Association for Information Systems
AIS Electronic Library (AISeL)

DIGIT 2019 Proceedings

Diffusion Interest Group In Information Technology

12-15-2019

A Systems Model of IS Success Using Agent-Based Simulation

Jennifer Jewer
Memorial University, jenniferj@mun.ca

Joerg Evermann
Memorial University, jevermann@mun.ca

A Systems Model of IS Success Using Agent-Based Simulation

Research-in-Progress

Jennifer Jewer
Memorial University
jenniferj@mun.ca

Joerg Evermann
Memorial University
jevermann@mun.ca

Abstract

Measuring the value realized from information systems (IS) and understanding the factors which influence success are critical to organizations. DeLone and McLean's IS success model is one of the most well-known theories in IS literature; however, the model has been primarily examined from a variance perspective and this offers an opportunity to explore ways to improve its explanatory capability. This study presents an agent-based simulation model of the IS success model based on complex adaptive systems theory. Principles from the unified theory of acceptance and use of technology, social learning theory, and expectation disconfirmation theory are incorporated in the model to capture individual behavior and interactions, feedback loops and emergent effects. The model is under development in the context of a hospital surge management system with the goal of extending the IS success model and to improve understanding of IS success in a complex digital ecosystem. The next steps are to calibrate the model and to conduct multiple case studies.

Keywords: IT adoption, IS success, systems theory, complex adaptive systems, agent-based modeling

A Systems Model of IS Success Using Agent-Based Simulation

Research-in-Progress

Introduction

With the increasing costs of information systems (IS) and a focus on generating value from IS investments, organizations are interested in measuring the benefits realized from those investments and understanding the factors which influence success. DeLone and McLean's model of IS success (1992; 2003) is one of the most well-known theories in IS and it has helped increase the understanding of the nature of IS success (Petter et al., 2008). However, a review of studies which have applied the IS success model identified conflicting results (Petter et al., 2008).

IS success has primarily been examined from a variance perspective (Petter et al., 2008). A variance model focuses on the covariation between the dimensions to determine if a causal relationship exists. However, this poses limitations to what the IS success model can explain (Burton-Jones et al., 2015). For example, while a variance study might find a relationship between information quality and use at one point in time, a systems study could show how the relationship changes over time, and how use and benefits emerge and evolve over time through planned and unplanned changes, thereby examining the effects within the complex digital ecosystem. The focus on the variance view in the IS literature is not limited to the IS success model. About 80% of the articles in leading IS journals on IT impact employ a variance view (Paré et al., 2008) and there have been calls to study IS theories from different perspectives (e.g. Markus & Robey, 1988; Nan, 2011; Wirth et al., 2014; Nan et al., 2014; Burton-Jones et al., 2015; Demetis & Lee, 2016;2017; Ortiz de Guinea & Webster, 2017; Alter, 2017; 2018). Markus & Robey (1988) suggested that the lack of consistent findings in IT impact research is due to the focus on deterministic theories (i.e. variance), neglecting process theories and the emergent perspective of systems theories. They proposed that this variance focus limits the understanding gained from the theories as they do not consider the dynamic relationship between the actors, technology and the environment. More recently, Alter (2017; 2018) criticized the inherently reductionist variance approach to IT adoption research, suggesting that it does not consider the larger digital ecosystem.

The systems perspective in particular has been proposed as a way to extend and offer alternative theories in IS research to ultimately improve understanding. Nan (2011) presented a complex adaptive systems (CAS) model of IT use to capture bottom-up processes as a way of improving understanding of collective-level use and outcomes. Then in 2014, Nan et al. developed a theoretical model of innovation diffusion using CAS theory. Demetis & Lee (2016;2017) used the systems perspective to explore the role of IT in anti-money laundering in order to demonstrate how IS research could be informed by a systems perspective. Wirth et al. (2014) proposed the use of work systems theory (WST) in technology acceptance research as a way to advance understanding of work practices and the relationships between work practices, participants and IT. Also using WST, Alter (2017; 2018) presented a new theory of IT innovation, adoption and adaptation in order to examine the post-adoption environment and how adoption occurs and how it may evolve over time.

The IS success model fundamentally shares the characteristics of variance, process and systems approaches and is suited to examination from multiple perspectives. In fact, DeLone and McLean (1992) intended the IS success model to have both variance and process considerations. Seddon (1997) criticized the inclusion of process and variance considerations; however, DeLone and McLean (2003) responded that this was one of the strengths of the model. Furthermore, DeLone and McLean (2003) acknowledge the importance of feedback effects in IS success (a characteristic of systems theory), but few have examined such effects (Burton-Jones et al., 2015). In a conceptual study, Burton-Jones et al. (2015) suggested that a systems perspective of IS success, examining the interacting parts and emergent properties of the model, revealed underlying problems in the model, such as the feedback effect, and that a systems perspective offered opportunities to examine such problems. They proposed that the organizational system, consisting of the IS and users, interact, which can lead to changes such as individual-level benefits realized from systems use. Furthermore, that organizational-level benefits can emerge out of these interactions.

Building on Burton-Jones et al.'s (2015) conceptual model of a systems perspective of IS success and Nan's (2011) CAS model of IT use, this study presents an agent-based simulation (ABS) model of IS success based on CAS theory. We examine, through an ABS model that computationally represents a CAS perspective of IS success, what IS success means, how it occurs, and the emergent phenomena that can occur. CAS theory incorporates three inter-related constructs – agents, interactions and the environment – to describe the behavior and associated outcomes of a set of interacting agents within a defined environment. It analyzes emergent phenomena without abstracting away interdependencies and interactions. In this study, CAS provides the theoretical lens for the process by which individual-level interactions and use create individual benefits and collaboratively create collective use and collective benefits. Using an ABS model, we explore how organizational benefits emerge from individual use and benefits, and the effect of benefits on use over time (feedback). In addition to the effects of the IS success elements (i.e. systems quality, information quality and service quality) on use and ultimately on benefits. An advantage of using ABS versus a variance-based approach is that it enables us to examine the impact of social interactions of multiple agents through social influence and social learning, and the influence of organizational actions and commitment. We feel that an increased understanding of these social influences over time offers us an opportunity for making the most significant contribution. A longitudinal study is in progress to examine the ABS model of IS success in the context of the implementation of a hospital surge management system at a rural community hospital emergency department (ED). We begin with a brief introduction of the IS success model, CAS and ABS. Next, the research context and the current state of the CAS-based ABS model is presented, followed by next steps and conclusion.

Literature Review

IS Success Model

DeLone & McLean first developed the IS success model in 1992. In 2003, DeLone & McLean presented a revised model (Figure 1). The model proposes 6 dimensions of success that are interrelated and that influence the success of the system. The dimensions of system, information and service quality influence intention to use, use and user satisfaction. A two-way relationship between use and user satisfaction is proposed and these dimensions both influence benefits. Finally, there is a feedback loop in the model with benefits influencing use and user satisfaction.

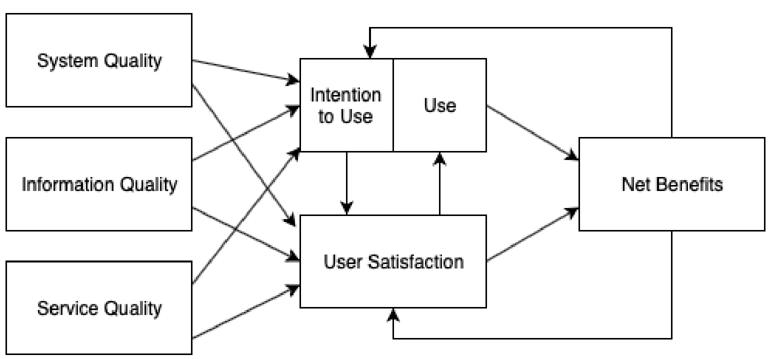

Figure 1. Updated DeLone & McLean IS Success Model (2003)

Complex Adaptive Systems

CAS theory refers to agents as the basic units of decision making and describes the capabilities of individual agents through IF-THEN statements. These represent the behavioral rules of the agents and are determined by theory. Learning and adaptation occurs over time (Holland, 1995). Holland (1995) defines CAS as:

> *"systems composed of interacting agents described in terms of rules. These agents adapt by changing their rules as experience accumulates. In CAS, a major part of the environment of any given adaptive agent consists of other adaptive agents, so that a portion of any agent's efforts at adaptation is spent adapting to other adaptive agents…To understand CAS we must understand these ever-changing patterns" (p. 10).*

There are three key characteristics of CAS: evolution, aggregate behavior, and anticipation (Holland, 1992). First, over time, the agents evolve, the "ability of the parts to adapt or learn is the pivotal characteristic of CAS" (Holland, 1992, p. 19). Second, aggregate behavior is exhibited, and it is an understanding of the aggregate behavior that is the focus of CAS. This aggregate behavior is not just a sum of the actions of the parts. CAS theory enables the examination of how aggregate behavior emerges from the interactions of the parts. Third, CAS anticipates. "In seeking to adapt to changing circumstance, the parts can be thought of as developing rules that anticipate the consequences of certain responses" (Holland, 1992, p. 20). This adaptation can take place over different time periods (months to years, hours to days, etc.).

Typical examples of CAS include the immune system and central nervous system (Holland, 1995); however, CAS theory has been applied to areas in IS research, for example to IT supported team or organizational processes (Canessa & Riolo, 2006; Curseu, 2006; Raghu et al., 2004), IT-enabled organizational learning (Kane & Alavi, 2007), agile software development (Vidgen & Wang, 2009), bottom-up IT use (Nan, 2011), and innovation diffusion (Nan et al., 2014). The application of CAS theory to these IS domains has enabled modeling the complexities of the underlying processes and led to greater insights. However, to date, no studies have applied CAS theory to the IS success model. That is the focus of this study through the use of ABS as the analytical tool to represent the CAS model.

Agent-Based Simulation

ABS is a method to model, explain, and predict the state and behavior of a set of real organizational actors (agents) and organizational artefacts in software. An agent in ABS is typically modeled using three aspects. First, agents have mutable characteristics (state variables) such as perceived information quality, performance expectancy, satisfaction, etc. Second, agents have immutable characteristics (parameters), for example the likelihood or rate with which an agent changes values of a state variable based on some input. Third, agents can observe and act on other agents and artefacts. This includes behavioral rules, which may be static or adaptable. Being able to capture social behavior of agents in this way is typically an important aspect in ABS and one of the main reasons to use it as a research method. For these reasons, ABS models have been applied in the innovation diffusion domain (see Kiesling, Gunther, Stummer & Wakolbinger (2011) for a review).

One key ability of ABS is the ability to identify emergent behavior of the aggregate of agents and artefacts. For example, when modelling the IS success model, one may identify aggregate/organizational levels of use of the IS that arise from the social interactions of multiple agents, and that are not a property of any single agent. The key criterion for the ability to identify such emergent behavior is it's a-priori definition: One cannot identify what one has not defined. The example of aggregate use admits many ways in which to define this, for example as the mean or maximum use intensity of all agents, or any conceivable complex aggregate function. Another advantage of ABS over other research methods is that feedback loops can be captured easily. That is, ABS typically simulates the behavior of a system of agents over multiple time periods and can thus capture even non-linear feedback loops. Using the example of the IS success model, the use of an IS has, through the realized benefits, a likely impact on the information quality of that system, on the skill level of the agents, and the future intention to use the system again. Feedback loops may lead to emergent behavior (patterns) over time, which are difficult to predict a-priori. The ability to model these unanticipated and sometimes counterintuitive outcomes is a distinct advantage of the ABS approach.

The theoretical usefulness of an ABS rests on behavior exhibited by the model that has not yet been observed empirically. In other words, the ABS can make theoretically well-founded predictions that can inform future empirical work. After all, it is itself based on theory. The practical usefulness of an ABS rests on the ability to simulate changes, such as management interventions, and identify the likely effects on the system's properties.

Research Context

This study takes place at a rural, 80-bed hospital that is implementing an ED surge management system. ED overcrowding is a major issue in Canada as EDs are facing some of the longest wait times compared to other industrialized countries (Affleck et al., 2013; The Commonwealth Fund, 2010). The surge-management system is designed to enable frontline workers to anticipate and mitigate surges in patient volume and to respond accordingly. The system consists of a digital whiteboard application which will be installed in the nursing station in the ED. Applicable staff in the hospital will also be able to access the system through a smartphone app and will receive notifications of surge levels and associated actions through the app. The ED setting differs from other non-health contexts and even from other settings in the hospital. In the ED there are distinct team-based duties and unique roles (i.e. physician, nurse, nurse practitioner, paramedic, clinical and non-clinical manager, and clerk). The surge management system is common to all staff and affects the work of all staff, suggesting that individual and organizational benefits may strongly depend on the interplay between actors. The ED staff's existing teams and groups provide for a complex web of professional, social, and power relationships that will affect system attitudes and system use in complex ways. Additionally, the ED is a fast-paced environment with high visibility of other actors' actions, lending further importance to actor interactions. These characteristics make ABS the preferred choice for understanding the dynamics in the ED.

The hospital has implemented a manual version of the system and is preparing to implement the digital whiteboard system and app in the next few months. The surge management system will use data from the hospital IS and manual entry to perform real-time analysis using algorithms to predict patient flow and to calculate a surge level score. Each score has a set of prescribed actions to manage patient flow. For example, at level 5, actions include "Transfer boarded admitted patients to assigned inpatient beds immediately" and "Notify charge nurse on accepting unit to plan for a 30-minute transfer of admissions". Note that our notion of "IS" in this study is not confined to the software and hardware artefact itself, but encompasses the wider work system with its prescribed behavior rules based on the recommendations of the software system.

Systems Model of IS Success

Complex Adaptive Systems Model of IS Success

Using CAS theory as the overarching framework we are creating an ABS model of IS success using the building blocks of CAS - agents, their interactions, and the environment. The model incorporates the evolutionary and anticipatory nature of the system and it models aggregate behavior. We incorporate principles from the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003), social learning theory (Bandura & Walters, 1977) and expectation disconfirmation theory (Bhattacherjee, 2001) to capture agent behavior, interactions in the model, and the emergent effects. The environment is represented explicitly in the model through organizational commitment which is enacted through actions that the organization can take (i.e. improve the system and train staff). While our study is focused on the IS success model, we recognize that UTAUT is another prominent theory that explains intention and use and has been continuously shown to hold in a variety of studies (Williams et al., 2015). Further, the IS success model has been criticized for ignoring technology acceptance research (Wixom & Todd, 2005). For these reasons, we have included UTAUT in our initial CAS model. Ultimately, whether and how UTAUT concepts and relationships complement those of the IS success model is an empirical question that we hope to answer in part through the ABS results of the current study.

Agent-Based Simulation Model of IS Success

In our ABS, we have modelled human agents, the organization, the system, and their interactions. Figure 2 shows a diagram of the ABS model of IS success. All constructs from the DeLone & McLean model (i.e. Figure 1) are included in our ABS model (Figure 2) and are represented by parallelograms. The original intent of the model has been maintained; however, some of the relationships have been modified based on established theory in IS research, in particular UTAUT (Venkatesh et al., 2003) social learning theory (Bandura & Walters, 1977), and the expectation-confirmation gap theory that underlies service quality theory (Bhattacherjee, 2001). Table 1 shows modifications to the IS success model.

Direct Relationships in Original Model	Modifications with our ABS
Systems quality and use intention	Mediated by effort expectancy (UTAUT) (relationship supported by Wixom & Todd, 2005)
Information quality and use intention	Mediated by performance expectancy (UTAUT) (relationship supported by Wixom & Todd, 2005)
Service quality and use intention	No modification, relationship maintained
Systems quality, information quality and service quality and satisfaction	Satisfaction is an outcome of a gap between perceived benefit and performance expectancy (expectation disconfirmation theory)
Satisfaction and use/intention	No modification, relationship maintained
Satisfaction and benefits	Mediated by use/intention (UTAUT)
Use and benefits (individual and organizational)	No modification, relationship maintained
Feedback from benefits to use/intention	Feedback from individual benefits influences use/intention through the gap perceived in benefits received (expectation disconfirmation theory)
Additions to the Model	
Relationship between social influence and intention (UTAUT)	
Feedback between use intensity and skill level	
Feedback between social learning and skill level (social learning theory)	
Feedback - benefits depend on the average intensity of use weighted by the skill of agents	
Feedback between a benefits gap perceived at the organizational level resulting in staff training and system improvements (Clark et al., 2007). Staff training influences skill level and effort expectancy (UTAUT), while system improvements influence information, system and service quality	

Table 1. Comparison of New ABS Model to Original IS Success Model

In Figure 2 solid line links indicate interactions and dashed lines indicate feedback effects. State variables of human agents are shown in white, those of the system are have diagonal hatching, and those of the organization have a polka-dot pattern. While individual and organizational benefit may be seen as properties of the agents and the organization, we have modelled these with the IS, as the IS creates these benefits through its use by agents. Human agents are of different types, representing ED nurses, ED physicians, primary care paramedics, etc. Agents have links to other agents. These links are stronger within agent types than across agent types. Agent links are used to model the social effects on attitude, i.e. agents observe other agents' attitudes (indicated by the curved dashed line to "social influence") and this affects their own intention to use the system (feedback). This is based on the concept of social influence from UTAUT (Venkatesh et al., 2003). Agent links are also used to model social learning. Agents observe other agents' use of the system (indicated by the curved dashed line to "social learning") and that affects their skill level through a feedback effect (social learning; Bandura & Walters, 1977). These two social aspects are shown using the cloud symbol in Figure 2. Another feedback loop is from intensity of use to skills, indicating that high use maintains proficiency/skills while lack of use allows skills to deteriorate.

Agent state variables are from the IS success model (perceived information quality, perceived systems quality and perceived service quality), from UTAUT (effort expectancy, performance expectancy, facilitating conditions), and from expectation disconfirmation theory (the gap between expected performance and perceived benefits; Bhattacherjee, 2001). Perceived information quality and perceived systems quality are linked to performance expectancy and effort expectancy. This inclusion of object-based beliefs (information and systems quality) and behavioral beliefs (performance and effort expectancy) was supported by Wixom & Todd (2005) who argued that the relationships between use and benefits can only be understood by examining not only the direct effects from object-based beliefs about system characteristics, but also by examining the mediating factors related to behavioral beliefs. They went on to say that these object-based and behavioral beliefs "represent complementary steps in a causal chain from key characteristics of system design, to beliefs and expectations about outcomes that ultimately determine usage" (p. 91). For example, if the information is perceived as accurate and complete, and/or the system is perceived as functional and reliable, then this impacts the degree to which the belief that using the system will help job performance and/or the degree of ease of use. Additionally, the agent state variable skill level is linked to effort expectancy (i.e. similar to the experience moderator in UTAUT). As skill with the system increases, the amount of effort expected to use the system should decrease.

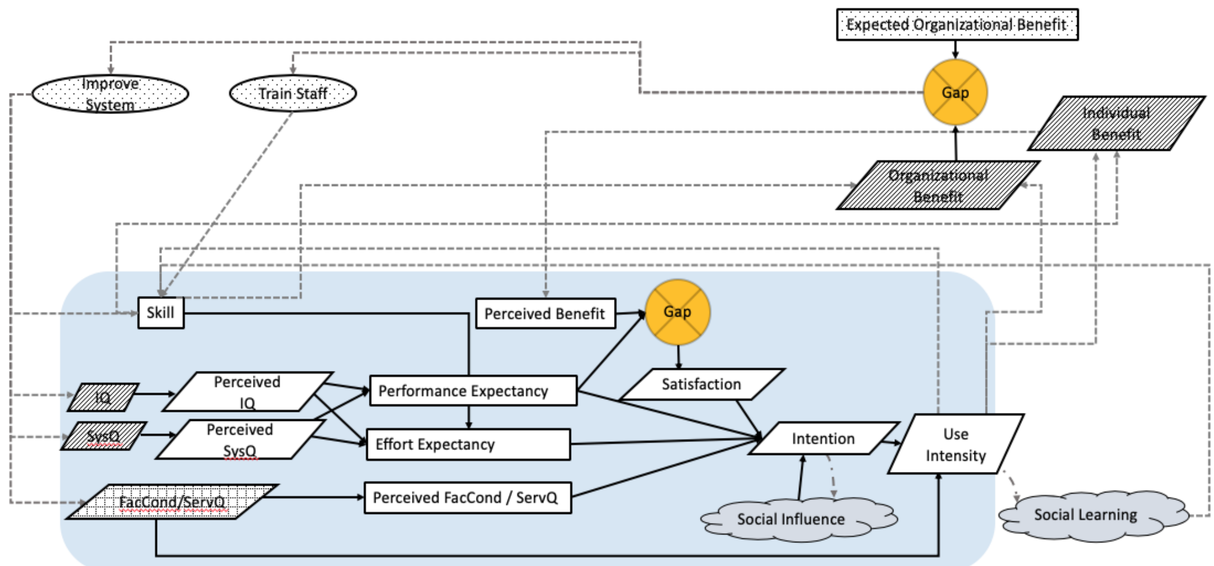

Figure 2. Agent-Based Simulation Model of IS Success

We have modelled facilitating conditions/service quality (shaded with dotted grid in Figure 2) as both an agent and an organization state variable. It is an agent variable because it can be a property of the system (i.e. system downtime, compatible with other systems), and it is also a state variable of the organization, even though in UTAUT and IS success it is modelled as an individual variable, because organizations can provide means to encourage or discourage use of a system in many different ways (i.e. support or manuals available), but these are typically provided to all agents. Facilitating conditions/service quality is linked directly to use intensity; however, perceived facilitating conditions/service quality, an agent state variable, is linked to intention (IS success model). For example, the perception that support services are available will positively impact intention, but if the support services are not actually available even though they were perceived as such, that will negatively impact use.

In our ABS, all links between state variables are linear functions depending on the parameters of individual agents. While many other link functions are conceivable, IS research has generally assumed linear functions only. The values of agent parameters are assigned probabilistically and every time a link is simulated, the specific value for that time-step is drawn from a probability distribution governed by the agent parameter. For example, each agent's parameter governing the link between performance expectancy and intention is drawn from a Gaussian distribution with mean of 0.7. A particular agent might then have a value of 0.65 for that parameter. When simulating each time-step, the actual influence of performance expectancy on intention is drawn from a Gaussian distribution with mean 0.65 and may be 0.67.

From the use of the system by agents (i.e. by their intensity of use and their skill in using the system), the system creates benefits for the individual user and aggregate benefits for the organization as a whole. A key question that is not answered by the IS success model is how these benefits are created, i.e. what is the correct functional form for determining system benefits from use. Again, many linear or non-linear functions are conceivable. At this point, we have used two options. First, benefits depend on the average intensity of use weighted by the skill of each agent. Second, benefits occur only if each agent's intensity of use, weighted by its skill, is above a certain threshold level. For future research, we will explore other functions.

Each agent observes/perceives its own individual benefit as a feedback loop. A gap (disconfirmation of beliefs) between the perceived benefit and performance expectancy impacts satisfaction which in turn influences the intent to use the system (expectation disconfirmation theory and IS success feedback loop). A negative gap (i.e. underperformance) between organizational benefits and expected organizational benefit results in an increase in organizational commitment through further staff training and/or improvements to the system (i.e. organizational involvement in corrective actions; Clark et al., 2007). The two polka-dot patterned ovals in Figure 2 represent these actions that the organization can take. The organization can decide to increase its commitment to the IS by improving the system, which in turn impacts the information quality, system quality, and facilitating conditions/service quality (i.e. feedback loop). When the system is adapted, the skill level of agents is likely impacted negatively, as system changes may invalidate some of their knowledge/skills. The organization can also show commitment by training their agents, thus affecting their skill level. We have modelled these effects probabilistically. For example, when the organization decides to train its agents, each agent's skill level is increased with a certain probability, but there is a (lesser) probability by which it can decrease. These actions are influenced primarily by the perception that the system is attaining the anticipated benefits (Clark et al., 2007).

Implementation, State of Work and Next Steps

At this stage in our research, the basic agent framework is defined and implemented. An important criterion for a valid ABS is that it should be bounded and stable. Bounded means that values of state variables do not diminish to zero (unless explicitly allowed by theory) or grow infinitely with time. Stability means that the system should not be chaotic, but its behavior may be cyclical or follow some other order. The ABS should also not be static, i.e. show no changes at all. We are currently adjusting our ABS parameters to ensure this necessary behavior. Through sensitivity analysis we will determine the upper bound by determining the point at which an increase in the value does not produce a noticeable impact on the process and outcomes. For example, if increasing satisfaction values to more than 50 does not produce noticeable impacts on the use process and outcomes, then we would use 50 to represent the state of being fully satisfied.

A critical step in creating a useful ABS is to calibrate the model to ensure internal validity. We are doing this using the findings from prior research and through this first study at the rural hospital. There are many design choices in the model itself, from the type of dependencies between variables, to the strengths of links between agents, and the various parameters involved in creating agents, IT systems, and organizations. To be trustworthy, and useful for deriving theoretically sound insights, an ABS has to be calibrated. Its parameters and modes of behavior have to be chosen in such a way that it replicates empirically observed behavior. Only then can one reliably extrapolate to as yet unknown behavior using an ABS. While bounded and stable behavior is necessary for a good ABS, an empirical calibration is sufficient for a theoretically useful ABS. We are currently identifying research that can aid in identifying known behavior with which to calibrate our model. Our intention is to conduct case studies at four additional hospital EDs which are implementing the same surge management system to test the usefulness of this CAS model of IS success. Our first study is in progress now, this will help to calibrate the model, and we will examine the external validity of the model through these longitudinal case studies. We will collect qualitative and quantitative data as the system is implemented and used at the hospital over the next year. This may lead to clarifications and improvements of the model.

Conclusion

In the absence of a systems perspective in IS research, we are exploring this CAS model as a complement to variance and process approaches to IS success. We present a CAS model of IS success in the context of a hospital ED surge management system, and use ABS as the analytical tool. The advantage of using systems modelling is that it enables us to capture the social behavior of users and the impacts, emergent behavior and feedback loops. These aspects are difficult to capture through variance or process approaches. Given the theoretical and practical significance of understanding the factors which lead to IS success, this study has the potential to make significant contributions as it provides a new conceptualization of IS success.

References

Affleck A, Parks P, Drummond A, et al. 2013. "Emergency department overcrowding and access block," *CJEM* (15:6):359-370.

Alter, S. 2017. "A Balanced Perspective on the Bright and Dark Sides of IT Based on a Systems Theory of IT Innovation, Adoption, and Adaptation," in *Proceedings of DIGIT 2017*.

Alter, S. 2018. "A Systems Theory of IT Innovation, Adoption, and Adaptation," in *Proceedings of the Twenty-Sixth European Conference on Information Systems (ECIS2018),* Portsmouth, UK.

Bandura, A., & Walters, R. H. 1977. *Social learning theory (Vol. 1)*. Englewood Cliffs, NJ: Prentice-hall.

Bhattacherjee, A. 2001. "Understanding information systems continuance: an expectation-confirmation model," *MIS Quarterly*, 351-370.

Burton-Jones, A., McLean, E. R., & Monod, E. 2015. "Theoretical perspectives in IS research: From variance and process to conceptual latitude and conceptual fit," *European Journal of Information Systems*, 24(6), 664-679.

Canessa, E., and Riolo, R. L. 2006. "An Agent-Based Model of the Impact of Computer-Mediated Communication on Organizational Culture and Performance: An Example of the Application of Complex Systems Analysis Tools to the Study of CIS," *Journal of Information Technology* (21:4), pp. 272-283.

Clark, T. D., Jones, M. C., & Armstrong, C. P. 2007. "The dynamic structure of management support systems: theory development, research focus, and direction," *MIS Quarterly*, 31(3), 579-615.

Curseu, P. L. 2006. "Emergent States in Virtual Teams: A Complex Adaptive Systems Perspective," *Journal of Information Technology* (21:4), pp. 249-261.

DeLone, W. H., and McLean, E. R. 1992. "Information systems success: The quest for the dependent variable," *Information Systems Research*, 3(1), 60-95.

DeLone, W. H., and McLean, E. R. 2003. "The DeLone and McLean model of information systems success: A ten-year update," *Journal of Management Information Systems*, 19(4), 9-30.

Demetis, D., and Lee, A.S. 2016. "Crafting theory to satisfy the requirements of systems science," *Information and Organization*, 26, 116–126.

Demetis, D.S. and Lee, A.S. 2017. "Taking the first step with systems theorizing in information systems: A response," *Information and Organization* 27, 163–170.

Holland, J. H. 1992. Complex adaptive systems. *Daedalus*, 121(1), 17-30.

Holland, J. H. 1995. *Hidden Order: How Adaptation Builds Complexity*, Reading, MA: Perseus Books.

Kane, G. C., and Alavi, M. 2007. "Information Technology and Organizational Learning: An Investigation of Exploration and Exploitation Processes," *Organization Science* (18:5), pp. 796-812.

Kiesling, E., Günther, M., Stummer, C., & Wakolbinger, L. M. 2012. "Agent-based simulation of innovation diffusion: a review," *Central European Journal of Operations Research*, 20(2), 183-230.

Markus, L. and Robey, D. 1988. "Information technology and organizational change: causal structure in theory and research," *Management Science*, 34(5), 583–598.

Nan, N. 2011. "Capturing bottom-up information technology use processes: A complex adaptive systems model," *MIS Quarterly*, 35(2), 505-532.

Nan, N., Zmud, R., and Yetgin, E. 2014. "A complex adaptive systems perspective of innovation diffusion: an integrated theory and validated virtual laboratory," *Computational and Mathematical Organization Theory*, 20(1), 52-88.

Ortiz de Guinea, A. and Webster, J. 2017. "Combining variance and process in information systems research: Hybrid approaches," *Information and Organization*, 27(3), 144-162.

Paré, G., Bourdeau, S., Marsan, J., Nach, H., and Shuraida, S. 2008. "Re-examining the causal structure of information technology impact research," *European Journal of Information Systems*, 17(4), 403-416.

Petter, S., DeLone, W., & McLean, E. 2008. "Measuring information systems success: Models, dimensions, measures, and interrelationships," *European Journal of Information Systems*, 17(3), 236-263.

Raghu, T. S., Jayaraman, B., and Rao, H. R. 2004. "Toward an Integration of Agent-and Activity-Centric Approaches in Organizational Process Modeling: Incorporating Incentive Mechanisms," *Information Systems Research,* (15:4), pp. 316-335.

Seddon, P. B. 1997. "A respecification and extension of the DeLone and McLean model of IS success," *Information Systems Research*, 8(3), 240-253.

The Commonwealth Fund. 2010. *The commonwealth fund 2010 international health policy survey in eleven countrie*s. Available at: http://www.commonwealthfund.org/~/media/files/publications/chartbook/2010/pdf_2010_ihp_survey_chartpack_full_12022010.pdf . Accessed August 8, 2019.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. 2003. "User acceptance of information technology: Toward a unified view," *MIS quarterly*, 425-478.

Vidgen, R., and Wang, X. 2009. "Coevolving Systems and the Organization of Agile Software Development," *Information Systems Research,* (20:3), pp. 355-376.

Williams, M. D., Rana, N. P., & Dwivedi, Y. K. 2015. "The unified theory of acceptance and use of technology (UTAUT): a literature review," *Journal of Enterprise Information Management*, 28(3), 443-488.

Wixom, B. H., & Todd, P. A. 2005. "A theoretical integration of user satisfaction and technology acceptance," *Information Systems Research*, 16(1), 85-102.

Wirth, J., Laumer, S., Maier, C., and Weitzel, T. 2014. "Using a work system theory perspective to review 25 years of technology acceptance research: proposing a research agenda" in *Proceedings of DIGIT 2019*.