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Multi-level analysis framework for reviewing IDT-based studies

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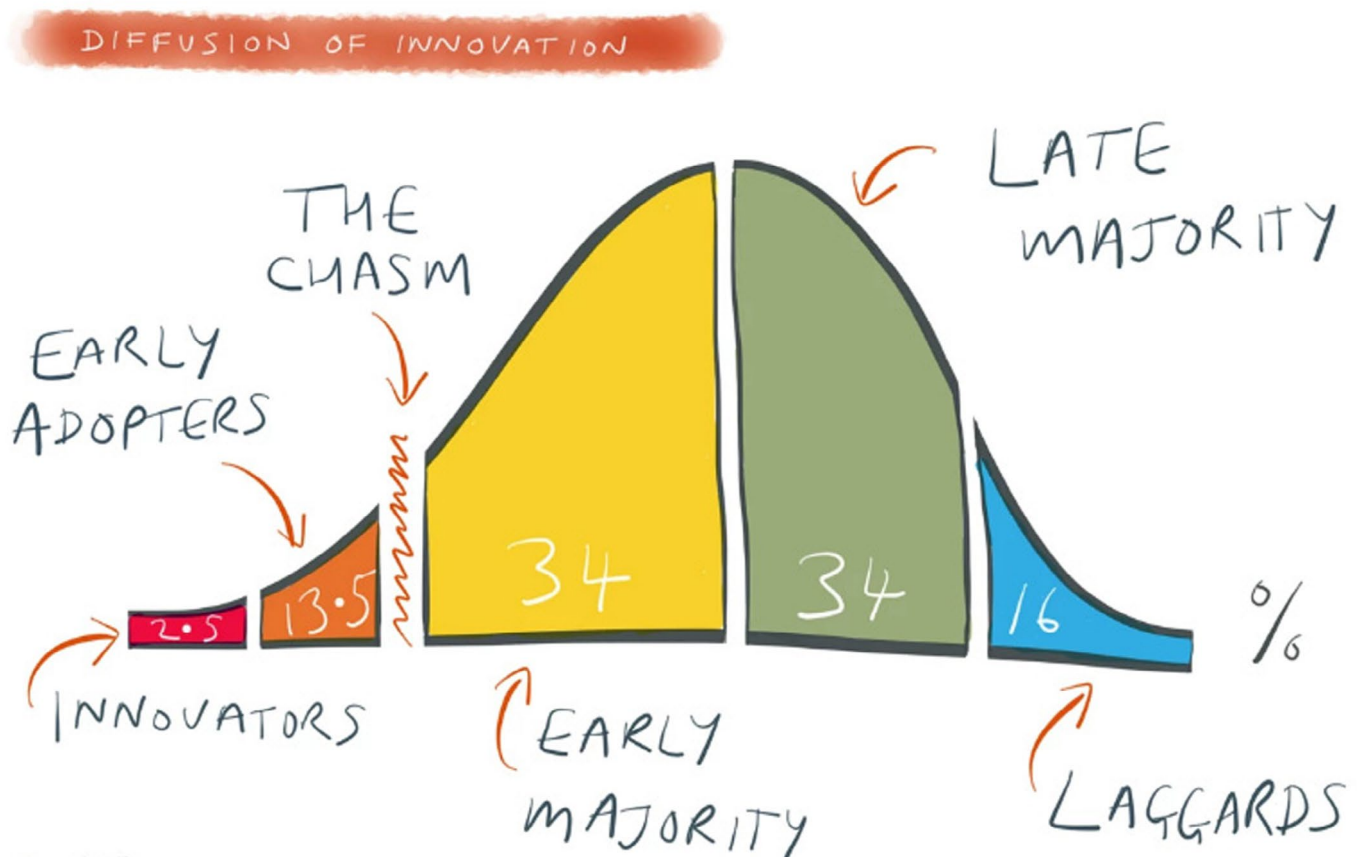
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OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

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Multi-level analysis framework for reviewing IDT-based studies

Mahdi Omid^{1*}, Qingfei Min¹ and Ali Omid²

Abstract: Researchers have for years emphasized the value of multi-level studies. This research attempts to develop a framework for analyzing IT adoption studies from a multi-level perspective. Specifically, it examines research involving Innovation Diffusion Theory (IDT), using a framework devised on the multi-level analysis guidelines proposed by two studies. Four empirical IDT-based research papers are reviewed by applying the developed multi-level analysis framework. In doing so, this paper finds that by following the proposed framework, researchers can avoid the weakness of level bias caused by single-level analysis. In addition, the framework provides insights for managerial strategies in successful information system implementation, adoption and diffusion. Finally, the proposed framework can be referenced by future researchers for conducting multi-level analysis on IT adoption-related topics.

Subjects: Management of IT; Engineering Management; Psychological Science; Management of Technology; Innovation Management; Behaviour

Keywords: multi-level analysis; innovation diffusion theory; IT adoption; construct IT systems



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PUBLIC INTEREST STATEMENT

These days, information technology (IT) is universally regarded as an essential tool in enhancing the competitiveness of the economy because it has significant effects on the productivity of firms. These effects will only be fully realized if, and when, IT are widely spread and used. It is crucial, therefore, to understand the determinants of IT adoption and the theoretical models that address IT adoption, implementation, and use. Given the changing nature of the IT artifact, the task to understand various behavioral, organizational, and institutional factors affecting the IT adoption and/or usage decision as well as the implementation process remains crucially valuable for insightful theoretical and practical implications.

In this study, we attempt to develop a framework for analyzing IT adoption studies from a multi-level perspective. Multi-level analysis resolves the problem of conflicting results, because it examines the links between levels (both individuals and teams).

1. Introduction

Researchers have emphasized the value of multi-level studies (e.g. the individual, group, or organizational level) for years. Goodman (2000) states that multi-level analysis resolves the problem of conflicting results, because it examines the links between levels. Un (2010) suggests that multi-level analysis is important in organizational research because organizational learning tends to occur at the level of both individuals and teams. When the focus is on information technology adoption (hereafter shortened as IT adoption), Burton-Jones and Gallivan (2007) argue that past research only emphasized single-level analysis, which may usually lead to a level bias.

In order to resolve this issue, they suggest that researchers focus on examining the multi-level nature of IT adoption when conducting research. Other researchers even provide advice for conducting such studies: Morgeson and Hofmann (1999) provide eleven guidelines that directly emphasize the nature of multi-level constructs, while Burton-Jones and Gallivan (2007) propose five guidelines to conduct multi-level research.

Innovation Diffusion Theory (IDT) provides well-developed concepts and empirical results that allow researchers to study technology evaluation, adoption and implementation. The theory assesses the possible rate of technology diffusion, and identifies numerous factors that facilitate or slow down technology adoption and implementation. These factors include characteristics of the technology, characteristics of adopters, and the means by which adopters learn about and are persuaded to adopt the technology (Rogers, 1983). Therefore, innovation diffusion is an increasingly popular reference theory for studies of IT. In this study, we propose a multi-level analysis framework for IDT-based studies by referring to both sets of guidelines mentioned above.

Innovation diffusion provides the advantage of abundant cumulative established practice. However, researchers must ensure that the context to which the theory is applied matches well with the context in which the theory was developed and assumed when first adopted. Alternatively, researchers must tailor the theory to explain contextual differences (Fichman, 1992). In the context of IT adoption, adoption decisions may be based on the benefits that the adopter expects to accrue, manage, encourage, (Leonard-Barton, 1988) or simply mandate (Moore & Benbasat, 1991). Fichman (1992) points out that owing to complicated factors that emerged in the context of IT adoption, the opportunities to apply classical diffusion “as is” are rare. Most research extends the concept to fit within the context studied. In this paper, we focus on reviewing and analyzing past empirical studies of IT adoption that applied IDT by using the proposed framework. Specifically, this paper concentrates on the analysis of past studies based on the multi-level perspective for the purpose of obtaining the insights of IT adoption. These analytical insights can be regarded as references for helping manage strategic decisions.

The remaining sections of this paper are organized as follows. Section 2 describes IDT, especially focusing on the elements, attributes and stages of the related models. Section 3 demonstrates the proposed multi-level analysis framework, while Section 4 presents the analysis of selected IDT-based studies by following this framework. Finally, Section 5 concludes and suggests important implications of this research.

2. Literature review

2.1. Innovation diffusion theory

An innovation is an idea, product, or process that is new to an adopter (Hage & Aiken, 1967; Rogers, 1983). When an organization adopts a new system that calls for fundamental changes in activities, this forms an innovation. On the other hand, diffusion is the “process by which an innovation is communicated through certain channels over a period of time among the members of a social system” (Rogers, 1995). IDT (Rogers, 1983) has been used to examine “the spread of things (e.g. seeds or grains) or practices (e.g. use of fertilizers or irrigation), which are new or perceived as new by members of a social environment” (Chatman, 1986). For example, Teo, Tan, and Wei (1995) use the

theory to address factors that potentially affect the intention of organizations to adopt certain information systems. Because the selected studies in this paper's analysis are based on IDT, the following sections provide useful background on several noteworthy IDT models: the elements of diffusion model, the attributes of innovation model, the social system, and the stages of adoption model.

2.2. Elements of diffusion model

The first IDT model is the elements of diffusion model. Here, researchers such as Tarde (1903) conceptualized patterned communication processes as social imitation, or the duplication of something new by members of a community. For example, when an individual observes hands clapping, they replicate this action. Barnett (1953) refers to diffusion as the basis of cultural change. Rogers (1983), who has done extensive analysis of studies that use diffusion theory to guide research, considers diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication concerned with the spread of messages that are perceived as new ideas. He conceptualizes the diffusion process as consisting of four essential elements: (1) innovation, (2) communication channels, (3) existence within a social system, and (4) time.

2.3. Attributes of innovation model

A second IDT model is the attributes of innovation model. Feder and O'Mara (1982) argue that innovation is the key factor in IDT. They use the attributes of innovation model to explain the characteristics of an innovation that may influence decisions of acceptance or rejection. Rogers and Shoemaker (1972) state that the six most important attributes that influence the adoption of an innovation are as follows:

- (1) *Relative advantage*: the degree to which an innovation is perceived as better than the practice or idea it supersedes. Rogers and Shoemaker (1972) note that "relative advantage, in one sense, indicates the intensity of the reward or punishment resulting from adoption of an innovation."
- (2) *Compatibility*: the consistency of an innovation with the existing values, practices, and needs of people (Barnett, 1979). This is the level of compatibility of an innovation that must be assimilated into an organization or individual's life. A study of the diffusion of treatment programs for alcohol abuse in organizations conducted by Fennell (1984) shows that the programs most readily accepted were those which were defined as compatible with the worker's needs and interests.
- (3) *Complexity*: the degree of difficulty involved in understanding or using an innovation (Pelz, 1983). The complexity of an innovation is an important factor affecting whether it is adopted. If the innovation is too difficult to use, an individual or organization will not likely adopt it.
- (4) *Trialability*: the degree to which an innovation can be used experimentally (Gartrell & Gartrell, 1979). It determines how easily an innovation may be experimented with as it is being adopted. If a user has a hard time trying and using an innovation, this individual will be less likely to adopt it.
- (5) *Observability*: the extent to which the results of an innovation are visible to others (Rogers & Shoemaker, 1971). More visible innovations will drive communication among people, groups, or social networks and will in turn create more positive or negative reactions.

2.4. The social system

A social system is defined as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal. It has structure, but it is a structure of events, as opposed to a structure of physical parts found in biological or other physical systems (Katz & Kahn, 1978). A social system

consists of a plurality of individual actors interacting with each other (Parsons, 1977). The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems. The social system usually constitutes a boundary within which an innovation diffuses.

2.5. Stages of adoption model

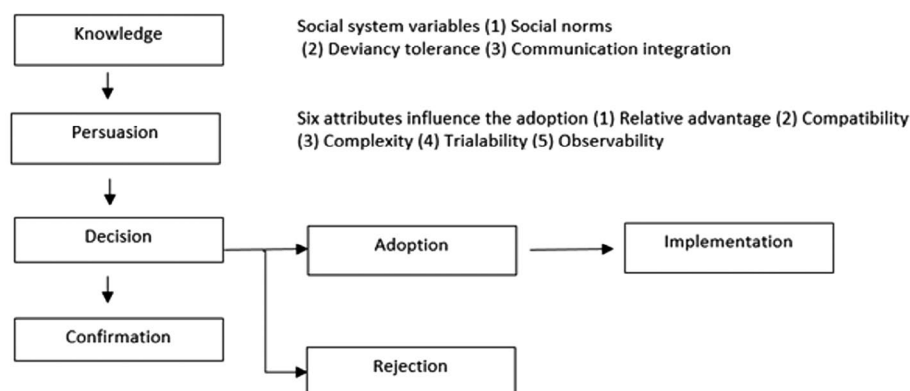
The stages of adoption model was developed by scholars to explain diffusion, a process of decision-making during which acceptance or rejection occurs. Researchers have noted that the decision to adopt an innovation is not an instantaneous action, but rather consists of a series of actions (Rogers, 1983). Actions in this decision-making process are affected by characteristics or attributes that are inherited from an innovation. For example, some individuals may want to see how a given innovation is in accordance with the individual's lifestyle (Brooks, 1958). Rogers and Shoemaker (1972) conceptualized the five stages of the adoption model as follows:

- (1) *Knowledge*: people are aware of an innovation and have some idea of how it functions.
- (2) *Persuasion*: people form a favorable or unfavorable attitude toward the innovation.
- (3) *Decision*: people engage in activities that lead to a choice to adopt or reject the innovation.
- (4) *Implementation*: people put an innovation into use.
- (5) *Confirmation*: people evaluate the results of an innovation decision already made.

To summarize, IDT has resulted in four major models: elements of diffusion, attributes of innovation, social system, and stages of adoption. The diffusion of an innovation involves four elements including the innovation, communication, social structure, and time. The attributes of an innovation explain the characteristics that may influence acceptance or rejection. The social system constitutes a boundary within which an innovation diffuses. Finally, the stages of adoption are used to explain the decision-making process by which adoption or rejection of an innovation occurs depending on the attractiveness of various attributes. The diffusion innovation model proposed by Rogers (1995) is shown in Figure 1.

This review of the major IDT models, especially the focus on elements, attributes, and stages, provides useful background information for determining where and how to approach IDT-based studies. Given this background, in the next section this paper constructs a multilevel analysis framework for IDT-based studies.

Figure 1. Diffusion of innovation model (Rogers, 1995).



3. Multi-level analysis framework

Many researchers have developed guidelines for conducting multi-level research (Klein, Dansereau, & Hall, 1994; Kozlowski & Klein, 2000; Morgeson & Hofmann, 1999). As mentioned within earlier sections above, some researchers (Morgeson & Hofmann, 1999) propose a series of eleven guidelines that directly emphasize the nature of multi-level constructs, while more recent efforts (Burton-Jones & Gallivan, 2007) offer five. Burton-Jones and Gallivan (2007) also further integrate and consolidate the previous eleven guidelines into three groups. Cross referenced with these two sets of guidelines, in this paper, we develop a multi-level analysis framework for IDT-based studies. This framework includes three major steps: IT adoption function analysis, IT adoption structure analysis, and IT adoption context analysis. These steps are necessary for building a thorough multi-level analysis of IT adoption. Details of the three steps are described as follows.

Step 1. Analyze IT adoption function.

Researchers must first check to see if the given study of IT adoption contains a multi-level construct. If the construct of the study has the same functional relationship at different levels, we can consider this study as a multi-level study.

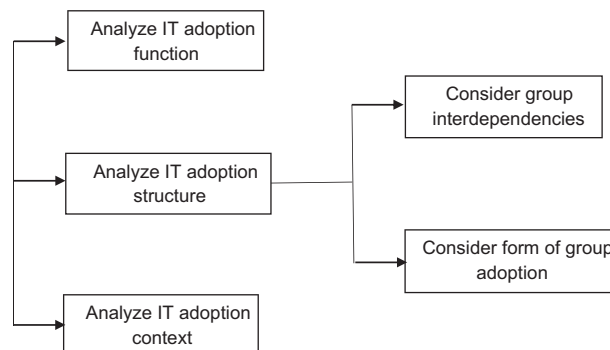
In the diffusion model, elements of the communication channel and the social system are a good starting place to identify multilevel constructs within IDT-based studies. The communication channel refers to the process of making acceptance or rejection decisions. It usually involves multi-level discussions regarding the decision-making process (Harris & Raviv, 2005), but occasionally such decisions are also based on a single CEO at a small firm (Hambrick & Mason, 1984; Mintzberg, 1979). On the other hand, the social system in the diffusion model is yet another source for multi-level investigation. As mentioned previously, the members or units of a social system may be individuals, informal groups, organizations, etc. Multi-level IDT-based studies focus on group or organizational level analysis while single-level studies only focus on individual level analysis.

Step 2. Analyze IT adoption structure.

- (1) Consider group interdependencies: researchers need to determine if the study of IT adoption includes group interdependencies. If the study shows that the group does use an information system, we can consider this study as a group IT adoption study.
- (2) Consider the form of group adoption: when group IT adoption exists, we should consider its form. Three forms of group constructs are distinguished by multi-level researchers: global, shared and configural (Kozlowski & Klein, 2000). Constructs are said to be global if the level of origin of the construct is at the level of the theory, and shared or configural if the origin level is lower than the theory level. In other words, the study of group IT adoption is either global or shared (configural) (Burton-Jones & Gallivan, 2007).

A review of each IDT-based study on the attributes of complexity and observability within the innovation model can help researchers understand IT adoption structure. As mentioned in the previous section, the complexity of an innovation is an important factor affecting the possibility of individual or organization adoption. It is true that the more complex the innovation, the more likely that the organizational level is involved, leading to the need for multi-level analysis rather than single-level. In addition, the observability of an innovation is the degree to which the result of an innovation is visible to others. Technology innovation may stimulate a lateral relationship within the existing organization structure, because communication becomes much easier across departmental boundaries (Galbraith, 1973; Olson, 1982). Therefore, since more visible innovation drives communication among people or groups, multi-level analysis is more appropriate than single-level analysis under this structure.

Figure 2. Framework for studying the IT adoption construct in a multi-level fashion.



Step 3. Analyze IT adoption context

- (1) Function view: it is important to identify the contextual factors that affect the relationship between IT adoption and related constructs.
- (2) Structure view: it is important to identify the contextual factors that affect the existence of or change in IT adoption at different levels of analysis.

The step 3 for IDT-based studies actually involves two previous steps (i.e. step 1 and step 2), but it focuses on the contextual perspective. Therefore, we can investigate the context of IDT-based studies from the perspectives of the elements of the communication channel and the social system in the diffusion model, or the attributes of complexity and observability in the innovation model. Furthermore, a detailed walkthrough of IDT-based studies according to the stages of adoption model may trace whether the study has multi-level characteristics or not. The five stages in the adoption model mentioned in the previous section provide researchers a chance to analyze this issue chronologically.

In summary, in this section, we demonstrate the proposed multi-level analysis framework based on the review of IDT models. Figure 2 illustrates this framework, which would help researchers in studying the IT adoption construct in a multi-level fashion.

The framework is then used to analyze selected studies related to IT adoption from the IDT literature in the following section.

4. Multi-level analysis framework for reviewing IDT-based studies

In this section, we identify and examine past studies that mainly focus on information technology adoption. Research conducted by Fichman (1992) presents a review of eighteen empirical studies of IDT published during the period of 1981–1991. These eighteen studies are then categorized into the IT diffusion framework, which is based on the criteria of the locus of adoption and class of technology. The locus of adoption focuses on whether the study emphasizes the individual or organizational level. Dividing Fichman's framework into four quadrants, studies in the right portion tend to consider multiple levels because the organizational level is stressed. The class of technology focuses on the level of knowledge burden or user interdependencies. Here, studies in the upper part of Fichman's framework tend to consider multiple levels because a high knowledge burden or user interdependencies is stressed. Therefore, the IDT-based studies we include in our analysis are selected from the first quadrant (upper right) of Fichman's framework. In the following subsections, we present a multi-level perspective analysis of IT adoption cases.

4.1. Adoption of database management systems by industrial firms

Ball, Dambolena, and Hennessey (1987) examine the relationship between the adoptions of database management systems (DBMS) and the characteristics of organizations and their personnel. The independent variables in this study include: (1) organizational characteristics (communication effectiveness, number of engineers and scientists in management, etc.) and (2) IT group characteristics (stage

in Nolan's Stage Theory (Nolan, 1979)). The findings suggest that organizations with high R&D commitments and a large number of engineers and scientists in management tend to be early IT adopters.

In terms of multi-level perspective analysis, we can see that Ball et al. (1987) consider IT adoption as a multi-level construct because the constructs have the same functional relationship at either the individual or group levels. In addition, the identifiable interdependencies help justify that group IT adoption exists. The DBMS in this study represents interdependencies mediated by a third party (Orlikowski, Yates, Okamura, & Fujimoto, 1995), because workflow and procedures that are embedded in the system are all centrally coordinated. For developing or measuring group IT adoption, the form of IT adoption in this case is the shared form, because the same functions of DBMS are used across organization members. Finally, Ball et al. (1987) also discuss several contextual factors that affect the relationship between IT adoption and its outcome. For example, hypothesis 1 in this study shows that the relationship between IT adoption and desired outcome should consider whether the innovative firms are selected in the adoption of DBMS. This is also a contextual factor that affect the existence of IT adoption.

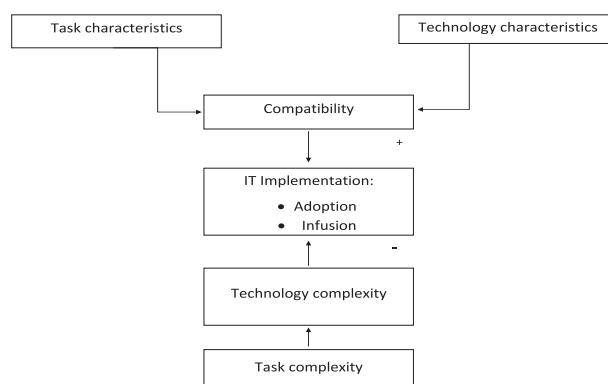
4.2. Adoption of MRP systems within industrial firms

Cooper and Zmud (1990) focus on the interaction between managerial tasks and IT, and the resulting effect, by examining the adoption of a production and inventory control information system (PICIS). More specifically, their study views IT adoption as an organizational effort directed toward the diffusion of IT to support particular tasks within a specific work context. Prior research has shown that successful innovation occurs when the task and the technology are compatible (Tornatzky & Klein, 1982). Therefore, the independent variables in Cooper and Zmud's study include several innovation characteristics, such as task compatibility, technology compatibility, and technical complexity. Their findings suggest that high task-technology compatibility (e.g. continuous manufacturing methods, make-to-stock marketing strategies) and low technological complexity (e.g. fewer parts per bill-of-material and per finished good) positively relate to system adoption. The research model for Cooper and Zmud's study is shown in Figure 3.

In terms of multi-level perspective analysis, Cooper and Zmud (1990) did not consider IT adoption as a multi-level construct because there is no construct with the same functional relationship at different levels. Their study explores the impact of factors such as task and technology, but ignores user or organizational factors. On the other hand, Cooper and Zmud (1990) prove that the group IT adoption exists, because they investigate managerial task interaction and find that it does indeed influence the adoption of a material requirements planning (MRP) system. For conceptualizing or measuring group adoption, the form of IT adoption in Cooper and Zmud's (1990) model is shared, because the MRP system considers the shared level of use across members. However, in the study, the contextual factors that affect the relationship between IT adoption and related constructs or affect the existence of or change in IT adoption could not be identified. As mentioned in the last statement by Cooper and Zmud's (1990), "Such studies will be more powerful if ... they adequately account for the 'fit' between the technology being examined and the work context within which the technology is being introduced". The contextual factors are not available.

Figure 3. The research model in (Cooper & Zmud, 1990).

Notes: + and – denote: respectively the positive and negative effect of the mentioned variables on system adoption.



4.3. Initiation, adoption and implementation of modern software practices in aerospace firms and federal agencies

Zmud (1982) examines the influence of centralization and formalization on organizational innovation by studying the initiation, adoption and implementation of modern software practices (MSP) for aerospace firms and federal agencies. The independent variables in Zmud's (1982) study include (1) organizational characteristics (centralization, formalization or structural overlays), and (2) innovation characteristics (technical vs. administrative and compatible vs. incompatible). His results show that centralization is positively associated with the initiation of compatible administrative innovations, and formalization is positively correlated with adoption of incompatible technical innovations. That is, Zmud's (1982) study supports the arguments that the innovation-organization interactions are used to explain the process of and conditions for organizational innovation. The interactions include "the multi-phased nature of the innovation process (Wilson, 1966; Zaltman, Duncan, & Holbek, 1973), an innovation's compatibility to organizational members (Moch & Morse, 1977), and the vested interests served by the innovation (Daft, 1978; Moch & Morse, 1977)". Furthermore, Zmud (1982) shows that the organizational location variables, such as centralization and formalization, must also be considered.

For analysis, we focus on the adoption phase of the innovation, although Zmud's (1982) study also considers the other two phases (i.e. initiation and implementation). In terms of multi-level perspective analysis, Zmud (1982) does consider IT adoption as a multi-level construct because some of the variables in his study have the same functional relationship at different levels. For example, the compatible or incompatible variable refers to the compatibility with members' interests in the organization. Zmud also considers each member's interest as well as group interests. The design of group IT adoption is evidenced by Zmud's study of interdependencies in aerospace firms and federal agencies. The form of IT adoption in Zmud's (1982) case is shared, because his study focuses on the shared level of adoption across members in organizations. Finally, the contextual factors that affect the relationship between IT adoption and its outcome are organizational characteristics, such as centralization, formalization, and structural overlays. For example, an organizational manipulation, i.e. extent of centralization and formalization, may facilitate or impede innovative behavior depending on specific innovation-organization interactions. The contextual factors that affect the existence of or change in IT adoption at different levels of analysis seem to be the organizational characteristics as well, however, no clear evidence is shown in Zmud's (1982) study.

4.4. IT adoption within the administrative offices of a southeastern university

Kwon (1990) examines the infusion of information technology within the administrative offices of a southeastern university in the United States. The independent variables include (1) management information system (MIS) maturity (age, applications, and equipment); (2) MIS climate (management support, user involvement, and management attitude); (3) work unit size; and (4) network behaviors (centrality, sources, intensity, link sources, and link intensities). The results show that the external communication intensity positively correlates with IT adoption for work groups with a favorable MIS climate.

In terms of multi-level perspective analysis, we can see that Kwon (1990) designs IT adoption as a multi-level construct, because some of the variables in the study have the same functional relationship at different levels. Kwon's (1990) study addresses the relationship between MIS maturity and IT infusion in a multi-level fashion because it focuses on both users' age and the organization's application usage history. Employees in administrative offices of a university use systems for collaboration, communication, and coordination in their daily life. Since collaboration, communication, and coordination are identified by Karsten (2003) as three main types of interdependencies, the study of interdependencies means that Kwon (1990) can design group IT adoption. The form of adoption in Kwon's (1990) case is configural, because different individuals have different purposes

Table 1. Analysis results in selected studies in a multi-level fashion

Steps of framework/studies	Ball et al. (1987)	Cooper and Zmud (1990)	Zmud (1982)	Kwon (1990)
(1) Function of IT adoption	•		•	•
(2) Structure of IT adoption				
Interdependencies	•	•	•	•
Form of group use	•	•	•	•
(3) Context of IT adoption				
Function view	•		•	•
Structure view	•			•

Note: • denotes the support of the steps of framework in the studies.

of use in the system within the university. Finally, the contextual factors that affect the relationship between IT adoption and its outcome are MIS climate, such as management support, user involvement and management attitude. The contextual factors that affect the existence of or change in IT adoption at different levels of analysis are also MIS climate-related. As Kwon's (1990) results show, a favorable MIS climate facilitates the strong relation between some network behaviors (e.g. intensity) and IT adoption.

To summarize, from a multi-level perspective to analyze the past studies on IT adoption in relation to IDT, all the studies facilitate the function and structural perspective of IT adoption except for Cooper and Zmud's (1990) study. In addition, Cooper and Zmud's (1990) study does not consider the contextual factors in both the function and structural view, and Zmud's (1982) study lacks a structural perspective. Table 1 summarizes the analysis results

In this study, the multi-level analysis framework developed in Section 3 is applied to analyze four selected empirical IDT-based research papers in Section 4. Through the framework, the IDT-based studies are analyzed in a multi-level fashion, which avoids the level bias caused by single-level analysis. In addition, important insights regarding information system implementation can be revealed through the steps of this framework. Managers or researchers can refer to the multi-level analysis framework for assisting managerial decision-making or research discussion when IT adoption-related topics are involved.

5. Conclusion

IDT-based IT adoption studies have been extensive; however, little research focuses on examining these studies from a multi-level perspective. In this paper, we develop a framework for analyzing IT adoption from a multi-level perspective by referencing and modifying multi-level guidelines proposed by two studies (Burton-Jones & Gallivan, 2007; Morgeson & Hofmann, 1999). We then analyze past IDT-based IT adoption studies using the developed framework. Our findings show that multi-level analysis can avoid the weakness of level bias caused by single-level analysis. In addition, the proposed framework for multi-level analysis on IT adoption provides insights when conducting multi-level analysis, and can help strategic managerial decision-making for successful information system implementation, adoption and diffusion. Therefore, this study suggests that future research on IT adoption related topics can conduct multi-level analysis by referencing the proposed framework. Possible linkages between levels can be examined, and thus conflicting results can be resolved.

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