MIS Quarterly

THEORY AND REVIEW

CAPTURING BOTTOM-UP INFORMATION TECHNOLOGY USE PROCESSES: A COMPLEX ADAPTIVE SYSTEMS MODEL

Ning Nan
Michael F. Price College of Business, University of Oklahoma,
307 W. Brooks, Room 305D, Norman, OK 73019 U.S.A. {nnan@ou.edu}

Appendix A

Summary of the Literature

The studies are selected from all articles published in nine premium journals that regularly publish scholarly research on IT use: *MIS Quarterly, Information Systems Research, Organization Science, Management Science, Administrative Science Quarterly, Decision Sciences, Journal of Management Information Systems, IEEE Transactions on Engineering Management,* and *Database for Advances in Information Systems*.

Research Perspective	Description	Related Studies
Technology acceptance	This research relies on variance-based models to examine antecedents of initial and continued IT use. The antecedents include individual cognition such as perceived usefulness of a new IT system and organizational factors such as management influence.	Bhattacherjee and Sanford 2006; Cooper and Zmud 1990; Davis 1989; Davis et al 1989; Edmondson et al. 2001; Joshi 1991; Joshi et al. 1999; Kim and Malhotra 2005; Kraut et al. 1998; Leonard-Barton and Deschamps 1988; Limayem et al. 2007; Lucas et al. 1988; Robertson 1989; Sabherwal et al. 2006; Taylor and Todd 1992; Tyre and Hauptman 1992; Venkatesh et al. 2003; Venkatesh and Davis 2000; Venkatesh et al. 2008; Zhu and Kraemer 2005
Task technology fit	This research examines the correspondence between task requirements, individual abilities, and the functionality of an IT system. It highlights the importance of the alignment between the three aspects in inducing positive IT-enabled task performance.	Goodhue 1998; Goodhue and Thompson 1995; Zigurs et al. 1999
Planned change	This research seeks to identify the sequence of activities (often referred to as "phases") in a typical IT use process and to prescribe the stage models as plans for IT use management.	El Sawy 1985; Lassila and Brancheau 1999; Nelson and Cheney 1987; Raho et al. 1987

Research Perspective	Description	Related Studies
System dynamics	These studies employ system dynamics models to examine how the accumulative and marginal effects (i.e., stock and flow) of human cognition, such as learning and commitment to using a new technology, can affect IT use behaviors and organizational performance.	Black et al. 2004; Repenning 2002
Actor-network analysis	This research views IT use as social political processes and employs the actor-network framework to examine how ongoing negotiations among alliance (i.e., actor-networks) with heterogeneous political interests lead to alignment of interests, which eventually enables IT use.	Braa et al. 2004; Sarker et al. 2006; Walsham and Sahay 1999
Social construction of technology	This research assumes that IT use is neither determined by human actors nor technologies, but enacted through interactions between the two without *a priori* plans. It usually relies on case studies to capture IT use enactment processes.	Avgerou and McGrath 2007; Boudreau and Robey 2005; Davidson and Chismar 2007; Garud and Kumaraswamy 2005; Lapointe and Rivard 2005; Leonardi 2007; Lyytinen and Rose 2003; Majchrzak et al. 2000; Malhotra et al. 2001; Orlikowski 1996, 2000; Robey et al. 2002; Robey and Sahay 1996; Tyre and Orlikowski 1994; Volkoff et al. 2007

Appendix B

Progress of the Literature on IT Use

Critical to the research objective is identifying studies empirically analyzing bottom-up IT use processes. The studies included in the "bottom-up linkage" row were selected according to two criteria. First, they collected quantitative or qualitative data regarding both individual- and collective-level IT use patterns and outcomes. Second, they explicitly analyzed the linkage from the individual-level to the collective-level IT use patterns and outcomes. (Note: The numbering of the potential research areas corresponds to the legend in Figure 1 of the paper.

Research Area \ Research Perspective	Technology Acceptance	Task Technology Fit	Planned Change	System Dynamics	Actor– Network Analysis	Social Construction of IT
(1) Individual level IT use	Bhattacherjee and Sanford 2006; Davis 1989; Davis et al. 1989; Joshi 1991; Joshi et al. 1999; Kim and Malhotra 2005; Kraut et al. 1998; Leonard-Barton and Deschamps 1988; Lucas et al. 1988; Sabherwal et al. 2006; Taylor and Todd 1995; Venkatesh and Davis 2000; Venkatesh et al. 2003	Goodhue 1998; Goodhue and Thompson 1995	Nelson and Cheney 1987	Black et al. 2004; Repenning 2002		
(2) Collective level of IT use	Edmondson et al. 2001; Zhu and Kraemer 2005	Zigurs et al. 1999	El Sawy 1985; Lassila and Brancheau 1999; Raho et al. 1987			
(3) Interactions					Braa et al. 2004; Sarker et al. 2006; Walsham and Sahay 1999	Avgerou and McGrath 2007; Boudreau and Robey 2005; Davidson and Chismar 2007; Garud and Kumaraswamy 2005; Lapointe and Rivard 2005; Leonardi 2007; Lyytinen and Rose 2003; Majchrzak et al. 2000; Malhotra et al. 2001; Orlikowski 1996, 2000; Robey et al. 2002; Robey and Sahay 1996; Volkoff et al. 2007

Research Area \ Research Perspective	Technology Acceptance	Task Technology Fit	Planned Change	System Dynamics	Actor– Network Analysis	Social Construction of IT
(4) Dynamic patterns			El Sawy 1985; Lassila and Brancheau 1999; Nelson and heney 1987; Raho et al. 1987	Black et al. 2004; Repenning 2002	The same as the cell above	The same as the cell above
(5) Top-down linkage	Cooper and Zmud 1990; Kim and Malhotra 2005; Kraut et al. 1998; Leonard-Barton and Deschamps 1988; Sabherwal et al. 2006; Tyre and Hauptman 1992; Venkatesh and Davis 2000; Venkatesh et al. 2003; Zhu and Kraemer 2005		El Sawy 1985; Nelson and Cheney 1987			Avgerou and McGrath 2007; Boudreau and Robey 2005; Davidson and Chismar 2007; Garud and Kumaraswamy 2005; Orlikowski 1996, 2000; Robey and Sahay 1996
(6) Bottom-up linkage						Lapointe and Rivard 2005, 2007; Orlikowski 1996, 2000; Volkoff et al. 2007

Appendix C

Pseudo-Code of a Simulation Session

Create 53 employees (50 specialists, 2 managers, and 1 director)
Ask each employee {
    Set the 30-tuple, with each dimension takes a value of -1, 0, or 1 with equal probabilities
    Set learning rate p_1 = the learning rate treatment of the current simulation session
    If I am a manager
        [**Set** learning rate = 1.25 × p_1]
    If I am a director
        [**Set** learning rate = 1.5 × p_1]
    If the current workplace rigidity treatment = "rigidity"
        [form a tie with a randomly chosen superior]
    Else
        [form a tie with another randomly chosen employee]
}
Create the ITSS
Ask the ITSS {
    Set the 30-tuple, with each dimension takes a value of 0
    Set the flexibility p_2 = the ITSS flexibility treatment of the current simulation session
}
Create the work requirements
Ask the work requirements {
    Set the 30-tuple, with each dimension takes a value of -1, 0, or 1 with equal probabilities
}
Run one tick of the model clock {
    Ask the ITSS [adapts to the majority practices of employees]
    Ask each employee [learn from the ITSS and learn from each other (the order of these two actions is randomly determined)]
}
Repeat the "Run one tick of the model clock" procedure 12 times
Set assimilation of the ITSS = average (the proportion of identical values between the 30-tuples of the ITSS and the employees)
Set IT-based work performance = average (the proportion of identical values between the 30-tuples of the work requirements and the employees)

References

Avgerou, C., and McGrath, K. 2007. "Power, Rationality, and the Art of Living through Socio-Technical Change," *MIS Quarterly* (31:2), pp. 295-315.

Bhattacherjee, A., and Sanford, C. 2006. "Influence Processes for Information Technology Acceptance: An Elaboration Likelihood Model," *MIS Quarterly* (30:4), pp. 805-825.

Black, L. J., Carlile, P. R., and Repenning, N. P. 2004. "A Dynamic Theory of Expertise and Occupational Boundaries in New Technology Implementation: Building on Barley's Study of CT Scanning," *Administrative Science Quarterly* (49:4), pp. 572-607.

Boudreau, M.-C., and Robey, D. 2005. "Enacting Integrated Information Technology: A Human Agency Perspective," *Organization Science* (16:1), pp. 3-18.

Braa, J. R., Monteiro, E., and Sahay, S. 2004. "Networks of Action: Sustainable Health Information Systems across Developing Countries," *MIS Quarterly* (28:3), pp. 337-362.

Cooper, R. B., and Zmud, R. W. 1990. "Information Technology Implementation Research: A Technological Diffusion Approach," *Management Science* (36:2), pp. 123-139.

Davidson, E. J., and Chismar, W. G. 2007. "The Interaction of Institutionally Triggered and Technology-Triggered Social Structure Change: An Investigation of Computerized Physician Order Entry," *MIS Quarterly* (31:4), pp. 739-758.

Davis, F. D. 1989. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly* (13:3), pp. 319-339.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. 1989. "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science* (35:8), pp. 982-1003.

Edmondson, A. C., Bohmer, R. M., and Pisano, G. P. 2001. "Disrupted Routines: Team Learning and New Technology Implementation in Hospitals," *Administrative Science Quarterly* (46:4), pp. 685-716.

El Sawy, O. A. 1985. "Implementation by Cultural Infusion: An Approach for Managing the Introduction of Information Technologies," *MIS Quarterly* (9:2), pp. 131-140.

Garud, R., and Kumaraswamy, A. 2005. "Vicious and Virtuous Circles in the Management of Knowledge: The Case of Infosys Technologies," *MIS Quarterly* (29:1), pp. 9-33.

Goodhue, D. L. 1998. "Development and Measurement Validity of a Task-Technology Fit Instrument for User Evaluations of Information Systems," *Decision Sciences* (29:1), pp. 105-139.

Goodhue, D. L., and Thompson, R. L. 1995. "Task-Technology Fit and Individual Performance," *MIS Quarterly* (19:2), p 213-236.

Joshi, K. 1991. "A Model of Users' Perspective on Change: The Case of Information Systems Technology Implementation," *MIS Quarterly* (15:2), pp. 229-242.

Joshi, K., Joshi, K., and Lauer, T. W. 1999. "Transition and Change During the Implementation of A Computer-Based Manufacturing Process Planning System: An Analysis Using the Equity Implementation Model," *Engineering Management, IEEE Transactions on* (46:4), pp. 407-416.

Kim, S. S., and Malhotra, N. K. 2005. "A Longitudinal Model of Continued IS Use: An Integrative View of Four Mechanisms Underlying Postadoption Phenomena," *Management Science* (51:5), pp. 741-755.

Kraut, R. E., Rice, R. E., Cool, C., and Fish, R. S. 1998. "Varieties of Social Influence: The Role of Utility and Norms in the Success of a New Communication Medium," *Organization Science* (9:4), p 437-453.

Lapointe, L., and Rivard, S. 2005. "A Multilevel Model of Resistance to Information Technology Implementation," *MIS Quarterly* (29:3), pp. 461-491.

Lapointe, L., and Rivard, S. 2007. "A Triple Take on Information System Implementation," *Organization Science* (18:1), pp. 89-107.

Lassila, K. S., and Brancheau, J. C. 1999. "Adoption and Utilization of Commercial Software Packages: Exploring Utilization Equilibria, Transitions, Triggers, and Tracks," *Journal of Management Information Systems* (16:2), pp. 63-90.

Leonard-Barton, D., and Deschamps, I. 1988. "Managerial Influence in the Implementation of New Technology," *Management Science* (34:10), pp. 1252-1265.

Leonardi, P. M. 2007. "Activating the Informational Capabilities of Information Technology for Organizational Change," *Organization Science* (18:5), pp. 813-831.

Limayem, M., Hirt, S. G., and Cheung, C. M. K. 2007. "How Habit Limits the Predictive Power of Intention: The Case of Information Systems Continuance," *MIS Quarterly* (31:4), pp. 705-737.

Lucas, Jr., H. C., Walton, E. J., and Ginzberg, M. J. 1988. "Implementing Packaged Software," *MIS Quarterly* (12:4), pp. 537-549.

Lyytinen, K., and Rose, G. M. 2003. "The Disruptive Nature of Information Technology Innovations: The Case of Internet Computing in Systems Development Organizations," *MIS Quarterly* (27:4), pp. 557-595.

Majchrzak, A., Rice, R. E., Malhotra, A., King, N., and Ba, S. 2000. "Technology Adaptation: The Case of a Computer-Supported Inter-Organizational Virtual Team," *MIS Quarterly* (24:4), pp. 569-600.

Malhotra, A., Majchrzak, A., Carman, R., and Lott, V. 2001. "Radical Innovation Without Collocation: A Case Study at Boeing-Rocketdyne," *MIS Quarterly* (25:2), pp. 229-249.

Nelson, R. R., and Cheney, P. H. 1987. "Training End Users: An Exploratory Study," *MIS Quarterly* (11:4), pp. 547-559.

Orlikowski, W. J. 1996. "Improvising Organizational Transformation over Time: A Situated Change Perspective," *Information Systems Research* (7:1), pp. 63-92.

Orlikowski, W. J. 2000. "Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations," *Organization Science* (11:4), pp. 404-428.

Raho, L. E., Belohlav, J. A., and Fiedler, K. D. 1987. "Assimilating New Technology into the Organization: An Assessment of McFarlan and McKenney's Model," *MIS Quarterly* (11:1), pp. 47-57.

Repenning, N. P. 2002. "A Simulation-Based Approach to Understanding the Dynamics of Innovation Implementation," *Organization Science* (13:2), pp. 109-127.

Robertson, D. C. 1989. "Social Determinants of Information Systems Use," *Journal of Management Information Systems* (5:4), pp. 55-71.

Robey, D., Ross, J. W., and Boudreau, M. C. 2002. "Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change," *Journal of Management Information Systems* (19:1), pp. 17-46.

Robey, D., and Sahay, S. 1996. "Transforming Work Through Information Technology: A Comparative Case Study of Geographic Information Systems in County Government," *Information Systems Research* (7:1), pp. 93-110.

Sabherwal, R., Jeyaraj, A., and Chowa, C. 2006. "Information System Success: Individual and Organizational Determinants," *Management Science* (52:12), pp. 1849-1864.

Sarker, S., Sarker, S., and Sidorova, A. 2006. "Understanding Business Process Change Failure: An Actor-Network Perspective," *Journal of Management Information Systems* (23:1), pp. 51-86.

Taylor, S., and Todd, P. 1995. "Assessing IT Usage: The Role of Prior Experience," *MIS Quarterly* (19:4), pp. 561-570.

Tyre, M. J., and Hauptman, O. 1992. "Effectiveness of Organizational Responses to Technological Change in the Production Process," *Organization Science* (3:3), pp. 301-320.

Tyre, M. J., and Orlikowski, W. J. 1994. "Windows of Opportunity: Temporal Patterns of Technological Adaptation in Organizations," *Organization Science* (5:1), pp. 98-118.

Venkatesh, V., Brown, S. A., Maruping, L. M., and Bala, H. 2008. "Predicting Different Conceptualizations of System Use: The Competing Roles of Behavioral Intention, Facilitating Conditions, and Behavioral Expectation," *MIS Quarterly* (32:3), pp. 483-502.

Venkatesh, V., and Davis, F. D. 2000. "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies," *Management Science* (46:2), pp. 186-204.

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. 2003. "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly* (27:3), pp. 425-478.

Volkoff, O., Strong, D. M., and Elmes, M. B. 2007. "Technological Embeddedness and Organizational Change," *Organization Science* (18:5), pp. 832-848.

Walsham, G., and Sahay, S. 1999. "GIS for District-Level Administration in India: Problems and Opportunities," *MIS Quarterly* (23:1), pp. 39-65.

Zhu, K., and Kraemer, K. L. 2005. "Post-Adoption Variations in Usage and Value of E-Business by Organizations: Cross-Country Evidence from the Retail Industry," *Information Systems Research* (16:1), pp. 61-84.

Zigurs, I., Buckland, B. K., Connolly, J. R., and Wilson, E. V. 1999. "A Test of Task-Technology Fit Theory for Group Support Systems," *Database for Advances in Information Systems* (30:3/4), pp. 34-51.