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SOME CHALLENGES AND GUIDELINES FOR CONDUCTING MULTI-LEVEL MODELING IN INFORMATION SYSTEM RESEARCH

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ABSTRACT

To date, few IS researchers have made use of multi-level modeling in their studies. This is unfortunate because organizational processes often span multiple levels of the organization. As such, multi-level modeling (MLM) has the potential to enhance our understanding of how IS can be deployed and used effectively in organizations. To this end, this paper reflects on the use of MLM in IS research. We illustrate the pertinent issues and challenges involved by describing how the widely used organizational level construct "Assimilation" will change conceptually and operationally if it is extended to the interorganizational level. Based on our analysis we conclude that while MLM is not a panacea, or appropriate for all research questions, identifying and including higher-level constructs in IS research models offers rich opportunities for IS research.

Keywords

Multi-level modeling, assimilation, dyads, aggregation, hierarchical linear modeling

INTRODUCTION

Few studies in information systems (IS) research make use of multi-level modeling (MLM) (a notable exception is Burton-Jones and Gallivan's (2007) conceptualization of the system usage construct). This is unfortunate because organizational processes often span multiple levels of the organization (Klein and Kozlowski, 2000; Hitt et al, 2007). As such, MLM has the potential to enhance our understanding of how IS can be deployed and used effectively in organizations. To this end, this paper reflects on the use of MLM in IS research. To illustrate the pertinent issues and challenges involved in utilizing MLM, we draw on the organizational level construct "Assimilation", which has been widely operationalized as a dependent variable in technology diffusion research. In doing so, we describe how the assimilation construct will change conceptually and operationally if it is extended to the interorganizational level. Based on our analysis, we provide reasons why it may be inappropriate to approach MLM by simply extending constructs found at one level to another level of analysis. Finally, we offer a different approach to MLM in IS.

ASSIMILATION: A WIDELY USED CONSTRUCT IN IS RESEARCH

Assimilation is a widely used organizational level construct in technology diffusion research (Fichman, 2000; Swanson and Ramiller, 2004; Zhu et al, 2006). Essentially, assimilation refers to the process of diffusion of an information technology within an organization from initiation—when either a technology-push or organizational-need creates awareness of a technology—through to infusion, which relates to when the technology is being used to its fullest potential within the organization's work systems (Kwon and Zmud, 1987; Cooper and Zmud, 1990). Assimilation is generally operationalized using a Guttmann scale, from 0=No Awareness; 1=Adoption decision; 2=In the process of build/deployment (adaptation); 3=Limited Deployment; and 4=General deployment (Infusion). For example, Ravichandran (2005) used deployment as a measure of assimilation in his study of the relative influence of uncertainty and organizational learning on assimilation. In Cooper and Zmud's (1990) study of assimilation of MRP systems, these authors employed a similar scale to measure the influence of task-technology fit and task complexity on adoption and diffusion. While Cooper and Zmud related their measures to specific features of the technology rather than deployment, in both cases, assimilation was operationalized as cumulative

APPROACHES TO UTILIZING ASSIMILATION AT THE INTERORGANIZATIONAL LEVEL

Ignoring the interorganizational relationship

To describe how we might extend this construct to the interorganizational level, we may first think about how doing so could be approached. One approach could be to treat organizations separately and ignore the interorganizational relationship altogether. Thus, while the context is interorganizational, the unit of analysis is at the organizational level. Bala and

Venkatesh (2007) used this method when they examined the effects of relational, institutional, and inertial forces on technology assimilation. These authors proposed firm dominance as a moderator of a focal organization's assimilation of interorganizational systems (IOS) and found that relationship specificity was a driver of assimilation for non-dominant firms, while assimilation in dominant firms was determined by relationship depth and how far the relationship could be extended (i.e. relationship extendability). This approach to multilevel modeling treats assimilation within an interorganizational relationship as two (or more) separate processes.

Extending assimilation to the interorganizational level

A second approach would be to extend the assimilation construct to the interorganizational level. Extending assimilation in this manner essentially treats the construct as homologous at interorganizational and organizational levels. In effect, this means that organizational and interorganizational assimilation are parallel and have the same (if not very similar) antecedents and consequents. An advantage of this approach is that if constructs are truly homologous, we can produce theories that are very parsimonious and powerful. The disadvantage is that constructs at different levels of analysis are rarely homologous, so to simply extend them across levels often results in theories with little explanatory or predictive potential (Klein and Kozlowski, 2000). This is a serious consideration across multiple fields of study, including organizational psychology (Cohen et al, 2003), communications science (Ess and Suddweeks, 2001), health care (Diez-Roux, 1998), and political science (Baybeck and Huckfeldt, 2002). The term "ecological fallacy" is often employed to describe errors that result from presuming one level of analysis provides information about another level.

That being said, to go about extending the construct in this way, we would first consider factors that foster or hinder assimilation at the organizational level. External factors that foster technology assimilation at the organizational level include institutional forces such as *mimetic forces* (i.e. the prevalence of the technology in the focal organization's industry and the perceived success of organizations within the industry that have adopted the technology; *normative forces*, which relate to shared norms among organizations within an industry; and *coercive forces*, defined as formal or informal pressures exerted on the focal organization by other organizations upon which the focal organization is dependent (e.g. Bala and Venkatesh, 2007; Soares-Aguiar and Palma-dos-Reis, 2008).

Following organizational level studies, we may posit that the same relationships hold for interorganizational assimilation. However, since the unit of analysis is at the interorganizational level, it cannot simply be assumed that both organizations face the same institutional pressures. For example, perhaps the partnership is a collaboration of firms in different industries (e.g. air travel industry, car rental, and hotels). It may be that in one industry there is strong mimetic pressure to adopt the technology, while in another there is not. Further, if one of the partners is a dominant firm (i.e. the other organization relies on it for resources), it opens up the possibility that one of the partners in the relationship faces strong coercive pressure from the other. Consequently, institutional forces in both industries must be taken into account.

A similar problem arises when considering barriers to interorganizational assimilation. From an organizational learning perspective, knowledge barriers are viewed as a primary deterrent to organizational assimilation of technology (Ravichandran, 2005). In an interorganizational relationship, both partners may have different levels of knowledge stocks—i.e. technical know-how and ability to convert externally acquired knowledge into organization-specific knowledge (Ravichandran, 2005). Therefore, both parties' knowledge stocks must be considered independently, and in concert, to fully understand the impact of knowledge barriers on interorganizational assimilation. Finally, economic-based perspectives direct attention to how uncertainty about the evolution of the adopter network impacts organizations' adoption decisions (Ravichandran, 2005). To this end, adoption bandwagon research suggests that structural characteristics of adopters reveal information about the value of a technology investment—for example, adoption of technologies by large firms has been shown to be value-enhancing (Terlaak and King, 2007). When considering models of interorganizational assimilation, researchers may need to take into account the structural characteristics of the interorganizational partnership rather than of individual organizations.

The dyad as the unit of analysis

The above discussion implies that modeling interorganizational assimilation requires all the antecedents of organizational assimilation to be reconsidered based on the *relationship* between the partners. Indeed, it seems intuitive that the unit of analysis for interorganizational assimilation should be the relationship itself, or the *dyad* (Klein and Rai, 2009). However, this creates issues both in terms of specifying the research model and data collection. First, in the research model all constructs need to be specified for each party in the relationship. Thus a research model would include institutional forces (firm A), institutional forces (firm B), technology uncertainty (firm A), technology uncertainty (firm B), and so on. Assimilation would also have to be specified as assimilation (firm A) and assimilation (firm B). If all relevant constructs from the organizational level were included, researchers would quickly arrive at a model that is very complex. This limits the

number of constructs that can be included in a dyadic model and introduces potential internal validity issues. Another issue that limits the size of the model is that because a dyadic model has at least twice the number of constructs, researchers can quickly run into sample size problems. This problem is exacerbated because dyadic data is very difficult to collect, so sample sizes are usually much smaller than normally expected (Klein and Rai, 2009).

The problems outlined in the preceding paragraphs can be summarized as follows. To capture the influences on different organizations' attempts at interorganizational assimilation—without slipping back to the organization as the unit of analysis—researchers must either (1) focus on the relationship itself (which creates methodological and data collection issues), or (2) consider that interorganizational assimilation is a quite different construct than organizational assimilation. In light of this, and the expectation that researchers would run in to similar problems with other widely-used constructs found at other levels of analysis, this paper advocates that IS researchers exercise extreme caution when extending constructs found at one level to another level of analysis. Extending constructs without careful consideration to how the construct may change conceptually and operationally is likely to produce misspecified models, leading to inconsistent findings and erroneous conclusions.

AN ALTERNATIVE APPROACH

Having outlined issues involved in extending constructs from one level of analysis to another, we now offer a different approach to promoting multi-level research. As a first step, following Klein and Kozlowski (2000), we suggest it is inappropriate to conduct multi-level research on topics or in contexts where research is still in an exploratory phase. As Klein and Kozlowski suggest, there are good reasons for conducting research at separate levels of analysis when relationships and constructs have not been well established. In this case, jumping into multilevel research too early is likely to result in theoretical confusion. For this reason, our first recommendation is that the IS field, delay conceptualizing multilevel models for contexts such as interorganizational relationships until issues with measurement and data collection have been resolved. For example, in the interorganizational context, there is much still to be understood about the relationship between organizations (Klein and Rai, 2009). In this instance, once the IS field has developed a clearer understanding of how two or more organizations become an "interorganization" it may be appropriate to consider the use of MLM.

Second, IS researchers cannot assume that findings can be aggregated from one level of analysis to another, or that because data has been collected at a single level of analysis that it is not linked in some way to higher level processes (House et al., 1995). Perhaps the benefits of using structural equation modeling—e.g. its ability to provide some indication of causality and test multiple DVs simultaneously—has caused IS researchers to overlook that the impact of higher level constructs on lower level outcomes could be tested using hierarchical linear modeling (HLM). Using this statistical technique, models of technology acceptance (for example) could be tested across organizations, as well as multiple groups of users within organizations, to determine if any of the variance in behavioral intentions or use behaviors can be explained by dependence on a higher level. This might provide insight into whether collective "perceived usefulness" or "use behaviors" exist, and the extent of their influence.

Aggregation

Some constructs can be aggregated because they are, what Klein and Kozlowski (2000) term, "global properties". These are usually structural properties such as department size, etc. As a starting point, IS researchers could begin to use global properties in research models to examine how they interact with individual level phenomena to explain individual level outcomes. The next type of higher level construct is referred to as having "shared properties" among group members—these are constructs such as "technology embeddedness" or "norms". These constructs are measured at the individual level and may be aggregated to the higher level or analyzed using HLM.

It is important to note potential problems associated with aggregating data. First, aggregation does not account for size variance among groups. For example, suppose a researcher was measuring technology embeddedness across groups of users within an organization. One group may have three users, while another has twenty. A second problem is that we may lose the richness of potentially meaningful individual level data, such as the variance in use behaviors among users nested in the same group. This reduces the power to detect effects of predictors on the dependent variable. Thus, if the researcher believes that aggregation of data appropriate, it is good practice to provide empirical support in the form of reliability and agreement indices.

Hierarchical Linear Modeling (HLM)

An alternative approach to dealing with shared property constructs is to use HLM to adequately align the data with the analytical model used for hypothesis testing (Hofmann, 1997; Cohen et al, 2003). HLM makes it possible to test the effects of both higher level and individual level predictors on an individual level outcome and partition explained variances from

each level. Using the example of technology embeddedness within organizational groups, the procedure estimates a separate regression equation for each group, where the final results represent an average of these separate regression equations (Bryk and Raudenbush, 2001). Consequently, the influence of technology embeddedness (as a shared property of each organizational group) on individual use intentions and behaviors, as well as cross level interactions, can be evaluated without biasing the estimation of the predictors. This leads to more accurate standard error estimates than can be provided by ordinary least squares (OLS) regression, which assumes that individual level outcomes are not dependent on variables at another level of analysis (Hofmann, 1997; Cohen et al, 2003). The implication is that IS researchers conducting micro-level research do not need to confine their models to individual level perceptions—some perceptions are shared level properties of the group, and these properties of the group may have an independent effect on individual outcomes over and above that which can be explained at a single level of analysis.

Finally, in some instances a group level construct is "configural"—these constructs measure the extent to which variability exists within the group (e.g. in terms of demographics and individual differences) (Klein and Kozlowski, 2000). These constructs are more difficult to deal with because they imply differences within a group. However, for research questions where it is important to gain an understanding of how diversity in the group affects individual level thinking and behavior, it may be useful to include a measure of variability.

CONCLUSION

This study introduced the concept of interorganizational assimilation to illustrate difficulties involved in extending constructs found at one level to another level of analysis. In light of these difficulties, we propose a different approach, which involves deciding when not to conduct a multilevel study, as well as identifying constructs that have global, shared, or configural properties and including these constructs in IS research models. We believe that multi-level studies offer rich opportunities for IS research because they can help resolve inconsistencies between levels and address gaps in our knowledge. However, MLM is not a panacea, nor is it appropriate for all research questions. As always, IS researchers should let the question determine the method, not the other way round.

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