmitter's remaining battery life could be relayed as well.

Once the basic keg volume, date time, and location data are beamed from the Keg Sensor/Transmitter through the Uplink/Gateway into the SaaS software database, a number of actions will now take place that involve acting upon the data gathered.

Institutional customers of SteadyServ can set up their organizational accounts to enable their firm representatives to access their account information. The setup process requires each individual's smartphone number, among other data. All authorized individuals in that firm are allowed to access their account information which should give them insight into the status of their beer inventory and enable them to activate alerts when it is time to replenish the beer. Alerts can be sent using a number of ways: an alert sent as simple SMS text message sent to mobile phones; pop-up push alerts sent to iPhones and Android phones; email messages; recorded voice alerts sent to smartphones, etc. The alerting system uses the individual's smartphone's location based service. Workers get alerts only when they are in an area within the designated longitude and latitude boundaries associated with their workplace as defined in the SaaS database. Workers can choose to receive alerts whether or not they are working during official working hours.

A retail representative can design alerts based on the relative importance of a beer brand and type. So, for instance, if "Molson Canadian" beer is more popular than "Heineken," then, the retail representative can set up the SaaS software in such a way that he/she receives an alert when the system reports a 35 percent remaining volume for "Molson Canadian" beer and 10 percent remaining volume for "Heineken" beer.

Retailers have a number of options for reordering beer once after an alert has been received. First, using an SMS text message, they can contact their beer distributor rep directly. Second, they can send an SMS text message to an SMS gateway designed to transmit electronic data interchange (EDI) transactions to the beer distributor's ordering system. A third party system vendor usually controls this process. Third, they can use the user interface of the software to voice call to the beer distributor's sales rep. Fourth, they can use a reorder app on an iPhone or Android phone that communicates via EDI with the beer distributor's ordering system. Finally, retailers can set their accounts in such a way that automatic reorder messages tailored to the specific demand for a beer type and brand are sent to the beer distributor. So, for example, a rule can be specified in the SaaS software so that "Molson Canada" beer is automatically replenished if the volume falls below the 40 percent level only on Fridays, Saturdays, and Sundays.

Developers of application programming interfaces (APIs) will also have opportunities to write software programs for applications that can access the captured data for a variety of real-time software applications.

Structure of domination

The different elements of the RFID system used for the keg solution represents the "structure of domination" in the way work was conducted because the built-in assumptions, features, and standardized procedures embedded in business processes involved controlled the way inventory was managed in the retailer, distributor, and beer brewer establishments that used the SteadyServ keg solution. RFID system deployment involves complexities related to the physical elements of the working environment. Hershberger articulated the challenges of using RFID technology for the keg solution (Hershberger, 2015): "So it turns out using an IOT device, including RFID, in the coolers is [a] pretty hostile environment. It's pretty hard. So [it] must operate in 32-38 degree temperatures 24 by 7. It must be self-powered by lithium battery, which does not like cold. It must last three years. It must have built materials underneath $100. A full keg actually weighs 170 pounds, which gets dropped off [of] the back of a semi which is

54 inches tall. [A sensor needs to be placed underneath] and the keg could be [stacked too high]. It's a smash force of 2,000 pounds --- so you need to have an IOT device that can withstand 2,000 pounds of smash force. [You also] need to be able to measure [the beer liquid] down to a single pint of beer, which is about eight ounces out of a keg that holds 180 pints. And you need to know exactly when it's going to run out. Meaning I need to know in the next 15 seconds that that keg over there is going to be empty. You need to be able to designate up to 10 different keg sizes and 20 various options….You [also] need to be able to recognize up to 40,000 different types of beers that are commercially available globally. You must be able to use [an] RFID tag to isolate alphanumerically every single keg and never ever have the same number [used] twice. You need to remove the human process with a semi-automated intelligence process. And you need to be able to house the RFID reader and ZigBee transmitter in that device that sits in that horribly complex environment that does not like anything like temperature, power consumption, the whole nine yards…" (Hershberger, 2015).

Social consequences

1) Social structure and social consequences of IT

The focus here is on how IT is implemented, assimilated, and adopted by end users and the resulting outcomes within the social structures that defined the social context of deployment. IT is the medium of human action. Using the structuration perspective, the concept of interpretive schemes, resources, and norms are used to understand how the end users' behavior in the organization is mediated by IT which either facilitates certain outcomes or constrains others. The potential of IOT to provide competitive advantage in the marketplace at this stage has been articulated by Iansiti and Lakhani (2014) and Burkitt (2014). At this stage of the game, perhaps the most significant change emerging as a result of IOT technological possibilities is the attention given to it at the "C suite" level of the firm. A major part of crafting an IOT strategy is determining a new business model for offering IOT-enabled products and services.

In SteadyServ, Hershberger, CEO of SteadyServ articulated their business model, which was to deliver business intelligence-enhanced services to retailers, distributors, and beer brewers (Hershberger, 2015). SteadyServ created a technological solution enabled by IOT to solve supply chain problems associated with beer and tap management. In fact, apps for iPhone and Android smartphones have been developed to facilitate the deployment experience of retailers, distributors, and beer brewers. Without the SteadyServ beer keg solution, there was no instrumentation in place to assist in inventory management in different retail establishments serving beer. Orders and beer replenishment were based on sheer guesses. With increasing competitive pressures in the marketplace, the beer industry had to figure out how to "demand match" beer products with significant micro-trends determined by local tastes, economics, social dynamics, and product seasonality (Hershberger, 2015).

2) Action and social consequences of IT

Retailers using the SteadyServ's iKeg system benefit from the significant improvements in corporate decision making as a result of fine-grained tracking information that give real-time updates on the state of the firm's inventory system. Carl Bruggemeier, CEO of CZH Hospitality, a firm overseeing restaurant and hospitality projects across the US shared this:

"For me, it's all about having near real-time information about all of my draft beer products at my fingertips," Bruggemeier says (Dudley, 2015). "I can get a variety of reports and information on my handheld device. The system allows me to understand my customer's purchasing trends,

look at my inventory and compare the information from SteadyServ with the reports I get from my point of sale systems, so that I can verify that I'm getting all the money I should. It has become an invaluable management tool for all the young people that work for me." "The most important thing it has done for us is that we don't run out of the beers our customers wish to purchase," Bruggemeier says. "This makes the customer very happy because previously we might have run out of a very popular and great selling product. There are two outcomes from that – you have an angry customer and you miss out on potential revenue." "We can look at a trend and say 'our customers are telling us they like pale ales' for example," Bruggemeier explains. "We may only have one or two available, but with this information we can go and find others to complement what we already sell. This helps increase customer satisfaction to thereby increase our revenues." "For many years the hospitality industry lagged behind others in the appropriate use of technology, and I think we suffered because of it," he concludes. "I think systems like SteadyServ and the explosion of this kind of technological improvement and availability of data is going to make those that adopt it eminently more powerful in their marketplace and completely responsive to their customers' needs." (Dudley, 2015).

Another significant action SteadyServ undertook was collaborating with Intel Corporation and with the world's best brewers including Heineken, Boston Beer, New Belgium Brewing, Constellation Brands, Molson Coors, and more, in developing the keg IOT-based solution (Hershberger, 2015).

3) Measures of success

Hershberger articulated the different metrics SteadyServ recognized in measuring the success of the keg IOT-based solution (Hershberger, 2015): brewers increased the efficiencies of their marketing campaigns; in-field sales staff increased sales, revenues, and the firm's market share; distributors increased the acquisition and retention of high performing taps and high value retailers; distributors gained a better understanding of the optimum beer mix for each retailer/customer, which, in turn, enabled them to focus on high value customers; retailers increased their draft beer revenue margins and reduce waste; and SteadyServ's return on investment had gone beyond a tenfold increase annually.

Kuehne + Nagel Firm

The following are the findings for applying the three theoretical frameworks to Kuehne + Nagel.

Socio-Technical Systems Theory and Affordances Theory

The concept of "functional affordances" allows us to analyze how end users (i.e., in this case, K+N workers and more specifically, CareTeam members) who subscribe to emerging action goals related to monitoring the temperature of the pharmaceutical and biologic goods shipments under their care headed for various destination points in the world, interpret the material properties of the CartaSense "U sensor-based" IT infrastructure system (Tables 3 and 4).

Table 3: Conceptual analysis of the functional affordance of PharmaChain's temperature monitoring of pharmaceutical products at Kuehne + Nagel

Material Properties Of Information Systems	**Use Context**		
	Structure	**People**	**Task**
-Monitoring Features: 1)CartaSense "U sensors" are attached to and are used to monitor the pharmaceutical products. 2) A communications server uses a web service technology interface to share captured RFID data with external applications. 3)K+N software logs temperature data, times of readings, receipt of measurements, whether the tags were connected to the system at the time of measurement, and reader position, among others, and transfers this data to a database. 4)K+N software also detects temperature deviations from set thresholds and alerts CareTeam to act when exception cases are encountered. 5)PharmaChain system is linked with K+N Login customer portal, which gives all participating firms visibility into all shipment information.	+ K+N has prepared for volatile environment by adapting flexible management structures and processes +K+N business model is both agile and resilient; adaptive management style has been adopted + K+N's "Focus + Excellence" programmed enabled it to develop innovative products and services (i.e., such as PharmaChain) to address needs of specific industry customers + K+N has offered innovative, scalable solutions such as PharmaChain to the pharmaceutical industry and win business contracts from new customers + K+N seeks to use digitization to standardize and automate their services	+ Appropriate end users interpret summary RFID data in the logistics reports generated by the K+N software. + CareTeam members take appropriate remedial action to prevent product spoilage or adulteration when exception cases emerge --- such as when temperature thresholds are exceeded or violated. + CareTeam members perform corrective and preventative action or CAPA and perform root cause analysis whenever there's a problem with the shipment or a deviation from expected standards. + Appropriate end users inform all involved regulatory agencies of the storage and transportation conditions the pharmaceutical product shipments were subjected to from point of origin to final destination.	+ effective pharmaceutical and biologic goods inventory management effect: affordances, if realized, can help shippers such as drug manufacturers where their shipment is at any point in time from the time of departure from origin to arrival at the point of destination + corrective and preventative action effect: affordances, if realized, enable K+N's CareTeam member to undertake effective and appropriate remedial actions to prevent spoilage or wastage of pharmaceutical goods whenever temperature and storage thresholds are violated.

6)PharmaChain system is integrated with Cargo 2000, an airline industry initiative created to ensure compliance with high levels of customer service quality expectations in handling air freight.	+ By 2015, K+N owned 116 logistics facilities and office buildings. K+N also opened its Singapore Logistics Hub and added it to its European logistics center in Leipzig (whose logistics capacity was recently doubled)	+ K+N PharmaChain end users transfer relevant information to the Cargo 2000 system to ensure compliance with airfreight delivery standards. + K+N PharmaChain end users transfer relevant information to the K+N Login system to provide total supply chain visibility to all stakeholders involved in a shipment.	+ information transparency effect: affordances, if realized, will enable appropriate regulatory agencies be apprised about the storage and delivery conditions shipments were subject to --- which is especially important during shipment delays or other problem situations. + effective decision making effect: affordances, if realized, will enable shippers to make sound business decisions on the handling and managing of their shipments whenever exception cases arise in the course of the shipment's journey.

The concept of "functional affordances" in this case study allows us to accomplish the following: (1) identify what relevant functional affordances there are that apply to K+N's PharmaChain, analyze how end users (i.e., in this case, K+N logistics workers in the different logistics centers and hubs and the CareTeam members); (2) understand how these end users who subscribe to emerging action goals related to monitoring the movement and temperature

and storage conditions of the pharmaceutical goods interpret the material properties of an IOT-enabled CartaSense IT infrastructure system; and (3) understand the nature of the structure and tasks that end users are working with.

The "function" of an "organizational affordance" is expected to be the same across different individuals and different organizational levels. So, for instance, the functionality of the organizational affordance called "temperature monitoring for pharmaceutical goods" will be the same for all kinds of end users at K+N. However, in terms of "structure" of an affordance, what is monitored (i.e., there are different types pharmaceutical product shipments) and the specific purposes of these products will be different across all K+N clients/shippers. The manner in which PharmaChain, though, works within the context of the U sensor wireless mesh network will work and how this system will interact with K+N Login and K+N Cargo 2000 will be the same for all of the K+N's clients.

Table 3 focuses on the key affordance featured in this case study of K+N: PharmaChain's temperature monitoring of pharmaceutical products at Kuehne + Nagel using CartaSense mesh network of wireless U sensors.

The authors define actualization of affordances as "…the actions taken by actors as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcomes in support of organizational goals…." (Strong et al., 2014, p. 70). In order to move from being an "affordance potential" to being an "actualized affordance," there are certain goal-directed actions required of the relevant end users in the logistics industry. Table 4 features goal-directed actions required on the part of K+N workers in item number (4) in order to actualize desired outcomes.

An immediate concrete outcome is a specific expected outcome from the "actualization" of an affordance. In the K+N case study, examples of immediate concrete outcomes are successfully delivering pharmaceutical products as promised, fulfilled guaranteed transit times, adoption of good distribution practice compliance, effectively mitigating problem situations with proactive remedial action, making supply chain visibility information accessible, and promptly informing regulatory agencies involved when needed. These concrete outcomes are viewed as useful for realizing the overarching organizational goal, which in the case of K+N would be guaranteeing high-level customer service quality in the form of timely deliveries wherein pharmaceutical and biologic products remain in a potent and useful state for the sake of the end consumers. These immediate concrete outcomes also serve as an "intermediary" between "actualization" outcomes and a firm's organizational goals (Strong et al., 2014).

Whether or not the K+N logistics worker or CareTeam member achieves its desired organizational level outcomes depends on the consistency, extent, and alignment of the collective actions of these workers with the goals set forth by K+N. Strong et al. (2014) further explain that an "affordance" is defined by a set of characteristics related to the nature of an immediate outcome. However, an organization's members may actualize a functional affordance in a variety of ways appropriate to their particular organizational setting.

Thus, what we will find is that while different K+N logistics workers and CareTeam members will be interacting with the same PharmaChain solution, what each K+N worker chooses to "actualize" in terms of a specific immediate outcome related to having the ability to "monitor the temperature and other ambient conditions surrounding a pharmaceutical shipment" or ensuring timely delivery of a shipment could be different. For instance, a number of CareTeam members could be involved mitigating a situation where a case of a vaccine has been frozen by mistake instead of refrigerated. Freezing has a profound and irreversible impact on a protein-based biologic product, and so, this particular case of vaccine has been compromised. The team members will report the situation to the client/shipper (i.e., a pharmaceutical firm) and agrees to absorb a financial penalty and asks

the client to reconsider the disposition of the remaining cases of vaccines in the pallet that were not frozen. In another case, K+N logistics workers in the Singapore distribution center encounters a one-day delay of arrival of 10 pallets of an anti-flu drug from California. They, in turn, communicate with the pharmaceutical firm in California via the K+N Login customer portal and request a remapping of the route for the delivery to the next port of call, which is Hong Kong.

Apparently, K+N has achieved a level of success as manifested in the reaching of desired outcomes. This is described using the concept of the "immediate concrete outcome" and the accompanying data vignettes in Table 4 which illustrate how successful K+N end users have reached certain organizational goals.

Table 4: Organization-PharmaChain Solution Affordance: temperature monitoring of pharmaceutical products at Kuehne + Nagel

1) PharmaChain Solution Features (material properties of information systems):

(1)CartaSense "U sensors" are used to monitor the pharmaceutical products. The U sensors are attached to the goods/products whose temperature and location are being monitored. Data from these sensors are transmitted to RFID readers when the shipment arrives at a waypoint or its final destination (Greengard, 2015). These U sensors can monitor temperatures ranging from -35 degrees Celsius to + 65 degrees Celsius with both internal and external probes that support relative humidity within the (0-100%) range.

(2) An advanced mesh network connects innumerable wireless U sensors with each other and with a "gateway."

(3) The "gateway" connects the mesh network in a specific spot to a central communication server through the use of either a public or private network.

(4)Data from all the gateways are gathered real-time by a "communications server," which uses a web service technology interface to share this data with external applications. All U sensor data gathered are, then, transferred to the K+N software which logs temperature data and detects deviation from acceptable thresholds. Other data such as temperature measurements, times of readings, receipt of measurements, whether the tags were connected to the system at the time of measurement, and reader position, among others, are transferred by this software to a database.

(5)Technical applications are software products that allow end users to view the data gathered in a usable format. Technical applications may run on any web-enabled device.

(6)"Business analytics software" can do further data analysis in order to produce meaningful reports showing things like warehouse mapping, shipment location, temperature thresholds reached, etc.

2) Characteristics of Actors

+ Appropriate end users at any point in the K+N supply chain should have the skills to interpret

the logistics reports generated by the K+N software.

+ Upon receipt of alerts, CareTeam members should be able to take appropriate remedial action to prevent product spoilage or adulteration.

+ CareTeam members should be able to perform corrective and preventative action or CAPA and perform root cause analysis whenever there's a problem with the shipment or a deviation from expected standards.

+ Appropriate end users in the K+N PharmaChain supply chain should be able to inform all involved regulatory agencies of the storage and transportation conditions the pharmaceutical product shipments were subjected to from point of origin to final destination.

+ K+N PharmaChain employees should be able to transfer relevant information to the Cargo 2000 system to ensure compliance with airfreight delivery standards.

3) Example of immediate concrete outcomes from data

Terry Sell, Pharma and Temperature Controlled Airfreight Services, K+N, shared the following concerning actual accomplishments achieved by K+N in delivering PharmaChain services:

+ K+N has enabled pharmaceutical supply chain visibility and help clients manage shipments:

"…So in summary, with enabling of the visibility system with our technology provider, we have increased the visibility and control over shipments…."

+ K+N's CareTeam has facilitated proactive remedial action to protect shipments:

"….We have been able to mitigate in-transit issues. We've had active containers meaning they're actively controlled containers mechanically fail. We've been able to catch that, and it is something once we've caught that we have a plan in place to combat that…."

+ K+N has reduced product release time:

" [We have been able to] reduce the product release time, again, so with that pre-clearance, giving them [the clients/shippers] the higher confidence interval that their product is safe, and when they do have their data log or stuff they're pulling off which is reactive, when they do download that information it is going to be exactly what we told them it's going to be, so giving them that confidence, increased confidence that they can begin the downstream pre clearance process…."

+ K+N has helped their clients (shippers) reduce their shipping costs.

+ K+N has been able to fulfill their delivery promises and ensured that products arrive at destination points in a form useful to end customers:

"…So again taking that 14 days [delivery time] down to 5 days. That's very critical for them to get the product to market, and then making sure that the patient, again this always has to come back to the patient, so making sure that the patient gets the product in the right condition at the

right time…."

+ K+N has provided their clients timely, complete, and accurate information to enable them to make the right business decisions concerning their shipments:

"…[We have also given]…these companies (i.e., clients) better information and data to support business decisions. So that's, again, we've had a real positive experience with our technology partner CartaSense, we've had a real positive experience with some of our customers who have adapted or have adopted this technology, and we continue to see more and more customers wanting this. So, as they understand what the value is, as they understand what we can give them in terms of information and data, if we're talking about risk mitigation, risk minimization, you know… these are the kind of things that they want to see…."

4) Goal-directed actions needed to actualize an affordance

-need to know the science behind the monitoring of cold-chain pharmaceutical products
-need to interpret data relevant to pharmaceutical cold chain products like temperature, heat, and refrigeration or freezing thresholds, etc.
-need to respond appropriately to exception situations or deviations from standards using corrective and preventative actions to avoid product waste or spoilage
-need to inform regulatory agencies involved in the shipment about conditions the shipment was subjected to, especially in cases of problems or shipment delays
-need to ensure that pharmaceutical products arrive at the end user/consumer destination points in a form that is useful to the consumer
-need to ensure that pharmaceutical products pass all storage and delivery "tests" to ensure that the products arrive in viable form and state

5) Applicable goals and organizational context

-K+N seeks to ensure that pharmaceutical products are safe and effective when they arrive at their client's site
-K+N guarantees transit/delivery time
-K+N guarantees good distribution practice in the course of providing delivery services
-K+N provides appropriate proactive interventions when required
-K+N uses qualified equipment and collaborates with third party providers
-K+N seeks to provide three levels of pharmaceutical cold chain services:
(1)Level 1: services for shipments that do not require special handling and have no particular temperature requirements
(2)Level 2: services for shipments that require specific temperature ranges, but no any special handling procedures
(3)Level 3: services for temperature-sensitive cargo with special handling requirements
-K+N seeks to ensure that their clients/shippers can manage their pharmaceutical goods inventory efficiently and effectively
-K+N has to assist client so that the latter does not get involved in lawsuits filed by their customers
-K+N seeks to help their clients/shippers reduce their shipping costs
-K+N seeks to provide their clients/shippers relevant, accurate, complete, and actionable intelligent information that will enable these clients to make sound business decisions
-K+N seeks to protect their clients by ensuring compliance with all regulatory advisories and

guidelines pertaining to the shipments

Structuration Model of Technology (Orlikowski)

The following are the findings of this study concerning the implementation of K+N's PharmaChain solution for pharmaceutical and life sciences products using the theoretical framework of the structuration model of technology by Orlikowski.

Structure of Signification

K+N's PharmaChain was deployed in March 2011 (Greengard, 2015). The specific elements of K+N's PharmaChain that make up the CartaSense wireless monitoring solution by air and ground shipments are the following (CartaSense, 2015). First, there are the wireless sensors and in the case of K+N, the "U sensors" used to monitor the pharmaceutical products. The U sensors used for the PharmaChain solution can monitor temperatures ranging from -35 degrees Celsius to + 65 degrees Celsius with both internal and external probes that support relative humidity within the (0-100%) range.

An advanced mesh network enables the connection of innumerable wireless U sensors with each other and with a "gateway." Second, the "gateway" connects the mesh network in a specific spot to a central communication server through the use of either a public or private network. Third, data from all the gateways are gathered real-time by a "communications server," which, in turn, uses some kind of web service technology interface in order to share this data with external applications. Fourth, "technical applications" are software products that allow end users to view the data gathered in a usable format. The data gathered can consist of measurements, mesh network architecture data, or other valuable data. Technical applications may run on any web-enabled device. Fifth, "business analytics software" can do further data analysis in order to produce meaningful reports showing things like warehouse mapping, shipment location, temperature thresholds reached, etc.

The U sensors are attached to the goods/products whose temperature and location are being monitored. Data from these sensors are transmitted to RFID readers when the shipment arrives at a waypoint or its final destination (Greengard, 2015).

"U sensors" detect a U sensor gateway within range and starts transmitting data to it. Using some kind of network whether it is a local area network (i.e., Ethernet gateway) or cellular communications network (i.e., general packet radio service or GPRS gateway), the U sensor gateway, in turn, connects with a communications server. The "U sensors" automatically form a dynamic, self-healing mesh network which is resilient even when exposed to rough radio frequency conditions. Resident sensors can also function as "repeaters" for other wireless sensors that cannot sense a U sensor gateway nearby.

All U sensor data gathered are, then, transferred to the K+N software which logs temperature data and detects deviation from acceptable thresholds. Other data such as temperature measurements, times of readings, receipt of measurements, whether the tags were connected to the system at the time of measurement, and reader position, among others,
are transferred by this software to a database.

K+N's 24/7/365 CareTeam is alerted via a Web-based shipment tracking system when acceptable temperature thresholds are exceeded, and its members, then, take appropriate remedial action to prevent product spoilage or adulteration. There is also a U sense gateway dashboard that enables K+N workers have supply chain visibility and help manage reader data reception and transmission throughout the journey of the products.

The IT infrastructural elements of this temperature monitoring application are installed in hundreds of points along K+N's global supply chain consisting of warehouses and logistics facilities that oversee the logistics of pharmaceutical and life sciences products of its clients. Chapman, K+N's global pharmaceutical product manager, said, "It's not something every company chooses to use or deploys for all products and situations….It's something that's valuable for critical shipments involving high-value products, and the partnership between our customers and our company is constantly expanding." (Greengard, 2015).

Operational data from the U sensor mesh network is also linked with K+N's Cargo 2000 system to ensure compliance with air freight delivery standards required by this initiative.

Structure of Domination

Moving "cold chain" pharmaceutical products demands thorough scientific knowledge of the product and the nature of the environments where it moves and is stored throughout the delivery journey. A second key requirement is the ability to document data on the operating environments and establishing that they are scientifically sound. Cold chain engineers, packaging engineers, and logistics-related workers should understand these environmental conditions and product parameters better than any inspector. Guidance documents from regulatory agencies spell out valuable criteria for creating tests to ensure the products are protected while in transit and during short-term storage. These tests should accurately represent real-time and real-world shipping environments, primary and secondary shipping containers, transport and storage durations, seasons, and climatic zones. The global supply chain for pharmaceutical products usually include different transportation and several climatic zones, and land, air, and water modes of transportation, each with their accompanying temperature fluctuations.

An information system supporting the documentation needs of the peculiar logistics requirements for pharmaceutical products needs to capture detailed records of stability data, geographical data (including climatic zones), shipping and storage durations at each point in transit, and contingency procedures for delivery delays, out-of-specification conditions, or other unforeseen exception events.

RFID technology should be able to capture all relevant ambient data regarding the pharmaceutical product shipment in order to fulfill regulatory requirements. In the case of K+N, the CartaSense solution offers end-to-end monitoring and alerting abilities using advanced wireless sensor networking (Berkovitch & Leshem, 2014). Vendors need to introduce new paradigms for monitoring assets, providing real-time information, and enabling ad-hoc corrective actions such as increasing or decreasing the air condition temperature set point while in transit, moving the goods from a warm location back to the fridge room, etc.

The quality of the goods is often related to the remaining shelf life of the product, which is often difficult to predict as complete information is usually unavailable on the history of the product environment from the product's creation to its actual arrival time. Also, goods on the same pallets coming from the same manufacturing facility, using the same mode of transportation, can have very different environmental profiles. One pallet in the same shipment may have waited longer on the dock and may have been exposed longer to hotter sunlight, for instance, than other pallets in the same shipment. Adding a wireless sensor to each pallet enables capture of the exact temperature history at each point in transit and the product's shelf life can be more accurately calculated.

Structure of Legitimation for both SteadyServ and Kuehne + Nagel

Standards that govern IOT represent "the structure of legitimation" because they sanction the configuration of the specific elements of the IOT solution used and propagate a set of "norms" about what constitutes a workable IOT solution within different corporate contexts/environments. Observance of IOT standards is important because: (1) standards specify tried and tested solutions which could greatly help a firm deploy IOT solutions under real world conditions; (2) standards require specific IOT solution components provided by vendors and integrators off-the-shelf, thus, helping firms avoid unnecessary development efforts and vendor lock in; and (3) standards enable solutions that are compatible with related business applications.

At this time, there is no central body of standards that can be applied to all possible IOT applications. The use of industrial IOT standards would be relevant specifically for SteadyServ's product monitoring initiative or K+N's temperature monitoring service. The efforts of three specific bodies would have the most impact on the two firms, though.

The first organization is that of the Open Interconnect Consortium (OIC), which is supported by Intel, Samsung Electronics, Hewlett Packard, Lenovo, Dell, among a total of 50 vendor firms. These firms are working to back up open-source standards covering device discovery, communication, data exchange, among other functions. The OIC has developed the source code embodying the consortium's specifications for certified IOT products and released it to developers in 2015 (Lawson, 2014).

The second organization focusing on enterprise IOT is the Industrial Internet Consortium (IIC) consisting of about 100 members including Microsoft, Samsung, Huawei Technologies, General Electric, Cisco Systems, IBM, and Intel (Lawson, 2014). Its approach is different in that rather than developing IOT standards, it intends to work with different standards bodies to coordinate efforts of industries where IOT and older machine-to-machine technologies have been deployed. In so doing, the IIC will define requirements for standards, design reference structures, and create testbeds for these standards.

The third organization is the IEEE (The Institute of Electrical and Electronics Engineers) P2413, which has a working group devoted to organizing the variety of IOT specifications developed by different industry consortia (Lawson, 2014). It will do so by converting information from different IOT platforms into a commonly understood body of data objects.

With the variety of standards bodies emerging, a good predictor of who might prevail is the size, reputation, and momentum of the firms behind them. These are consortia that will more likely gain greater traction and immediate market recognition.

Social consequences

1) Social structure and social consequences of IT

<u>K+N PharmaChain and K+N Login</u>

The supply chain logistics operations of pharmaceutical and life sciences are a complex system of interactions involving multiple parties. Terry Sell from Pharma and Temperature Controlled Airfreight Services – North America, K+N shared this:"[The] current situation is that there are multiple handoffs between different parties. In the freight forwarding world, we don't own [all] assets for the most part. We may have a few trucks here and there, but typically we're not owning our own aircraft. So this is where we have to involve other stakeholders, other providers,

and make sure that they are willing to help us in that transit process…."(RFIDJ, Live! Transcript, 2015).

Relationships among K+N clients and trading partners are supported by a Web-enabled value network platform called K+N Login, thus, enabling a digital horizontal social structure supporting integration among these participants. Functioning as a customer portal, K+N Login is a comprehensive supply chain management platform designed to enable K+N clients optimize critical logistics, procurement, and customer service processes; reduce logistics costs; and provide an "up-to-the-minute quick" view of one's inventory in motion using land, sea, and air transportation (K+N, 2015a). This customer portal links shippers, consignees, third-party service providers like warehousing and distribution center owners with K+N, enabling always on real-time communications along a firm's entire supply chain.

Achieving supply chain visibility is a critical feature of a customer portal such as K+N Login. The portal reports and summarizes important supply chain events and generates exception alerts in cases of critical plan changes or expected or actual service interruptions. In the service of shippers, the portal provides information on the location and status of all products shipped worldwide and across all transportation modes, to allow them to manage them down to the purchase order and item level. The portal's event manager releases a notification message to the appropriate end users once a status or key process step has been reached or is about to be reached. The system also generates a confirmation or pre-advice when conditions set by business parameters designed by clients are reached. The portal also has an escalation mechanism that can identify plan changes and potential or actual service disruptions. If an event is overdue, the escalation mechanism will generate alerts to accelerate the response time of the appropriate parties, and thus, the system is assisting these clients in avoiding complaints from their customers and additional costs they may incur due to product delivery delays.

The portal also assists K+N clients in becoming more effective shipment and logistics planners. The portal has tools that consider a variety of cost factors --- such as transport, handling, and inventory --- in determining budgets. Planners can create and streamline operational plans using information on multiple logistics variables. The portal's interactive delivery planning (IDP) features enables on-line planning, and supports delivery planning and business processes for FCL (full container load) and LCL (less than container load) seafreight shipments. Shipping forecasts based on cargo arrivals and departures can be generated. Deliveries can be prioritized base on the need for a particular product. The portal's booking tool enables clients to place bookings more flexibly. Clients may submit shipping instructions and request equipment, advise pick-up addresses, and obtain cargo-readiness dates. Data collected by the portal can also help clients evaluate the performance of their supply chain trading partners and thus, assist them in deciding whether or not to continue their relationships or contracts with these third parties.

K+N Login has SAP Business Objects integrated into it providing portal members with digital reporting tools --- dynamic performance reports/scorecards, volume statistics, freight spend reports, leadtime reports, and fill reports. A built-in portal dashboard presents end users with an overview of logistics activities and order processes in their respective supply chain. Business intelligence tools enable end users to "data mine" collected logistics data for effective planning and decision making.

K+N PharmaChain and Cargo 2000

Because of the complexity involved in logistics operations, this industry is ideal for creating Web-enabled value network electronic environments that can accommodate all necessary entities and participants involved in the process of moving physical goods by land, sea, and air. The PharmaChain solution is integrated with another such Web-enabled environment called "Cargo 2000" (K+N, 2015b). Data captured by PharmaChain is integrated with Cargo 2000.

Terry Sell from Pharma and Temperature Controlled Airfreight Services – North America, K+N, shared this: "…And then we also want to make sure it [PharmaChain] was integrating within our systems. Our visibility system, KN Login, and also it also interacted with the other Cargo 2000 systems which is an industry wide system that gives us information and data so we can match everything up…."

"….We needed to make sure that we had our visibility system in place interacting with industry systems, the Cargo 2000 which gives us data and information, and make sure that that worked with our technology provider with their servers as well so that we could go into the actual monitoring process…." (RFIDJ, Live! Transcript, 2015).

Cargo 2000 is a collaborative initiative of over 35 of the world's leading airlines, forwarders, and third parties involved in air freight services under the auspices of the International Air Transport Association (IATA) (K+N, 2015b). In response to customer demand for high level of service not previously attained in the air freight industry, Cargo 2000 seeks to create shipping process steps and interfaces for the exchange of shipment data among all parties involved and ensure that door-to-door delivery can be planned precisely and monitored using a master operating plan (MOP). Cargo 2000 consists of a three-pronged approach: planning, controlling, and reporting. In the planning step, the MOP involves calculating a shipment cycle based on the process framework, which subsequently creates a route map. This map defines the "latest by" times for the completion of key processes along the transport chain. All firms involved in a shipment collaboratively plan a route map using the standard data interfaces provided by Cargo 2000 which seamlessly combine the route maps of carrier and forwarder.

In the controlling step, the agreed upon route map is issued and the shipment is monitored against this map from origin to destination. The IT systems of both carrier and forwarder are linked to the Cargo 2000 system and are updated when a milestone is completed. Cargo 2000 generates alerts whenever there is a deviation from the route map. This instigates communication between the forwarder/carrier and the shipper/consignee to enable corrective measures to bring the shipment back on schedule. If the delay is considerable and the original plan cannot be followed, then, a new delivery schedule is calculated and the route map adjusted. Exception codes are entered into the Cargo 2000 system to record causes and responsibilities for the shipment delay.

In the reporting step, it is important to establish whether or not the delivery promise was kept and to document reasons when it is not. Cargo 2000 members use standardized procedures and exception codes in reporting their performance. Data submitted by the members are the basis of monthly reports detailing the most frequent causes and responsibilities for shipment delays.

2)Action and social consequences of IT

Moving "cold chain" pharmaceutical products demands thorough scientific knowledge of the product and the nature of the environments where it moves and is stored throughout the delivery journey. A second key requirement is the ability to

document data on the operating environments and establishing that they are scientifically sound. Cold chain engineers, packaging engineers, and logistics-related workers should understand these environmental conditions and product parameters better than any inspector. Guidance documents from regulatory agencies spell out valuable criteria for creating tests to ensure the products are protected while in transit and during short-term storage. These tests should accurately represent real-time and real-world shipping environments, primary and secondary shipping containers, transport and storage durations, seasons, and climatic zones. The global supply chain for pharmaceutical products usually include different transportation and several climatic zones, and land, air and water modes of transportation, each with their accompanying temperature fluctuations.

An information system supporting the documentation needs of the peculiar logistics requirements for pharmaceutical products needs to capture detailed records of stability data, geographical data (including climatic zones), shipping and storage durations at each point in transit, and contingency procedures for delivery delays, out-of-specification conditions or other unforeseen exception events.

Unlike the previous section that articulated social structure changes, "action" refers to very specific courses of action afforded by the PharmaChain solution for its end users. Terry Sell of K+N aptly described the existence of PharmaChain as providing K+N workers "proactive" action capabilities: "…A paradigm shift within our company is now we have the ability to act on things…." (RFIDJ, Live! Transcript, 2015).

One important consequence of PharmaChain is K+N's ability to reduce its product release time while in transit by fast-tracking product clearances: "….So if you have data and information that shows that your product is safe and effective, you can start to pre-clear that. You can start to prepare your downstream supply chain. So that's something where you don't have to wait until information is received from a data recording device that was placed on the freight. It's taken off after it has cleared customs, then they give it to the regulatory authorities, they approve it. You can start that process much more rapidly. So that's kind of an added benefit…."(RFIDJ, Live! Transcript, 2015).

Another key action possibility is the ability of K+N logistics workers to take corrective actions when there are deviations in the desired temperature levels of pharmaceutical products while in transit: "….When you're talking about if something does happen in transit, whether as a deviation in temperature on the product, now you can have immediate root cause analysis, and this is where it becomes another critical timing factor because if a deviation occurs, the typical deviation can take anywhere from 7 to 14 days to take and have a full deviation, full CAPA (i.e., corrective and preventive action) process complete. What that means is that is product that is not in the market for sale. So if it's in deviation status or needs to have a CAPA attached to it, …that item is placed in quarantine or in hold. So if you can speed up that deviation process and take it from 14 days down to 5 days, that has a profound impact, and again, making sure the market can get that product, making sure you can have cash coming in quicker because you're selling that product quicker…." …."(RFIDJ, Live! Transcript, 2015).

In the case of pharmaceutical products, information tracked on deviations from allowable temperature ranges is very important in deciding on the disposition of the products. When pharmaceutical product shipments run in the millions of dollars, acting expeditiously to save the shipment from wastage of outright disposal is a significant benefit for the shipper client of K+N:

"….But also, when you have a deviation, what's important here, if you have a deviation it doesn't necessarily mean that your product is no good. So if it's frozen, if it's a biologic product, you'll know very quickly that you have to have a disposal process or you're going to bring it back to the origin for disposal. If it's a product that has more stability to it, meaning that it can accept

outside of the refrigerated state, 2-8 C maybe to 10 C, then you have what's called time out of range, and you can measure and manage time out of range with this type of system, so you'll know exactly how long it was exposed to temperatures outside of the acceptable range, and then you can make a shelf life calculation…." (RFIDJ, Live! Transcript, 2015).

Another very important entity involved in the logistics process is the regulatory authority like the U.S. Food and Drug Administration (US/FDA). Regulatory agencies need to be apprised about the disposition of the pharmaceutical product shipments that may have been compromised: "…You can give your regulatory authorities, your partner overseas the information so they can make a business based decision. But having that makes it much easier to get these, get these problems cleared up and get it through the CAPA process. You have the ability to mitigate in-transit issues. So again if something is going wrong, if you start to see an alert come out saying hey we're trending too high, well, that's going to be information you can use to make a phone call, so that's how you can be proactive is when you see something happening in real time and it's not correct or doesn't look right, you can make the phone call to make sure things are right. You reduce the product losses. If we know something is not going right, we've got a 24/7 365 team that will sit and monitor these things. They do get push notifications, push alerts, push alarms, so again it is something where that team can help to reduce product loss, and then again, anytime you have information or data, you can help that to drive business decisions…. Are you using the right airlines? Are you using the right process? Can you optimize your packaging? So these are [some things] to consider." (RFIDJ, Live! Transcript, 2015).

Going back to PharmaChain's purpose, which is temperature tracking, mitigating actions can be taken by the appropriate workers --- in the case of K+N, this would be CareTeam members --- if they have the right information at the right time about the disposition of the pharmaceutical product shipments.

Terry Sell once again shared: "So if we look at the outputs this is, again, we're talking about the ambient temperature outside of a packaging system. So it could be a container, it could be a passive palate shipper, insulated shipper with gel packs, but this would be what the actual shipping system is exposed to, and this is the actual product temperature, so you can have a lot of good data from that. GPS. Also make sure you see what's going on from the GPS perspective. What is your trucker doing, what routes is he taking? Is he taking a consistent route? If it's high value do you want him taking a consistent route? Do you want him changing routes? So these are all things we can monitor and start to measure as well. The push notifications, so again, talking about having our 24/7/365 CareTeam. They're getting the alerts, temperature alarm. So what are they going to do about it? How are they going to react upon it? Again, we can build processes based upon that as well. So these are some things that are outputs. So, when we talk about the alerts, not only do we get the alerts and the alarms, we can notate that in the system, so it is something where we can say ok we had an alarm on this sensor, temperature was above the upper threshold for 15 minutes, and then say see details. That's where you can have a corrective measure in there, so when you have a deviation your quality departments at your customers' companies will pull that open, they'll see what the corrective measure was. It gives them information again to make that immediate decision whether or not you know they can close up the CAPA (corrective and preventive action) based upon that. We also talked about how deviations can be measured, the amount of time. So you have the amount of time out of range, you have where it happened. So, these are all things that we can start to measure and monitor and give it information to customers so they can make again business decisions --- so it's very powerful. And, then, importantly is when we talk about the integration of Cargo 2000 feeds. All these three that are codes here, these are Cargo 2000 feeds. And what that does is it gives who had control of that shipment, where was that shipment

in the transport process. So, you've got the temperature information here, you get the dates and times here, now you've got the ownership here. So, when you're talking about who was the stakeholder that had a challenge, whether it was on the aircraft, aircraft departed, it arrived here, was there something that went wrong here? This is what is really powerful is when you can start taking all of the data and crunching it together to create really good information and giving that to your customers so that they can see how they can improve their process. What is going right in the process and what is trending wrong? So even if the packaging is successful, the product was safe, we might find something where we're trending wrong. What's going on there? So again it's using data and information and using it in a good format to try and create business decisions and evaluate where your risk is and where your risk could be. Has something changed?" (RFIDJ, Live! Transcript, 2015).

3) Measures of success

K+N's success in providing PharmaChain can be measured in a number of ways. K+N has enabled pharmaceutical supply chain visibility and help clients manage shipments. The firm's notable CareTeam has facilitated proactive remedial action to protect shipments in cases where established temperature thresholds, for instance, were violated or when shipment deliveries were delayed. K+N has also provided their clients timely, complete, and accurate information to enable them to make the right business decisions concerning their shipments, should they have to supplement or override CareTeam decisions. K+N has reduced product release time and accelerated the movement of the pharmaceutical goods through all clearances points. K+N has been able to fulfill their delivery promises and ensured that products arrive at destination points in a form useful to end customers. In the very end, K+N has helped their clients (shippers) reduce their overall shipping costs, while delivering high-quality specialized logistics services.

Terry Sell, Pharma and Temperature Controlled Airfreight Services, K+N shared this:
"So in summary, with the enabled… enabling of the visibility system with our technology provider, we have increased the visibility and control over shipments. We have been able to mitigate in-transit issues. We've had active containers meaning they're actively controlled containers mechanically fail. We've been able to catch that, and it is something once we've caught that we have a plan in place to combat that. So we've found a mitigation strategy for mechanical failure. We're able to help people avoid cost. So are they doing too much? Are they overshooting from a patching perspective, making it too robust? Are we right sizing? So this is where we have to help them to make right business decisions based upon data because in this industry it is based upon scientific rationalization. You can't do it just because you think it's going to be the best way to go. If you can prove it, and you can prove internally to the quality department and the regulatory authorities, that's where you have to be. Reduce the product release time, again, so with that pre-clearance, giving them the higher confidence interval that their product is safe, and when they do have their data log or stuff they're pulling off which is reactive, when they do download that information it is going to be exactly what we told them it's going to be, so giving them that confidence, increased confidence that they can begin the downstream pre clearance process. We talked enough about CAPA, but it is something immediate root cause analysis. So again taking that 14 days down to 5 days. That's very critical for them to get the product to market, and then making sure that the patient, again this always has to come back to the patient, so making sure that the patient gets the product in the right condition at the right time and also giving these companies better information and data to support business decisions. So that's, again, we've had a real positive experience with our technology partner Cart Essence, we've had a real positive experience with some of our

customers who have adapted or have adopted this technology, and we continue to see more and more customers wanting this. So as they understand what the value is, as they understand what we can give them in terms of information and data, if we're talking about risk mitigation, risk minimization, you know… these are the kind of things that they want to see. So with that being said I thought I'd just pass these around very quickly if you'd like to see the actual sensors that go on shipments. And again, nothing… this is not earth shattering technology. It's actually simple technology by design, but it is highly effective, and it's having the entire plan in place with the technology provider on how to deploy this…." (RFIDJ, Live! Transcript, 2015).

CONCLUSIONS

This study features the contextualization of our knowledge around the use and effects of information systems in firms within the specific context of a startup firm offering a beer inventory management solution, SteadyServ, and a global logistics firm specializing in pharmaceutical cold chain shipment deliveries, both using IOT-enabled information systems. This qualititative analysis has woven functional affordances into the relationships among the subsystems of the socio-technical work systems (i.e, iKeg solution in SteadyServ and the PharmaChain solution in K+N). This case study's data is based primarily on transcripts of talks given by key executives from the two firms that have presented in the annual RFID Journal Live! Conference in April 2015 where they described and explained their respective firm's IT system deployment experience. Based on this primary data and secondary data from published sources, evidence is presented for the socio-technical conditions that allow the material properties of information systems to emerge in order to create "functional affordances" needed for IOT/sensor-enabled product monitoring. This research project identifies the appropriation mediators needed in the use of the information systems in order to realize the built-in affordances of these systems (Wheeler & Valacich, 1996). These mediators consist of structure, action goals, user characteristics, and task characteristics required within the context of product monitoring for beer inventory management and temperature control tracking for pharmaceutical goods shipment.

Of great interest here is the deployment of IOT-based technologies because of the potential for creating innovative services that include data analytics capabilities backed up by cloud-based services used to produce actionable information needed for more effective supply chain management operations. Newly emerging innovations like IOT will create options for affordances if researchers could persevere in their understanding of these information systems and the functional affordances arising from their interpretation and use. The two case studies also highlighted the use of information technologies that have very specific use in terms of the needs addressed by the IOT initiative. The Tata Consultancy Group identified the four top areas for IOT applications based on the data the firm obtained from a global sample of firms: premises monitoring, product monitoring, supply chain monitoring, and customer monitoring (Tata Consultancy Report, 2015). The two case studies primarily highlighted product monitoring initiatives by the two firms.

Understanding and awareness of the affordances provided by these IOT-enabled information systems could be useful not only theoretically in terms of analyzing how technical and social subsystems interact and broadening the base of application of the three theoretical frameworks used here. There is a practical benefit as well in terms of gaining insight into creating explicit criteria in selecting hardware and software components from technology vendors, or, more specifically, RFID and sensor vendors, in order to ensure the realization of desired functional affordances.

REFERENCES

References available upon request.