The Diffusion and Assimilation of Information Technology Innovations

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Introduction

The task of deciding when and how to innovate is not an easy one. Consider the following managerial quandaries:

- A CIO has joined a firm that lags in the adoption of emerging information technologies. He wonders: just how innovative should this firm be going forward, and what can be done to position it to be more willing and able to assume the challenge of early adoption?
- A VP of marketing resides in a firm that generally leads in IT innovation, and must decide whether to endorse the immediate adoption of a particular innovation with major implications for marketing strategy. She wonders: are her firm's needs in this area and "readiness" to adopt sufficient to justify taking the lead with this specific innovation? If so, how should the assimilation process be managed?
- A product manager must design a deployment strategy for an innovative software development tool. He wonders: how fast can this technology diffuse? What kinds of organizations should be targeted for early adoption? What kinds of barriers will early adopters face? What can be done to promote adoption among these organizations, and to sustain diffusion across the much larger market of later adopters?

These sorts of questions—which motivate the bulk of research on the *diffusion* and *assimilation* of IT innovations—have become increasing commonplace. (*Diffusion* is the process by which a technology spreads across a population of organizations, while *assimilation* refers to the process within organizations stretching from initial awareness of the innovation, to potentially, formal adoption and full-scale deployment). The last quarter of the 20th century is often called the *information* age, although perhaps it would be equally appropriate to look upon this time as the *innovation* age. With the invention of the microprocessor in 1971, an era of accelerating innovation was launched that continues to this day. And not only has the pace of innovation increased in the general business environment, but it appears that the ability to innovate has begun to eclipse more traditional contributors to organizational competitiveness (Hamel, 1998). Some have argued that innovation will be *the* key determinant of competitiveness over the next decade (Afuah, 1998). Furthermore, as an increasing number of industries move to "winner take all" dynamics, the stakes for successful innovation have become high indeed (Frank and Cook, 1995; Shapiro and Varian, 1998).

Organizations that persistently ignore new technologies risk a slide into uncompetitiveness, yet being on the leading edge brings its own perils. The processes of diffusion and assimilation rarely unfold in a smooth and predictable fashion (Attewell, 1992; Fichman and Kemerer, 1999; Moore, 1992; Swanson and Ramiller, 1997). Chew et al. (1991) report that from 50-75% of advanced manufacturing implementations experience some kind of a failure. It has been reported that a similar percentage of business process reengineering projects do not meet key objectives (Brynjolfsson, et al., 1997).[1] From AI to (Gill, 1995) to CASE (Fichman and Kemerer, 1999) to ISDN (Lai, et al., 1993) it is not difficult to find examples of very promising technologies that failed to diffuse as expected.

Thus, the study of IT diffusion and assimilation represents a key area of investigation in the IT field. In this chapter, I present a broad overview of basic concepts, theories and research findings in this area. I begin with a general discussion of the role of theory and related issues. I then present a framework that classifies key constructs and their effects on diffusion and assimilation. Next, I describe several emerging streams of research in the field, and suggest directions for future research.

Fundamental Issues in the Study of IT Diffusion and Assimilation

The Role of Theory

The study of innovation diffusion has a long history as a multi-disciplinary field (Rogers, 1995), with contributions from sociologists, communication researchers, economists, organizational researchers, IT researchers, and many others. While there is much diversity across these traditions, they are unified by their concern with three basic research questions:

RQ 1: What determines the rate, pattern and extent of diffusion of an innovation across a population of potential adopters?

RQ 2: What determines the general propensity of an organization to adopt and assimilate innovations over time?

[1] See chapter on Business Process Change.

RQ 3: What determines the propensity of an organization to adopt and assimilate a *particular* innovation?

Nevertheless, no single theory of innovation exists, nor does it seem likely one will emerge. The closest the field has come to producing such as theory is Rogers' classical model of diffusion (Rogers, 1995) (see Table 1). However, while this model has quite rightly had a profound role in shaping the basic concepts, terminology, and scope of the field, it does not—nor does it aim to—apply equally well to all kinds of innovations in all adoption contexts.

TABLE 1: COMPONENTS OF THE CLASSICAL DIFFUSION MODEL

Component	Definitions/Generalizations
Definition of Diffusion	The process by which an innovation is communicated through certain channels over time among the members of a social system.
Typical Diffusion Pattern	Process starts out slowly among pioneering adopters, reaches "take-off" as a growing community of adopters is established and the effects of peer influence arise, and levels-off as the population of potential adopters becomes exhausted, thus leading to an "S-shaped" cumulative adoption curve.
Innovation Characteristics	Innovations possess certain characteristics (relative advantage, compatibility, complexity, trialability, observability) which, as perceived by adopters, determine the ultimate rate and pattern of adoption.
Adopter Characteristics	Some potential adopters are more prone to innovate than others, and can be identified as such by their personal characteristics (education, age, job tenure etc.). Adopters can be usefully classified according to where they adopt relative to others (innovators, early majority, etc.).
Adoption Decision Stages	The adoption decision unfolds as a series of stages, flowing from knowledge of the innovation through persuasion, decision, implementation and confirmation. Adopters are predisposed towards different kinds of influence (e.g., mass market communication versus word-of-mouth) at different stages.
Opinion Leaders and Change Agents	The actions of certain individuals (opinion leaders and change agents) can accelerate diffusion, especially when potential adopters view such individuals as being similar to themselves.

The classical model was synthesized from a body of research that focused primarily on *simpler* innovations being adopted *autonomously* by *individuals*. It applies less well to more *complex* technologies, to technologies where adoption decisions are *linked* in some important way, and to technologies adopted in and by *organizations* (Attewell, 1992; Eveland and Tornatzky, 1990; Fichman, 1992; Kelly and Kranzberg, 1978; Rogers, 1991).

Which brings us to a key point regarding the role of theory in innovation research. The absence of a general theory of innovation suggests that researchers should develop theories of the middle range—that is, theories tailored to specific classes of technologies, and/or to particular adoption contexts. In Table 2 below, I provide some examples of these sorts of models. Even so, some variables and relationships generalize more broadly than others. Therefore, I take two complementary approaches in presenting prior research in this area. In the next section, I present a framework structured around more generalizable variables and relationships. Then, in the following section, I focus on distinctive characteristics of different classes of IT innovations, and examine the implications of these characteristics for the study of diffusion and assimilation.

TABLE 2: EXAMPLE MIDDLE RANGE THEORIES OF DIFFUSION

Researcher	Context		Main Areas of Contrast with Classical Model
	Innovations	Adopters	
Markus 1987	Communication Technologies	Organizations	Inclusion of "critical mass" effects, e.g., the importance of highly resourced individuals in gaining critical mass; positing of distinctive "all or nothing" diffusion pattern.
Attewell 1992	Complex Organizational Technologies	Organizations	Inclusion of influences arising from institutions for lowering knowledge barriers (e.g., consulting firms, adoption as a service, technology simplification, special buyer-supplier relationships).
Swanson 1994	Information Technologies	Organizations and IT Units	Inclusion of IS unit characteristics (e.g., size, diversity, age of applications portfolio, professional orientation); classification IT innovation types; postulates differential effects of the same variables depending on IT innovation type.

Styles of Research

Most innovation studies conform to one of two general styles of research: *adopter* studies and *diffusion modeling* studies. Adopter studies are primarily interested in understanding differences in adopter "innovativeness." The typical approach is to survey organizations in some population of interest to capture data about: (1) the characteristics of those organizations[2] and their adoption contexts, and (2) the timing and/or extent of adoption of one or more innovations. The resulting dataset is then used to construct a variance model positing effects of organizational and contextual variables on innovativeness. Adopter studies are usually designed to address the latter two research questions listed above, i.e., what determines organizational innovativeness both in general (RQ 2) and with respect to particular technologies (RQ 3). However, they can also shed insights into the first question (see, for example, (Gatignon and Robertson, 1989)).

Diffusion modeling studies are primarily concerned with the first research question, i.e., what determines the rate, pattern and extent of technology diffusion (Mahajan, et al., 1990; Mahajan and Peterson, 1985; Parker, 1994). The typical approach here is to gather data on the timing of adoptions in some population, and then to fit a times series of observed cumulative adoptions to some functional form, such as the logistic distribution (Brancheau and Wetherbe, 1990). Some studies seek to infer support for alternative theories of diffusion based on the observed pattern of adoption for a particular innovation (Gurbaxani, 1990; Gurbaxani and Mendelson, 1990; Hu, et al., 1997; Venkatraman, et al., 1994). Others compare multiple innovations, seeking to explain why some innovations diffuse more rapidly and widely than others (Mansfield, 1993). Still others have a more applied focus and seek to make predictions about the future course of innovation for a technology (Rai, et al., 1998). Diffusion modeling studies represent a tiny fraction of IT innovation research to date. As a result, the main focus of this chapter will be on issues pertinent to adopter studies.

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[2] While organizational characteristics can serve as important determinants of innovation adoption, it is also true that once adopted, new technologies can have major impacts on organizational characteristics—see the chapter on Organizational Consequences of IT.

Measuring Innovativeness

Both styles of research—adopter studies and diffusion modeling studies—turn on the question of what it means for an organization to be "innovative" with respect to emerging technologies (Downs and Mohr, 1976; Fichman, 1999; Massetti and Zmud, 1996; Tornatzky and Klein, 1982; Zmud and Apple, 1992). The traditional notion centers on the timing of the formal adoption event, where adoption is usually defined as physical acquisition or purchase of the innovation (Rogers, 1995). Under this view, organizations that adopt relatively early are more innovative that those that adopt later or not at all.

If organizations always rapidly implemented innovations they adopted, then adoption timing would serve well as the universal definition of innovativeness. However, post-adoption behaviors can vary considerably across organizations. In fact, some research suggests that thorough and rapid implementation is the exception rather than the rule for many technologies (Fichman and Kemerer, 1999; Howard and Rai, 1993; Liker, et al., 1992). Furthermore, early adoption of one innovation does not necessarily ensure a systematic pattern of early adoption (Downs and Mohr, 1976). Owing to these limitations, several other measures have been developed, including aggregated adoption, assimilation stage achieved, and extent of implementation (see Table 3).

TABLE 3: MEASURE ADOPTER INNOVATIVENESS

Measure	Conceptual Definition	Example Operationalizations
Earliness of Adoption	Relative earliness of adoption among population of potential adopters.	Five-item categorical scale (Rogers, 1995) Adoption/non-adoption (Gatignon and Robertson, 1989) Elapsed time since adoption (Grover, et al., 1997)
Aggregated Adoption	The frequency or incidence of innovation adoption.	Number of software process innovations adopted (Zmud, 1982) Number of telecommunication innovations adopted (Grover and Goslar, 1993)
Internal Diffusion	The extent of use of an innovation across people, projects, tasks, or organizational units.	Number of microcomputers per employee (Bretschneider and Wittmer, 1993) Percentage of stores using scanners (Zmud and Apple, 1992) Percentage of electronic switches (Cool, et al., 1997) Volume and breadth of EDI use (Massetti and Zmud, 1996)
Infusion	The extent to which an innovation's features are used in a complete and sophisticated way.	Infusion of supermarket scanners (Zmud and Apple, 1992) Infusion of MRP (Cooper and Zmud, 1990) CASE features used (Howard and Rai, 1993) Depth of EDI use (Massetti and Zmud, 1996)
Routinization	The extent to which an innovation has become a stable and regular part of organizational procedures and behavior.	Routinization of government innovations (Yin, 1979) Routinization of supermarket scanners (Zmud and Apple, 1992)
Assimilation	The extent of assimilation of an innovation (where assimilation extends from initial awareness to full institutionalization).	Guttman-scale for of healthcare innovations (Meyer and Goes, 1988) Guttman-scale for software process innovations (Fichman and Kemerer, 1997a)

The degree to which alternative measures all tap into a more general notion of innovativeness, or, alternatively, capture distinct notions of innovativeness that require distinct models and explanatory variables, has been the subject of debate. Some compelling arguments have been developed for why different measures of innovativeness should be kept distinct (Downs and Mohr, 1976; Tornatzky and Klein, 1982). Yet, more recent empirical studies cast some doubt on these arguments, and suggest there may be considerable overlap and consistency in results across these measures (Damanpour, 1991; Fichman, 1999; Zmud and Apple, 1992). While there is not yet a definitive answer to this important question, researchers undertaking work in this area should be acquainted with these issues before selecting an innovativeness measure.

In addition, researchers should consider some key methodological issues. For example, the most rigorous studies now use survival analysis techniques when adoption timing is the outcome variable (Grover, et al., 1997; Pennings and Harianto, 1992b; Russo, 1991; Singer and Willett, 1991). Studies employing assimilation stage must take care to confront the issue of "differently direction effects," i.e., variables that promote progress thorough early assimilation stages, but inhibit progress through later stages, or vice versa (see section on Organizational Characteristics below). Studies using extent of implementation must consider how to account for non-adopters, i.e., whether to assign them some arbitrary score for innovativeness or to exclude them from the analysis. If the latter is chosen, this can introduce problems resulting from range restriction in study variables (Hoffman, 1995), because analysis confined only to those organizations innovative enough to have *already adopted*.

Factors Affecting the Diffusion and Assimilation of IT Innovations

In this section, I classify factors affecting innovation diffusion and assimilation into broad categories, and comment on key conceptual and methodological issues for each category. In selecting factors to highlight, my emphasis is on the most well established and generalizable factors. As illustrated in Figure 1, these factors are grouped into three categories: (1) those pertaining to the technologies and their diffusion contexts; (2) those pertaining to organizations and their adoption contexts; and (3) those pertaining to the combination of technology and organization. These three categories map to the three basic research questions identified earlier as follows. The first category (technologies and their diffusion contexts) have the most direct impact on the rate and pattern of diffusion of a technology (RQ 1). The second category (organizations and their adoption environments) relate to the question of what determines the organizational propensity to adopt multiple innovations over time (RQ 2) and to adopt particular innovations (RQ 3). The final category (factors describing the intersection of organization and innovation) only pertain to RQ 3.

Technologies and Diffusion Environments

Innovation Characteristics. A central notion in the study of innovation is that technologies possess attributes or characteristics, and that these characteristics have systematic effects on diffusion and assimilation. Rogers (1995) highlights five such characteristics, including *relative advantage*, *compatibility*, *complexity*, *trialability* and *observability* (see Table 4). Tornatzky and Klein (1982) provide a meta-analysis spanning Rogers' five characteristics and several others. In more recent work, Moore and Benbasat (Moore and Benbasat, 1991) have developed an instrument

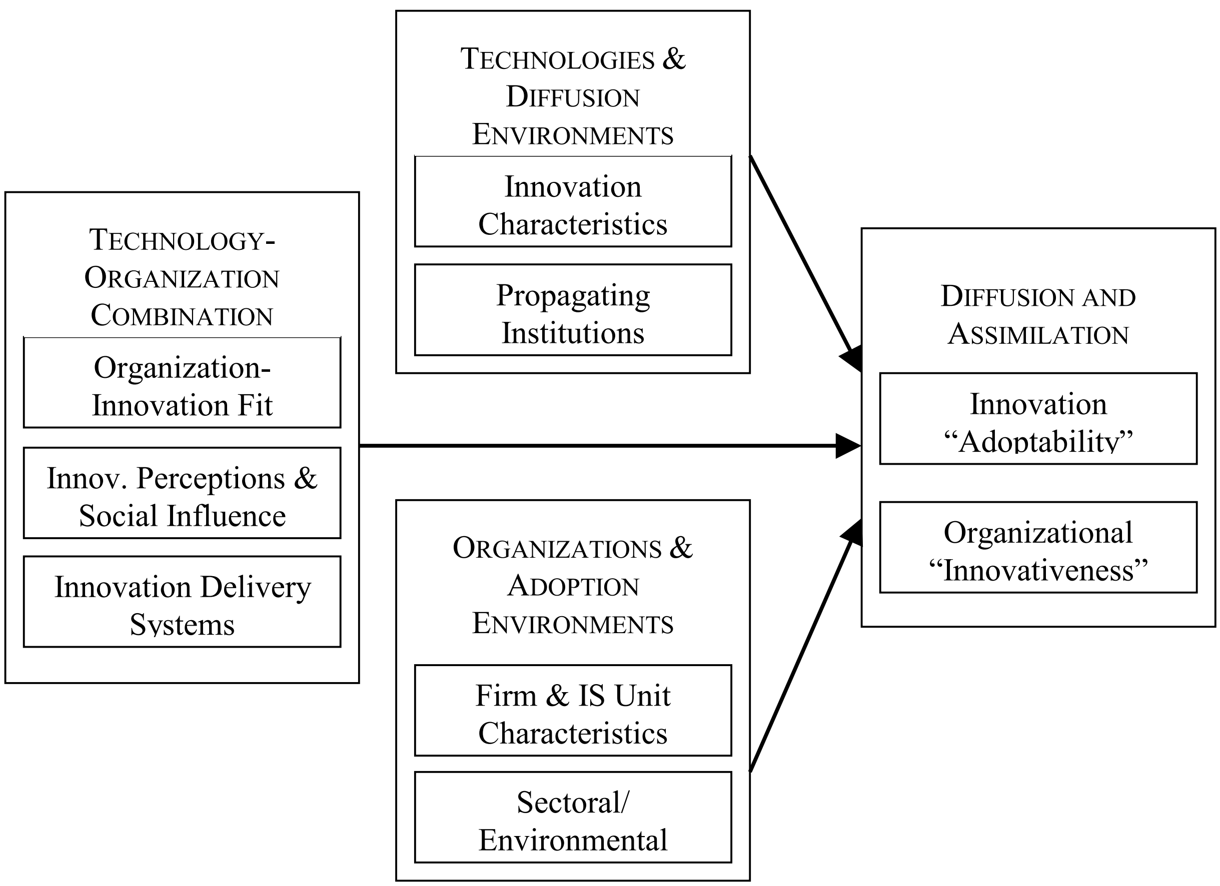

FIGURE 1. FACTORS AFFECTING IT INNOVATION DIFFUSION AND ASSIMILATION

to measure eight characteristics of information technologies. Other notable works in this area include Downs and Mohr's (1976) examination of conceptual and measurement issues related to innovation characteristics, Leonard-Barton's (1988) explication of characteristics related specifically to technology implementation, and Ramiller's (1994) detailed review and assessment of the *compatibility* construct.

In general, innovations possessing favorable characteristics tend to be more attractive and easier to adopt, and therefore tend to diffuse more rapidly than those with less favorable characteristics Rogers (1995). While this basic proposition is rather simple, the actual study of innovation characteristics presents challenges. Consider the statement "technology X is highly complex." This could be taken to mean the technology is objectively and invariably complex for all organizations. Alternatively, it could mean the technology is complex for some organizations (e.g., because they lack associated knowledge and skill), but not for others. In the first case, complexity counts as a *primary* characteristic of an innovation, while in the second case it counts as a *secondary* characteristic (Downs and Mohr, 1976). Values for primary characteristics have been assessed based on logical inferences about the innovation in question (e.g., (Attewell, 1992; Fichman and Kemerer, 1993) or by relying on expert judgments (e.g., (Meyer and Goes, 1988). Values for secondary characteristics can be inferred from objective features of the organization (e.g., (Cooper and Zmud, 1990), and can also be captured by soliciting the perceptions of key informants (e.g. (Premkumar, et al., 1994)).

TABLE 4: INNOVATION CHARACTERISTICS

Innovation Characteristics (Relation to Innovation)	Related Work
Classic Innovation Characteristics: Relative Advantage (+), Compatibility (+), Complexity (-), Trialability (+), Observability (+)	(Cooper and Zmud, 1990; Downs and Mohr, 1976; Meyer and Goes, 1988; Moore and Benbasat, 1991; Ramiller, 1994; Rogers, 1995; Tornatzky and Klein, 1982)
Other Characteristics: Cost (-), Communicability (+), Divisibility (+), Profitability (+), Social Approval (+), Voluntariness (+/-), Image (+), Usefulness (+), Ease Of Use (+), Result Demonstrability (+), Visibility (+)	(Downs and Mohr, 1976; Leonard-Barton, 1988; Moore and Benbasat, 1991; Tornatzky and Klein, 1982)

Some researchers view *primary* and *secondary* as mutually exclusive categories, and argue that there are few (or possibly no) characteristics that qualify as primary (Downs and Mohr 1976; Tornatzky and Klein 1982). This is an unsatisfying result, because it leaves no way to conceptualize characteristics at the level of a technology. Perhaps a more useful approach would be to soften the distinction between primary and secondary, and to recognize that many innovation characteristics can have facets of *both*. So, we could take complexity, when viewed as a primary characteristic, to mean a technology is likely to be perceived and/or experienced as complex by most organizations in a population relative to other common technologies confronting that population. In fact, it appears Rogers implicitly embraces this soft-primary view by arguing that it is how the members of a population *collectively perceive* the characteristics of an innovation that determine its rate of adoption in that population (Rogers, 1995, Chapter 5). This does not preclude complexity from being treated as a secondary characteristic in another (or even the same) study by measuring the characteristic in relation to particular adopters.

Propagating Institutions. Although some technologies initially emerge as more complex, expensive and incompatible than others, these initial characteristics can be moderated by the actions of institutions seeking to *propagate* those innovations (Eveland and Tornatzky, 1990; King, et al., 1994; Reddy, et al., 1991; Robertson and Gatignon, 1986; Swanson and Ramiller, 1997). These institutions—which include R&D laboratories, government agencies, technology vendors, consulting firms, and user groups—help to determine the level of resources applied to the task of communicating, promoting and enhancing a technology, and therefore can have a great deal of impact on the rate of technology diffusion (see Table 5).

TABLE 5: PROPAGATING INSTITUTIONS AND THE DIFFUSION ENVIRONMENT

Factors	Related Work
Propagating Institutions: Promotion (+), Advertising (+), Pricing (+/-), Technology Standardization (+), Technology Simplification (+), Technology Sponsorship (+), Subsidies (+), Reputation (+), Industry Competitiveness (+)	(Attewell, 1992; Eveland and Tornatzky, 1990; Gatignon and Robertson, 1989; Katz and Shapiro, 1986; King, et al., 1994; Mahajan, et al., 1990; Mahajan and Peterson, 1985; Reddy, et al., 1991; Robertson and Gatignon, 1986; Swanson and Ramiller, 1997)

Early work in this area examined the effect of *communication channels* on diffusion, and found that adopters tend to respond to mass media channels during the knowledge stage of innovation, but place more emphasis on word-of-mouth during the decision stage (Rogers, 1995). In more recent work, researchers have gone beyond communication channels to consider other factors, including:

- Characteristics of supplier organizations, including *reputation*, extent of *marketing support*, and extent of *R&D support* surrounding the innovations they introduce (Robertson and Gatignon, 1986);
- The degree to which propagating institutions actively promote adoption via *sponsorship* or outright *subsidies* (Katz and Shapiro, 1986; King, et al., 1994; Rogers, 1991);
- The degree to which the technology is *standardized* (Attewell, 1992; King, et al., 1994; Robertson and Gatignon, 1986).

The ideal way to study propagating institutions is to analyze several technologies over time, comparing the effects of these institutions on unfolding diffusion processes. However, researchers have apparently found this approach feasible for only the simplest and most readily available factors, such as *pricing* and *advertising* expenditures (Mahajan, et al., 1990). As a result, most research relies on other approaches. Economists usually employ analytical modeling (Katz and Shapiro, 1986) or historical case studies (Cusumano, et al., 1992). Organizational and IT researchers have also used historical cases (Attewell, 1992; Cats-Baril and Jelassi, 1994). A third approach is to infer the effects of supply-side factors overall based on whether earlier adopters of a particular innovation report being influenced by such factors (e.g., (Gatignon and Robertson, 1989)).

Organizations and Adoption Environments

A central tenet of diffusion research is that to understand why some organizations are more innovative that others, we must look to the characteristics of those organizations, their leaders, and the environment in which the operate. Most studies of organizational innovation have been performed with this general objective in mind, and the same has been true of IT innovation studies (Fichman, 1992; Prescott, 1995). In this section, I briefly survey this work.

Organization and Leader Characteristics. Scores of organizational characteristics have been identified that distinguish more innovative organizations from those less prone to innovate. Table 6 provides a summary of some of the most prominent of these variables, organized into four categories: (1) organizational size and closely related structural variables, (2) other structure features of organizations, (3) personal characteristics of leaders and the workforce as whole, and (4) characteristics of the communication environment. (For a nice summary of rationales linking many of these variables to innovativeness, see (Damanpour, 1991). I address each of these four categories briefly in the paragraphs below.

1. Size and Related Characteristics. Among organizational characteristics, greater *size* has been most consistently related to adopter innovativeness (Rogers, 1995, Chp. 10.) This is a bit surprising, since in other domains, such as new product introduction, there has been mixed evidence over whether large or small firms lead the way (Lind, et al., 1989). Perhaps the best explanation is that size serves as a proxy for other positively related variables, such as *scale*, *wealth*, *specialization*, and *slack resources* (Tornatzky and Fleischer, 1990, p. 162).

TABLE 6: ORGANIZATION AND IS UNIT CHARACTERISTICS

Factors	Related Work
Size and Related variables: Host Organization Size (+), IS Unit Size (+), Scale (+), Slack Resources (+)	(Bretschneider and Wittmer, 1993; Damanpour, 1991; Fichman and Kemerer, 1997a; Grover, et al., 1997; Kimberley and Evanisko, 1981; Lind, et al., 1989; Meyer and Goes, 1988; Swanson, 1994)
Other Structural Characteristics: Centra-lization (-), Formalization (-), Specialization (+), Vertical Differentiation (-)	(Damanpour, 1991; Grover and Goslar, 1993; Kimberley and Evanisko, 1981; Kwon and Zmud, 1987; Zmud, 1982)
Characteristics of Leaders and the Workforce: Professionalism (+), Education (+), Technical Expertise (+), Technical Specialists (+), Managerial Tenure (+), Receptivity Towards Change (+)	(Ball, et al., 1987; Damanpour, 1991; Fichman and Kemerer, 1997a; Grover, et al., 1997; Kimberley and Evanisko, 1981; Swanson, 1994)
Communication Environment: Information Sources and Communication Channels (+)	(Ball, et al., 1987; Nilakanta and Scamell, 1990; Rai, 1995; Zmud, 1983; Zmud, et al., 1990)

2. Other Structural Characteristics. Regarding other structural characteristics, it has been found that more "organic" organizations, i.e., those with lower *centralization*, *formalization* and *vertical differentiation*, will be more likely to embrace new ideas, and hence, will be more likely to initiate and adopt innovations (Zaltman, et al., 1973). Interestingly, some researchers have hypothesized that "organic" firms will have more difficulty establishing the kind of consensus and singularity of purpose required to successfully implement innovations that have been adopted, and thus, should be less likely sustain implementation (Downs and Mohr, 1976; Zaltman, et al., 1973; Zmud, 1982). Or in other words, these variables may have *differently-directioned* effects depending on the stage of assimilation. As it turns out, studies of IT innovation have not found much support for this hypothesis (Fichman and Kemerer, 1997a; Grover and Goslar, 1993; Nilakanta and Scamell, 1990; Zmud, 1982), and a recent meta-analysis of organization innovation has found that these variables have effects in the same direction throughout the assimilation process (Damanpour, 1991).

3. Characteristics of Leaders and the Workforce. Traditional models of innovation have identified many characteristics of individuals that predispose them to adopt innovations for personal use, outside of the organizational context. Not surprisingly, it has been found that these sorts of characteristics, when associated with key decision makers or aggregated across the entire organization, also have affects on organizational innovation. Prominent examples of such characteristics include *education level*, *professionalism*, *number of technical specialists*, *managerial tenure*, and *receptivity towards change* (Damanpour, 1991).

4. Characteristics of the Communication Environment. Traditional models of innovation also hold that diffusion is driven primarily by communication, i.e., that when and how a prospective adopter first hears about an innovation has a major influence on adoption. Naturally, then, organizations that make greater investments in a wide array of information sources and communication channels (e.g., professional society memberships, periodical subscriptions, external seminars, internal advanced technology groups) should be more likely to lead in innovating (Nilakanta and Scamell, 1990).

Adoption Environment. Organizations do not exist in a vacuum, but rather, operate in an environment that provides opportunities and imposes constraints. Thus we see that certain sectors, such as telecommunications and financial services, tend to lead in the adoption of IT innovations, while others tend to lag. Innovation researchers have identified a number of environmental factors that can influence the general propensity of an organization to innovate, including industry *concentration*, *competitive pressure*, *profitability/wealth*, *R&D intensity, IT intensity*, and *rate of technical change* (Eveland and Tornatzky, 1990; Meyer and Goes, 1988; Robertson and Gatignon, 1986) (see Table 7). Although environment factors have not been much used in studies of IT innovation, this appears to be changing with the recent interest in technologies, such as EDI, where environment factors are especially important.

TABLE 7: CHARACTERISTICS OF THE ADOPTION ENVIRONMENT

Factors	Related Work
Adoption Environment: Concentration/Competitiveness (+), Competitive Pressure (+), Profitability/Wealth (+), R&D Intensity (+), IT Intensity (+), Rate of Technical Change (+)	(Eveland and Tornatzky, 1990; Gatignon and Robertson, 1989; Iacovou, et al., 1995; Loh and Venkatraman, 1992; Meyer and Goes, 1988; Premkumar, et al., 1994; Robertson and Gatignon, 1986)

The Technology-Organization Combination

Many of the factors that affect innovation diffusion and assimilation are not characteristics of either innovations or organizations per se, but rather, describe a particular innovation-organization combination. For example, an innovation may be highly compatible for one organization but not another. Likewise, an organization may have a strong champion for one innovation but not another. Therefore, compatibility and champions are most appropriately viewed as describing the *combination* of innovation and organization, rather than either one in isolation. In this section, I survey three categories of such factors: (1) technology-organization "fit", (2) innovation perceptions and social influence, and (3) the *delivery system* used by organization to deploy an innovation.[3]

Organization-Innovation Fit. Even though an organization may exhibit a generally high propensity to innovate over time, it may still lag in the adoption of innovations that do not fit well with organizational needs, strategies, resources or capabilities. Likewise a generally less innovative organization may still choose to be an early adopter of innovation that constitutes a good fit. This suggests attention to organizational characteristics that capture the relative fit between innovation and organization (see Table 8). For example, *wealthy* organizations are particularly well positioned to adopt high cost innovations (Downs and Mohr, 1976). High *absorptive capacity* in a domain increases the organizational capacity to assimilate innovations in that domain (Cohen and Levinthal, 1990). This, in turn, suggests that the primary antecedents of absorptive capacity—*related* *knowledge* and *diversity of knowledge*—will also predict innovativeness with respect to particular innovations (Fichman and Kemerer, 1997a). Cooper and Zmud have shown that high *compatibility* between organizational tasks and the innovation predicts adoption of MRP (Cooper and Zmud, 1990).

TABLE 8: ORGANIZATION-INNOVATION FIT

Factors	Related Work
Organization-Innovation Fit: Absorptive Capacity (+), Related Knowledge (+), Diversity of Knowledge (+), Task-Technology Compatibility (+), Wealth (+)	(Boynton, et al., 1994; Cohen and Levinthal, 1990; Cooper and Zmud, 1990; Downs and Mohr, 1976; Fichman and Kemerer, 1997a; Swanson, 1994).

Innovation Perceptions and Social Influence. How potential adopters perceive an innovation is a key determinant of adoption (Rogers, 1995; Tornatzky and Klein, 1982). Since innovation perceptions vary across potential adopters and across technologies, they are a feature of the organization-innovation combination. Innovation perceptions can operate on two levels. When the focus is the formal organizational decision to adopt, it is the perceptions of leaders and key decision makers that matter. Most innovation studies have concentrated on this level, and have studied the generic innovation characteristics from Rogers' classical model (see Table 9).

TABLE 9: INNOVATION PERCEPTIONS

Factors	Related Work
Classic Innovation Characteristics: Relative Advantage (+), Compatibility (+), Complexity (-), Trialability (+), Observability (+)	(Brancheau and Wetherbe, 1990; Hoffer and Alexander, 1992; Lai, 1997; Moore and Benbasat, 1991; Premkumar, et al., 1994; Ramiller, 1994; Rogers, 1995)
Technology Acceptance Model: Usefulness (+), Ease of Use (+)	(1989; Davis, et al., 1989; Gefen and Straub, 1997; Karahanna and Straub, 1999; Szajna, 1996)

[3]See the chapters on IT-Enabled Radical Change and Business Process Change for more on the subject of crafting effective delivery strategies for innovative systems and technologies.

However, there is a second level to consider. Even after formal adoption, it often happens that individuals within the organization have broad discretion about whether to use an innovation, and how (Leonard-Barton and Deschamps, 1988b). Thus, a key element of the post-formal adoption process for many innovations is the extent to which the technology is *accepted* among intended users, and this intra-organizational adoption process is largely driven by individual perceptions of an innovation (Kraut, et al., 1998). While researchers in this stream have examined the influence of characteristics from Rogers classical model (Brancheau and Wetherbe, 1990), the bulk of this work has focused on two constructs originally identified by Davis as part of his *Technology Acceptance Mode (TAM),* namely perceived *usefulness* and perceived *ease of use* (Davis, 1989; Davis, et al., 1989).[4] (These two characteristics may be viewed as closely related to perceived *relative advantage* and perceived *complexity*, respectively.)

While few would doubt that innovation perceptions have a major influence on adoption, this naturally raises the question of just how these perceptions are formed. There are two main schools of thought here: the *rational/contingent* school and the *social learning* school (Kraut, et al., 1998; Webster and Trevino, 1995). Adherents of the first school argue that potential adopters form perceptions primarily based on an assessment of the objective features of the technology, as conditioned by their own particular needs and capabilities (or, in the case formal adoption decisions, by the organization's needs and capabilities). Adherents of the second school argue that technology perceptions are primarily socially constructed (Fulk, 1993), i.e., they are driven by an individual's observation of *group norms* and *co-worker attitudes and behaviors* toward the innovation (Webster and Trevino, 1995) (see Table 10). While earlier work cast the two perspectives as competing (Fulk, 1993), more recent work has argued for integrating the two perspectives (Karahanna and Straub, 1999; Kraut, et al., 1998; Webster and Trevino, 1995). This integrative perspective is consistent

[4] See chapter on Individual Technology Acceptance.

with Rogers model, which holds that innovation perceptions are affected not only by objective features of the technology, but also by the actions of *opinion leaders* and *change agents* (Leonard-Barton, 1985; Rogers, 1995, pg. 330).

TABLE 10: SOCIAL INFLUENCE

Factors	Related Work
Group Norms (+/-), Co-worker Attitudes and Behaviors (+/-), Opinion Leaders (+/-), Change Agents (+/-)	(Chin, et al., 1997; DeSanctis and Poole, 1994; Fulk, 1993; Karahanna and Straub, 1999; Kraut, et al., 1998; Leonard-Barton, 1985; Sambamurthy and Chin, 1994; Webster and Trevino, 1995; Wheeler and Valacich, 1996)

Innovation Delivery System. The means by which the implementation process is supported and managed for a particular innovation is the *delivery system* for that innovation (Leonard-Barton, 1988a). Much research has been devoted to identifying the characteristics of effective delivery systems (See Table 11). Some of the more popular factors in this category include the degree *top management support* and *technology championship* (Howell and Higgens, 1990; Rai and Bajwa, 1997), and level of *training* and other resources invested in organizational learning (Raho, et al., 1987). Another element of the delivery system concerns the extent to which the facilitating mechanisms developed by propagating institutions (see prior section on Propagating Institutions) are actually sought out and employed by a given adopter. So, the positive effects of such factors as *standardization*, *subsidies*, and *consulting services*, will be most beneficial for those organizations that actually give preference to standard technologies, take advantage of subsidies, employ consulting firms, and so forth (Robertson and Gatignon, 1986).

TABLE 11: INNOVATION DELIVERY SYSTEM

Factors	Related Work
Delivery System - Factors: Top Management Support (+), Technology Champion (+), Training (+), Links to Propagating Organizations (+)	(Howell and Higgens, 1990; Lai, 1997; Leonard-Barton, 1988; Premkumar, et al., 1994; Raho, et al., 1987; Rai and Bajwa, 1997; Robertson and Gatignon, 1986)
Delivery System - Process Models: Fit of Process Model with Technology and Organization (+)	(Brynjolfsson, et al., 1997; Chew, et al., 1991; Fichman and Moses, 1999; Gallivan, et al., 1994; Markus and Keil, 1994; Orlikowski, 1993; Orlikowski and Hofman, 1997)

Yet another key part of the delivery system is the *process model* used to guide innovation implementation (Leonard-Barton, 1988). Several prescriptive models of the implementation process have been developed each intended to address a different challenge. Thus, we now have models to address challenges related to organizational learning (Chew, et al., 1991); the need to coordinate of a large number of interdependent implementation elements (Brynjolfsson, et al., 1997); the need to deal with indeterminacy about what an organization can or should accomplish with the technology (Orlikowski and Hofman, 1997); the need to build "implementability" into technologies from the start (Markus and Keil, 1994); and to the need to sustain implementation commitment and momentum (Fichman and Moses, 1999). Other research has considered more general properties of implementation processes, such as the radicalness of change processes and sought outcomes, and the pace of change (Gallivan, et al., 1994; Orlikowski, 1993).

Distinctive Characteristics of IT Innovations and Implications

For many years, researchers examining the adoption of innovations in and by organizations relied on Rogers' classical model of diffusion—or models with similar structure and explanatory variables—to guide the model building process (Rogers, 1995). However, along with the classical model comes a set of assumptions, often times only implicit, about the nature of innovations and the typical circumstances surrounding their adoption (see Figure 2).

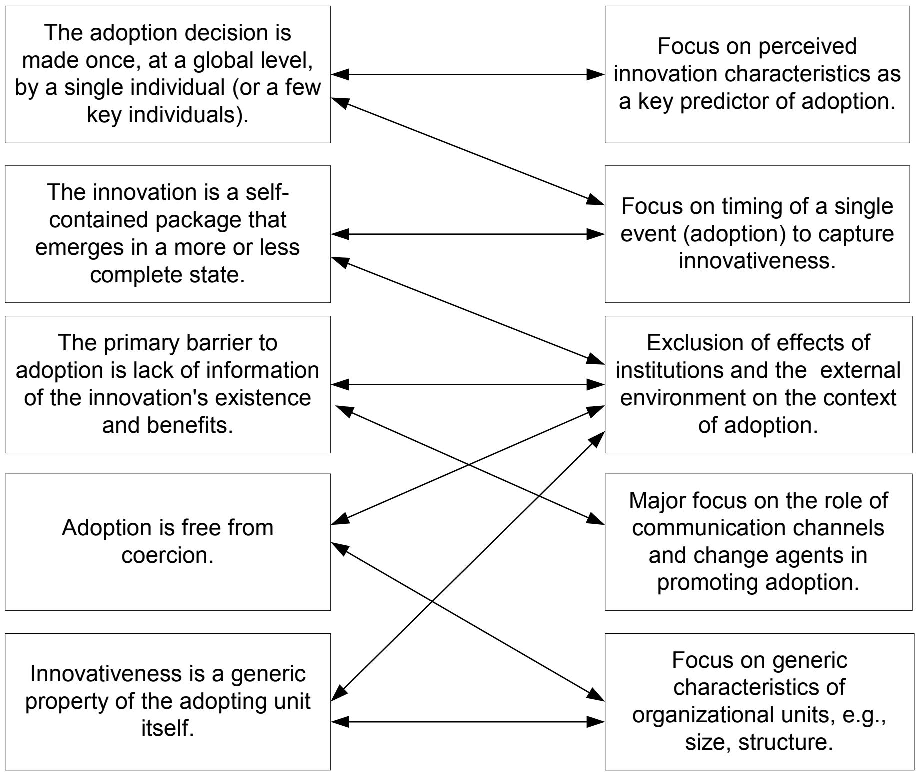

FIGURE 2: TRADITIONAL DIFFUSION MODELS AND RELATED DESIGN ELEMENTS

In some cases these sorts of assumptions hold—or at least do not introduce major problems—and traditional models can be expected to exhibit good explanatory power (Brancheau and Wetherbe, 1990). However, in other cases the assumptions do not hold, and so the burden falls on researchers develop new models—or extensions to traditional models—that better reflect the nature of the innovations under study. And this is just what many innovation researchers have done over the past decade or so. In this section, I identify several characteristics of IT innovations that are at odds with the implicit assumptions of traditional diffusion models, and summarize the implications of these characteristics for research on the diffusion and assimilation of IT innovations.

Two-Part Adoption Decisions

Many IT innovations involve a *two-part* adoption decision process, where a formal decision to make the innovation available to the organization as a whole is then followed by local decisions (by departments, workgroups, projects or individuals) about whether to actually use the innovation, and how (Leonard-Barton, 1988). Examples of innovations prone to two-part decision processes include software development tools (Fichman and Kemerer, 1999); work group support technologies (DeSanctis and Poole, 1994), and new communication technologies (Kraut, et al., 1998).

For these kinds of technologies, the very notion of *adoption* deserves special scrutiny. Should we consider an organization to have "really" adopted when senior managers give the go-ahead? Or would it perhaps be better to wait until some threshold level of actual use is reached? Depending on which definition is used, a vastly different conclusion may be drawn about the rate of diffusion of some technologies (Fichman and Kemerer, 1999). Likewise, what it means to *use* these technologies deserves additional scrutiny. Technologies can be used *faithfully*, in keeping with the intentions of designers, or *ironically* (Chin, et al., 1997; DeSanctis and Poole, 1994). Technologies can be used *richly*, in ways that expand the capacities of the medium, or they can be used *thinly* (Carlson and Zmud, 1999).

Two-part decision process mean that the latter stages of technology assimilation—from formal adoption to full institutionalization—become especially worthy of focused study. This, in turn, suggests that researchers develop richer models of the intra-organizational processes of innovation. One good example is *Adaptive Structuration Theory* (AST) (DeSanctis and Poole, 1994). As with models of innovation diffusion, AST posits that technologies have systematic features that influence the processes by which technologies are adopted and used. However, AST provides a more detailed view of the interplay between these features, the structures of adopting organizations, and the processes of technology appropriation.

More generally, two-part decision processes suggests the following design elements to researchers:

- Use measures that capture rich differences in post-adoption outcomes (see prior section on Measuring Innovativeness);
- Consider individual technology acceptance, and the factors that affect it, as a key elements of the implementation process (see prior section on Perceived Innovation Characteristics and the chapter on Individual Technology Acceptance);
- Focus attention on elements that have disproportionate influence on the latter stages of assimilation, such as factors associated with the delivery system and the process model supporting implementation (see prior section on the Innovation Delivery System);
- Develop richer models of the post-formal adoption process (as just described).

In fact, the prevalence of two-part decisions among IT innovations perhaps explains why IT researchers have taken the lead in moving the innovation field forward along the lines outlined above.

Knowledge Barriers and Organizational Learning

Although all technologies require some measure of organizational learning to be adopted, some fall on the extreme end of the spectrum in the demands they place on adopters for associated knowledge and skills. Such technologies are said to be subject to *knowledge barriers*, because the difficulty of acquiring the knowledge required to deploy them creates a barrier to diffusion (Attewell, 1992). Exemplars of IT innovations subject to knowledge barriers include technologies like Expert Systems (Gill, 1995), CAD/CAM (Liker, et al., 1992), and CASE (Fichman and Kemerer, 1999).

Knowledge barriers have important implications for innovation diffusion and assimilation. At the macro diffusion level, they suggest that vendors and other supply-side institutions, rather than focusing primarily on communicating the existence of an innovation and its benefits (as per traditional models of diffusion), should turn their attention to developing mechanisms that actively lower knowledge barriers over time (Attewell, 1992). Examples of such mechanisms include:

- Consulting and service firms that specialize in accumulating and disseminating technical know-how;
- Special buyer-supplier relationships that go beyond selling to include intensive training, technology sharing, and sponsorship of technology user-groups;
- New services that permit indirect use of the innovation (e.g., via outsourcing); and

- Technology standardization and simplification (Attewell, 1992).

At the micro level, organizations that are more able to bear the burden of organization learning[5] should be more likely to appear on the vanguard of adoption and assimilation. Characteristics of such organization include scale economies related to learning, pre-existing knowledge related to the focal innovation, and diversity in technical activities and knowledge (Attewell, 1992; Boynton, et al., 1994; Cohen and Levinthal, 1990; Fichman and Kemerer, 1997a). It also suggests a detailed focus on individual learning, and in particular, how the *nature*, not just the *extent*, of prior experiences with a technology can affect technology perceptions, appropriation, and use (Carlson and Zmud, 1999).

Finally, knowledge barriers suggest that organizations must be prepared to invest in mechanisms to facilitate knowledge acquisition during the assimilation process. Such mechanisms include intensive regimes of learning- by-doing on non-production systems (Fichman and Kemerer, 1997b); hiring of "mentors," a new kind of consultancy that actively promotes organizational learning as part of its consulting mission (Fichman and Kemerer, 1997b); use of prototyping and simulation (Chew, et al., 1991); and participation in learning-related joint ventures (Kogut, 1988; Pennings and Harianto, 1992b).

Increasing Returns and Bandwagon Effects

Telephones, e-mail, and communications technologies more generally are worth nothing to any one particular adopter unless others also adopt (Kraut, et al., 1998; Markus, 1987). These technologies illustrate an extreme case of a more general characteristic of many information technologies, namely, that the value of the technology to any particular adopter is determined largely by the size of the network of other adopters (Arthur, 1988; Farrell and Saloner, 1987; Katz and Shapiro, 1986; Schilling, 1998; Shapiro and Varian, 1998). Such technologies get more inherently attractive with each additional adoption, and hence, are said to possess *increasing returns* to adoption (Arthur, 1996). Exemplars include microprocessor chips (Arthur, 1996), packaged software (Brynjolfsson and Kemerer, 1997), and as just mentioned, communication technologies.

When a technology is subject to increasing returns, this sets the stage for a distinctive pattern of diffusion, one driven by positive feedback loops in adoption and associated "bandwagon" effects (Abrahamson and Rosenkopf, 1997; Arthur, 1996; Shapiro and Varian, 1998, Chp. 7). Characteristics of this diffusion dynamic include the following:

- A tendency towards more dramatic diffusion outcomes, i.e., rapid saturation when a self-reinforcing process takes hold, or abandonment when it does not (Abrahamson and Rosenkopf, 1997; Markus, 1987; Shapiro and Varian, 1998);
- A tendency for a "critical mass" of adoptions to be required before the technology becomes attractive to a broad community of adopters (Markus, 1987; Rogers, 1991);
- A tendency for markets to be *tippy*, i.e., once a particular instance of a technology gains the upper hand, it tends to go on to capture the market (Arthur, 1988; Kraut, et al., 1998);
- A tendency for *excess inertia* to develop around an existing standard because of reluctance among users to leave a mature network and join an immature one (Farrell and Saloner, 1987);
- A tendency for a community to become *locked-in* to widely adopted technology standards, even inferior ones such as the QWERTY keyboard (David, 1985; Schilling, 1998).

These diffusion patterns, in turn, have a number of implications for innovation researchers and managers. First, it suggests that the early part of the diffusion cycle is especially critical, and that strong *sponsorship* or the use of outright *subsidies* for early adopters may be required for some technologies, particularly those facing a well entrenched installed base, to reach "critical mass" (Katz and Shapiro, 1986; King, et al., 1994; Rogers, 1991). It has even been suggested that the diffusion of such technologies fall into two separate "regimes," with the pre-critical mass regime being driven by different forces than the post-critical mass regime (Cool, et al., 1997). Second, it suggests that the distribution of interests and/or resources in a potential adopter population can be particularly

[5] See the chapter on Managing Organizational Knowledge for more on the subject of organizational learning.

important; for example, a high degree of *heterogeneity* of interests and/or can make it possible for some technologies to bootstrap to "critical mass," even when the value of the innovation, in the absence of many adopters, is quite low for most candidate adopters (Granovetter and Soong, 1983; Huff and Munro, 1989; Markus, 1987; Oliver, et al., 1985). Third, because the ultimate value of an innovation is so dynamic and uncertain, it suggests that *managerial expectations*—about the future course an innovation, its complements, and its substitutes—will be especially influential in the in the minds of adopters (Rosenberg, 1976).

Incomplete Products/Infrastructure Dependence

Many IT innovations—especially more radical breakthroughs—initially emerge as *incomplete products* in that they only provide partial solutions to the problems they aim to address, or they are only are suitable for very specialized applications, or both (Levitt, 1986; Moore, 1992; Rosenberg, 1994, pg. 4). In extreme cases, an innovation simply can not be adopted prior to the diffusion of some necessary supporting *infrastructure*,[6] i.e., ISDN telephony applications require that ISDN be supported by telecommunication service providers. Other IT innovations that emerged as incomplete products include RISC and document imaging systems (Moore, 1992).

To be attractive to a mass market, such technologies must be broadened and deepened into a *whole product* solution (Moore, 1992). For, example, for object-oriented (OO) programming[7] to be attractive to most potential users, it must be combined with development methodologies, modeling tools, and databases that are compatible with OO (Fichman and Kemerer, 1997b). However, the primary means by which a technology is broadened and deepened is through self-reinforcing cycles of adoption and use (Fichman and Kemerer, 1999). This leads to a catch-22, where to be accepted and used a technology must become robust, but to become robust it must be accepted and used. To

[6] See chapter on Managing IT Infrastructures.

escape this catch-22, Moore has argued that suppliers must define a niche market narrow enough to enable development of whole product solution *in relation to that niche*. Then, widespread adoption within that niche can provide the further investment capital and market experience required to broaden the whole product solution to encompass nearby niches, and so on, until the technology has become attractive to the mass market.

Among adopters, incomplete products present especially high adoption risks. Since these technologies are also often subject to knowledge barriers, it can be difficult for managers to assess the full array of supporting components that comprise a whole product solution (Fichman and Kemerer, 1997b). This suggests that to manage these risks, adopters should chose initial application areas based on the feasibility of assembling a whole product implementation *in relation to that area*, not just based on the expected payoff from use in that area if the technology works as expected. Also, adopters can more explicitly acknowledge the risks involved through increased attention to expectation management, e.g., by evaluating the adoption of such technologies not according to the logic of traditional cost-benefit analysis, but according to the logic of real options (McGrath, 1997).

Linked Adoption Decisions

For most IT innovations, individual firms are free to adopt—or not adopt— based primarily on circumstances specific to their organization. This is not to say that they can ignore what other firms might do in *aggregate*, since, as explained earlier, there are compelling reasons to go along with the crowd in adopting some kinds of technologies. However, for some IT innovations the adoption decisions among two or more *particular* firms are tightly linked because the innovation changes the way they transact business. Exemplars include EDI, integrated supply-chain planning systems, extranets and other inter-organizational systems (Hart and Saunders, 1997).

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[7] See chapter on Acquiring Software Systems for descriptions of OO, CASE, component reuse and other innovations in software process technology.

When adoption decisions are linked in this way, the implications for models of innovation can be profound. To begin with, this linkage directs attention to the different *roles* firms may take with in a network of firms transacting business (Iacovou, et al., 1995; Premkumar, et al., 1994). Some may become *initiators* in the network and actively promote adoption, while others may prefer to be *followers*, with adoption being triggered by the actions of initiators. It also raises issues related to *power* (Hart and Saunders, 1997; Premkumar, et al., 1994; Williams, 1994). In some cases, a powerful firm may encourage adoption with subsidies other positive incentives (the "carrot" approach) or even compel adoption as a condition of doing business (the "stick" approach). As a result, different models of adoption may be required depending on a firm's role and relative power in the network. In addition, since these sorts of systems created new dependencies and vulnerabilities among firms, *trust* emerges as a key explanatory variable (Hart and Saunders, 1997; Hart and Saunders, 1998). Finally, since the initial decision to adopt may be triggered by different factors than subsequent decisions to expand use of EDI, this suggests the use of multiple innovativeness measures, each with some potentially distinctive explanatory variables (Hart and Saunders, 1998; Massetti and Zmud, 1996).

Future Research

Many promising avenues for future work are available to researchers interested in the diffusion and assimilation of IT innovations. In this section, I summarize a few of these research directions.

Tests of Recent Theoretical Work

The distinctive characteristics of IT innovations described above have motivated much of the recent theoretical work related to IT diffusion and assimilation. And recent tests of many of these ideas have been quite promising (see especially (Attewell, 1992; Boynton, et al., 1994; Cool, et al., 1997; Fichman and Kemerer, 1997a; Hart and Saunders, 1997; Kraut, et al., 1998; Pennings and

Harianto, 1992b) . However, the task of empirical confirmation has just begun. A vigorous stream of empirical research could be built around any one of these theoretical views.

In addition, since many IT innovations possess two or more of the distinctive characteristics described above, and since there are theoretical overlaps among them, future research could work towards combining multiple theoretical streams into a more integrated view of IT innovation. In fact, some recent work seems to be heading in just this direction. Fichman and Kemerer (1999) use knowledge barriers and increasing returns to explain the distinctive patterns of diffusion exhibited by software process technology innovations. Abrahamson and Rosenkopf (1997) draw on ideas related to organizational learning, increasing returns, and managerial fashion to model bandwagon effects in social networks. Kraut *et al.* (1998) combine elements from traditional DOI theory, increasing returns, and social influence to explain the intra-organizational diffusion (and non-diffusion) of competing video conferencing systems. Swanson and Ramiller (1997) combine ideas related to knowledge barriers, increasing returns, incomplete products, and managerial fashion into an institutional view of IT innovation (Swanson and Ramiller, 1997).

Generic Characteristics of IT Innovations

The effects of generic innovation characteristics has been a pillar of research on technology diffusion and assimilation. Yet, only recently—with the stream of research on *technology acceptance* (Davis, 1989; Davis, et al., 1989)—have researchers begun to seriously address the many conceptual and methodological difficulties (Tornatzky and Klein, 1982) with research in this area.[8] Future research could focus on incorporating the more rigorous elements of technology acceptance research into innovation field studies. This includes measuring innovation perceptions prior to adoption decisions, and in the case of organizational adoption, measured the perceptions of informants that will actually be influential in formal adoption decision process.

Also, it would be interesting to look beyond the perceptions of potential adopters when measuring innovation characteristics. As Figure 3 shows, there are two dichotomies in how innovation characteristics may be conceived—*primary* versus *secondary* (as discussed earlier), and *objective* versus *perceived*. Taken together, these two dichotomies result in four alternative approaches, only one of which (Quadrant I) has received much attention by innovation researchers.

	Perceived	Objective
Primary (Community level)	**III** Captures how complex (compatible, etc.) a potential adopter population collectively perceives a technology to be in relation to other common technologies adopted by the population. **Example**: None found	**IV** Captures how inherently complex (compatible, etc.) a technology in relation to other common technologies adopted by a population. **Example**: (Meyer and Goes, 1988)
Secondary (Adopter level)	**I** Captures how complex (compatible, etc.) a particular adopter perceives a technology to be relative to how other adopters perceive the technology. **Examples**: Most studies of IT innovation characteristics.	**II** Captures how inherently complex (compatible, etc.) a technology is for one adopter relative to how complex it is for other potential adopters. **Example**: (Cooper and Zmud, 1990)

FIGURE 3: INNOVATION CHARACTERISTICS

Measures from Quadrant I capture how complex (compatible, etc.) a potential adopter perceives a technology to be relative to how other adopters perceive the technology. In studies employing this approach, respondents typically reply to agree/disagree Likert scales, such as those developed by Moore and Benbasat (1991). Quadrant II, by contrast, captures how inherently complex (compatible, etc.) a technology is for one adopter relative to how complex it is for other potential adopters. For example, Cooper and Zmud (1990) capture the relative complexity of MRP adoption by looking at the complexity of assemblies for manufactured parts within responding firms,

[8] See chapter on Individual Technology Acceptance.

the idea being that MRP adoption will be experienced as more complex by firms with more complex assemblies. Meyer and Goes (1988) capture the relative compatibility of medical innovations in part by measuring the presence of staff physicians for the associated specialties.

Technology perceptions are affected by many factors beyond features of the technology itself and its interaction with features of the adopting unit. These other factors include the characteristics of the perceiver, and whether the prevailing social norms related to the technology are positive or negative (Kraut, et al., 1998). Therefore, the values of characteristics in Quadrants I and II can differ markedly for the same technology (e.g., managers might perceive a technology as less complex than it actually turns out to be).

Quadrants III and IV map the concepts from Quadrants I and II to the community level, thus averaging away local differences. As result, Quadrants III and IV capture differences across *technologies*, whereas Quadrants I and II capture differences across *adopters*. Although no examples could be found of Quadrant III measures (thus suggesting a potential research opportunity), Meyer and Goes (1988) show how expert opinions can be used to capture measures in Quadrant IV.

While it makes sense that Quadrant I measures are most pertinent to understanding timing of particular adoptions, for other kinds of questions—i.e., What determines the rate and pattern of diffusion? What determines the propensity to sustain assimilation of an innovation that has been adopted?—other approaches to incorporating innovation characteristics may be warranted. It might even be interesting to combine multiple approaches within the confines of the same study. This could be used to study such questions as: Which has the greater impact on adoption decisions, objective or perceived characteristics? On implementation outcomes? Does is ever happen that perceived characteristics *systematically* diverge from objective characteristics, either at the community or adopter level? When is this most likely to occur? What happens when it does?

Managerial Fad and Fashion

The effects of increasing returns provide a normatively rational explanation for the bandwagon dynamics observed for many innovations. However, not all examples of bandwagons can be attributed to normatively rational forces. From the hula-hoop to Beanie Babies, there are many instances *social bandwagons* driven by the forces *fad* and *fashion*. In an interesting stream of research, it has been argued that managerial innovations can be driven by similar forces (Abrahamson, 1991; Abrahamson, 1996; Abrahamson and Rosenkopf, 1997).

More specifically, this research posits that managers can feel pressure to keep up with current fashions in the domain of managerial innovations, and this pressure becomes an important determinant of adoption. Management-related institutions (consulting firms, university researchers, business "gurus") have an interest in creating fashion consciousness to increase demand for their innovative ideas and related services. And then, to the extent that adoption of new managerial ideas has become widespread, other forms of institutional pressure—from business partners, board of directors, and shareholders—can be brought to bear on perceived laggards. This pressure may result from a desire for the firm to look progressive, or an assumption that if an idea is popular it must hold merit, or a desire to be assured of doing no worse than the competition (Abrahamson, 1996).

Though IT innovations do of course always have a technical component, they are also managerial innovations (Swanson and Ramiller, 1997), and so it would be surprising if managerial fashion played no role in the diffusion and assimilation of IT innovations. This suggests several interesting research questions. To what extent do the forces of fad and fashion apply to IT innovations? How can we discriminate the forces of fad and fashion from the lure of genuine economic benefits that arise from increasing returns? Are organizations less likely to sustain the assimilation of innovations for which initial adoption was driven primarily by fashion consciousness?

Conclusions

Successful innovation is a key contributor to organization success. However, what it means to innovate successfully and how to build organizations and processes that facilitate more effective innovation are complex issues. Organizations can err by adopting too few innovations (i.e., fewer than their needs and capabilities would suggest) or by adopting too many. They can err by adopting the wrong innovations, ones that do not provide significant advantages given the organization's particular situation. They can err by adopting the right innovations but at the wrong time—so soon that the costs and risks of adoption exceed the likely payoff, or so late that the competition has already gained a competitive advantage. They can err by adopting the right innovations at the right time but failing implement them in a way that generates net benefits.

Fortunately, our understanding of the processes of innovation diffusion and assimilation has grown considerably since IT researchers first became interested in this area in the early 1980's. In this chapter I have endeavored to communicate the state of this knowledge. This chapter has summarized the major research questions, constructs, models and empirical findings that constitute the field. Yet, there is much more good work to be done. As researchers have considered the many distinctive characteristics of IT innovations, there has been a corresponding effort to develop more sophisticated models that go beyond traditional approaches—to incorporate the effects of institutions, knowledge barriers, increasing returns, adaptive structuration and social bandwagons to name a few. A rich opportunity exists going forward to confirm these promising streams and synthesize them into more complex and realist models of IT innovation diffusion and assimilation.

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