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Abstract
Most studies on IS innovation have focused on explaining the adoption of IT by individuals or individual organizations. In contrast, only few studies have studied adoption of IS innovations by IS development (ISD) organizations. The current study extends the recent work of Lyytinen and Rose 2003 on the adoption of radical Internet innovations in system development organizations. In this paper we develop a causal model to explain the propensity of ISD organizations to innovate radically by integrating the existing literature in radical innovation into a parsimonious model. The model explains the propensity of development organizations to engage in radical IS innovation in integrating two critical capabilities: 1) technical sensing i.e. the extent to which IS development organizations are prone to identify and adopt radical computing capabilities and development process innovations, and 2) market opportunity seizing: i.e. the extent to which the ISD organization is capable to transform these capabilities to producing radical innovations in IS deploying organizations. We identify ten predictors for radical IS innovation behaviors where seven factors tap into features of technological sensing, and three factors measure organizationâ s transformative capacity. We use time as a moderator to explain the decreasing radicalness of IS innovations over the technology lifecycle. We formulate an instrument to test the model and report of a planned sectoral study to validate the model. The study will also attempt to validate the findings about the disruptive nature of Internet computing across a broad sample of the ISD industry.

Keywords: innovation theory, radical innovation, IS innovation, adoption, innovation cores

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Explaining Radical Innovation in System Development Organizations

Introduction

In the past, radical innovation research in Information Systems (IS) has primarily investigated the adoption of software technologies, tools or novel telecommunication solutions (Fichman and Kemerer 1997, Grover *et al* 2003). Likewise in strategy and marketing literature there is emerging research on adopting radical E-business technologies (Srinivasan et al 2002). Yet, there is a dearth of research on the adoption of radical IS innovations by IS development organizations. In particular, we know little of what makes some IS development organizations capable to effectively transform emerging radical computing capabilities into novel business applications and services. This is an important research question both from the viewpoint of theory building and practice as ISD organizations form a critical link in anticipating deep changes in computing capability and shaping them into radical business innovations. By doing so they serve as critical mediators that help overcome learning barriers related to complex and untested IT technologies (Attewell 1992)

The goal of the paper is to define radical IS innovation as it applies to ISD organizations, and develop a model to explain why some ISD organizations are more innovative than others. The suggested model can be used to formulate nomological explanations how organizations transform radical computing innovations into radical applications. The paper draws upon the past research on IS innovation (Lyytinen & Rose 2003, Fichman & Kemerer 1997), and general theories on radical innovation (Hage 1980, Zaltman et al 1973, Dewar and Dutton 1986, Koberg et al 2003) by formulating a parsimonious and comprehensive model of radical IS innovation. By doing so it consolidates five years of fieldwork with innovative software firms as to explain their innovation behaviors and capabilities. We also observe how radical IS innovation behaviors are moderated by time between the genesis of the innovation and its current diffusion scope. [1]

The remainder of the paper is as follows. Section 2 defines and discusses the concept of radical innovation, and reviews the literature on radical IS innovation and radical organizational innovation. Section 3 formulates an explanatory model of radical ISD innovation for system development organizations and discusses the proposed instrument to tap into the phenomenon. Section 4 discusses the limitations of the proposed model and discusses future research to validate the model.

Past Research on Radical Innovation

Definition of Radical Innovation

Innovation can be described as an idea, a product, a technology or a program that is new to the adopting unit (Zaltman et al 1973). Innovativeness reflects the extent of novelty and uniqueness being nurtured by an organization within the context of an innovation or set of innovations (Grover et al. 2003). Innovations are normally classified as radical and incremental depending on the perceived degree of new knowledge embodied in the innovation that must be learned, and the associated height of learning barriers (Dewar and

[1] This is in line with popular theories of industrial marketing (e.g. crossing the chasm by Moore 1996) where it is deemed necessary to change observed features of the technology to make it diffuse over the whole population.

Dutton 1986, Attewell 1992). Innovation radicalness in the literature is defined as a trait that results in fundamental or significant change in inputs, outsputs or processes so that the innovation exhibits a significant departure in the adopting unit's behaviors (Hage 1980, Zaltman et al 1973, Dewar and Dutton 1986, Ettlie et al 1984). By doing so, radical innovations disrupt existing technological trajectories (Dosi 1982), and incorporate technological or process changes that are risky and more costly than those of incremental innovations (Dewar and Dutton 1986). From a learning perspective, radical innovations involve defining new problems and seizing new opportunities (exploration) in contrast to refining old certainties (exploitation) (March 1991). Overall, radical innovations integrate new and diversified knowledge, change assumptions about the environment, or technology, and / or develop new architectural principles that drive down cost or increase service quality or perception (Henderson and Clark 1990). Organizations can adopt both radical and incremental innovations both sequentially (punctuated equilibrium) and simultaneously (different innovation cores/ units) though the factors that explain the level of innovativeness in incremental vs. radical innovations are significantly different as observed in the ambidextrous model of innovation (Grover et al 2003).

We suggest the following general model to characterize and explain radical innovation as depicted in Figure 1. Both internal and external factors can drive the propensity to innovate radically (Grover et al 2003, Dewar and Dutton 1986, Damanpour 1996, Gatignon et al 2002). This increases the level of engagement in radical innovative behavior which leads to a higher likelihood of adopting behaviors that form significant departures from existing activities and practices (Damanpour 1996, Zaltman *et al* 1973). These activities, if sustained, and executed diligently will lead to disruptive innovations in industries by triggering drastic strategic choices and novel structural arrangements that change the base of competition, redefine a process, or redefine a product (Christensen 1998). Thereby radical innovations encompass higher order innovations that serve to create new industries, products or markets by making old certainties obsolete (Herbig 1994) . Many times radical innovations are comprised of technological advances so significant that no increase in scale, efficiency or design can make older technologies competitive (Tushman and Anderson 1986). Though industrial / strategic and behavioral definitions of radical innovation are separate, they are closely related constructs: radical changes in behaviors may or may not result in radical industrial innovations, whilst radical industrial innovations are always outcomes of preceding radical behavioral changes.

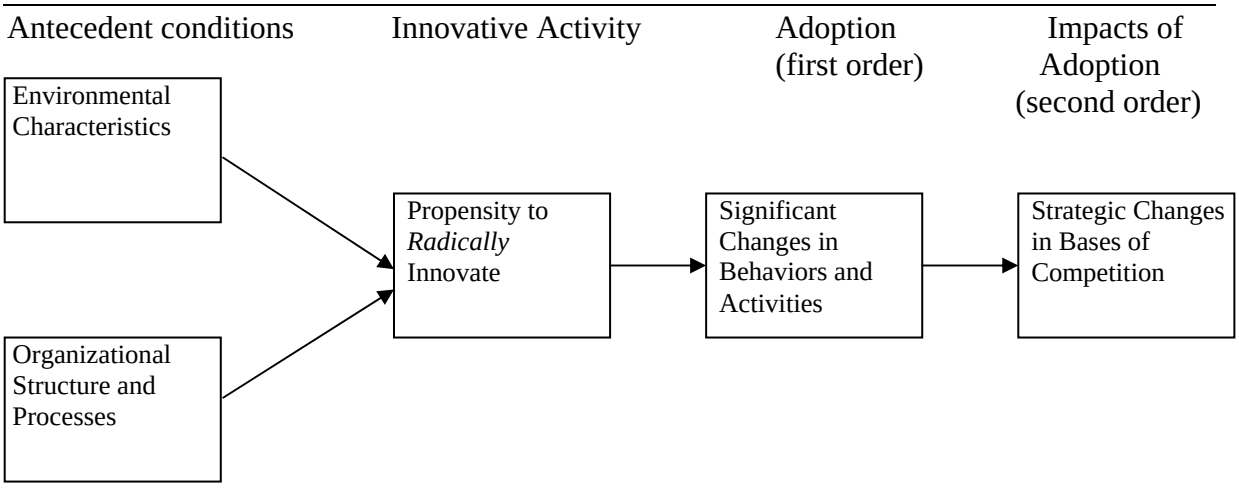

Figure 1. Model of Radical Innovation

Radical Innovation in the IS field

In the IS field, the concept of radical innovation has scarcely been applied. Most radical IS innovation research has focused on overcoming learning barriers created by complex IS solutions (Attewell 1992, Fichman and Kemerer 1997). At the same time there is a huge and rich literature in explaining how IT deployment creates strategic and competitive advantages.[2] In this stream of research, radical IT innovations like Amazon.com or the Sabre reservation system are but two examples how companies created new markets and unprecedented services or drastically drove down costs.

One reason for the lack of radical innovation research in the IS field is the inherent difficulty in addressing what radical innovation means in the IS field: it clearly has multiple sources and a broad scope that covers a range of activities in the IT value chain (Swanson 1994). Hence, radical innovation within IS is not a necessarily a singular event, but subsumes a causal chain of events which all portray significant departures from existing practices. A radical "IS innovation" must traverse through a complex ecology of IS innovations as illustrated in Figure 2 (Swanson 1994, Grover et al 1997, Lyytinen and Rose 2003). The figure shows three primary value adding activities in the IT domain: 1) creation of IT base technologies and capabilities by vendors and manufacturers (e.g. Intel, Microsoft, IBM), 2) development of application and services by software developers, system integrators and IS departments called IS development organizations (Accenture, IBM, CAP-GEMINI), and 3) and adoption of IT solutions by IS deploying companies (e.g. Amazon.com). Arrows in Figure 2 show how downstream organizations must adopt innovations produced and innovated by companies in the upstream to increase the overall scope of IT deployment.

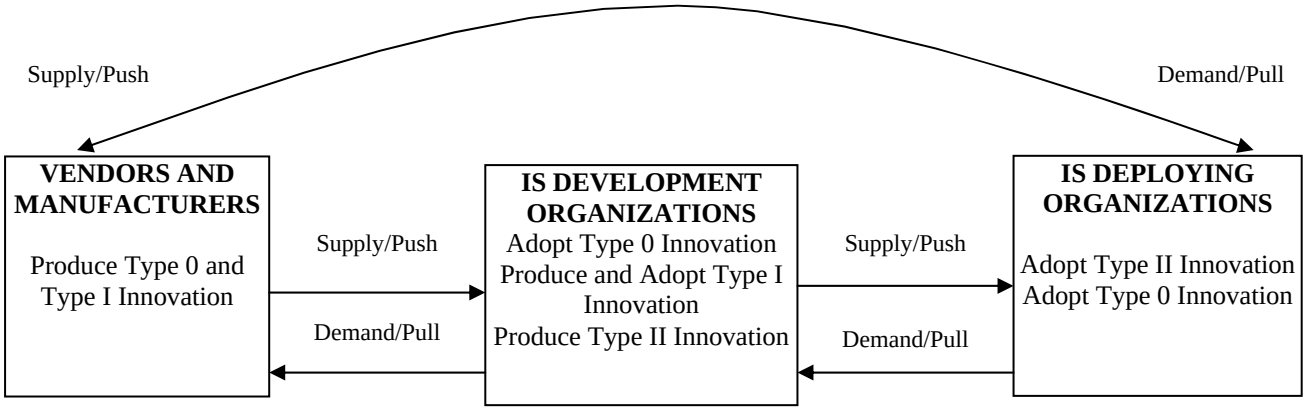

Figure 2. IT Value Chain and Realms of IS Innovation

Radical IT innovation in light of this model can mean many things (Lyytinen and Rose 2003): breakthroughs in computing capability and architectures (Radical Type 0 innovation), radical departures in ways to develop and design computing applications (Radical Type I innovation), or novel applications and/or ways of applying them (Radical Type II innovation). The value chain also suggests that radical innovations can take place in any part of the value chain in ways that do not necessarily affect other parts. In this case we talk of radical IT base, development or IS innovations.

Due to the technology dependent nature of IS innovation, IS development organizations adopting radical Type 0 and I innovations *together* may result in *production* of

[2] Evaluating and discussing this literature is clearly beyond the scope of this paper. See e.g. recent review by Wade and Hulland (2004).

radically new applications (Type II) for IS deployment organizations. In situations like this, ISD organizations take part in *disruptive IS innovation* (Lyytinen and Rose 2003a) where pervasiveness and radicalness characterize innovation activities across all innovation types and subtypes. These disruptions are outcomes of radical changes in the IT base, including architectural innovations, where existing components in the computing base can be assembled in novel ways via new modalities to create significantly different products and services (Henderson and Clark 1990). As identified in Lyytinen and Rose (2003a, 2003b), Internet computing was a disruptive innovation created by (Type 0) architectural change (TCP/IP-based tools and n-tier computing) made radical with the addition of browsers, data formatting standards and software platforms (J2EE, .Net, etc.) that enabled development of radically new services across the other innovation types (I and II). Lyytinen and Rose 2003a is the first study to find evidence of radical innovation across the IT value chain (Figure 2) and it suggests how ISD and the adopters of software services can be transformed by radical innovation. However, there is no research to date that identifies the characteristics of firms that engage in radical innovation adoption/creation cycles. Further, the case studies in Lyytinen and Rose 2003 do not provide evidence of the existence of disruptive innovation across the general ISD industry.

The research issue for the IS field is to understand the extent that abrupt changes in computing capability (Type 0) *can* and *will* lead to radical innovations in the development activities (Type I) and the consequent production of radical applications (Type II) when these changes are adopted by the IS development organizations. Further, what characteristics explain radical innovation and adoption across the ISD value chain. We conjecture that this radical innovation capability is produced by two combined capabilities within some ISD organizations: 1) the capability of IS development organizations to adopt radical Type 0 and I innovations, and 2) the capability of ISD organizations to successfully *transform* these new capabilities into radical Type II innovations that are adopted by client organizations. Together these traits define the *radical innovative capacity of ISD organizations* and we argue that it is critically dependent on the simultaneous mobilization of both capacities. The first capability -- *technology absorbtion* -- is reflected in an organization's ability to efficiently sense, acquire and absorb new technologies and to deploy them effectively (called technological sensing in Srinivasan *et al.* 2002). The second capability -- *market opportunity seizing* -- is reflected in an organization's: (1) ability to observe occasions of radical IT deployment; (2) to successfully attract clients that are predisposed for adoption of radical IT innovation; (3) to sense the needs or opportunities for radical innovation within their client organizations; (4) to effectively communicate technological capability in business terms to their clients; and (5) to apply absorbed technological capability over a number of application domains (Koberg et al 2003). In other words, succesful radical innovators among ISD organizations can effectively and continuously identify and match the needs and strategic opportunities of IS deploying organizations (clients) with the emerging computing capabilities.[3]

The following questions constitute research questions in radical IS innovation from the view point of ISD organizations:

1) What explains the adoption of Type 0 and I radical innovations by some ISD organizations (technological absorption capability)?

[3] Note that Figure 2 emphasizes that radical innovation is not a product of one-way communication from ISD organizations to their clients. Our model recognizes that there is a combination of supply/push and demand/pull mechanisms and that ISD organizations engaged in radical innovation can be effective at either or both active pushing or reactive sensing of client demands and environmental pressures.

2) What explains the predisposition or tendency of some ISD organizations to transform type radical 0 and I innovations to production of radical Type II innovations (transformative capacity)?
3) Can evidence of interrelated radical innovation be found in all three innovation types across a portion of the ISD population and thus validate the notion of disruptive innovation in ISD?

Adoption and Creation of Radical Innovation

The literature identifies a combination of factors that explain the adoption or creation of radical innovation. With regard to ISD organizations we observed ten factors that *simultaneously* predict the adoption of radical Type 0 and Type I innovations and the production of radical Type II innovations. While there is a wealth of literature on non-radical innovation adoption (Damanpour 1996), the existing literature on radical innovation is scarce (Koberg et al. 2003; Srinivasan et al. 2002). This is expected as radical innovations are less common (Koberg et al. 2003), difficult to define and measure, and strenuous to study and observe. It is no wonder they have not been the focus of innovation research except under specific conditions (e.g. periods of disruptive innovation in Lyytinen and Rose 2003a and 2003b). The specific role of and circumstances surrounding ISD organizations, which operate at the forefront of radical IS innovation, however, requires that IS researchers are heedful to radical innovation behaviors.

A diligent literature search identified only nine empirical studies that explain characteristics of radical innovation adopters and creators[4]. Out of these nine, seven explicitly model radical innovations (Damanpour 1996; Dewar et al. 1986; Ettlie et al. 1987; Germain 1996; Grover et al. 2003; Koberg et al. 2003; Srinivasan et al. 2002).[5] Yet, of these seven, only two deal with information technology (Grover et al. 2003, Srinivasan et al. 2002), and none involve ISD organizations. Two additional studies were identified on this topic by additional examination of the literature. Both of these deal with ISD organizations' innovation adoption, but neither explicitly states radical innovation. Fichman *et al*. (1997) looked at the adoption of object-oriented programming languages (OOPL) by ISD organizations. The study explains that OOPL adoption requires a significantly high degree of new learning, which suggests that the studied innovation is radical (Srinivasan 2002). The study is based on the earlier work by Attewell (1992) which argued that at early adoption phases IT innovations are more radical in that they require a degree of organizational change that is "hard to overstate" (Fichman *et al*. 1997, p. 1347). With the passage of time these innovations become less radical as the environment provides complementary assets that lower the learning burden. Another IS study is Grover *et al*. (1997), which measured the early adoption of complex Type 0 innovations (OOPL, local area networks, relational databases, etc.) by IS departments.

From this limited literature we learn that radical IS innovation in ISD organizations can be predicted by a combination of ten characteristics, which can be categorized as internal (organizational) or environmental variables. These ten antecedents to radical innovation adoption are listed in Table 1 (and identified as

[4] Radical innovation *creation* literature was also sought out. Only Koberg et al. 2003 was found to address creation of radical innovation. No other empirical studies explaining radical innovation characteristics were identified.

[5] Note that Grover, V., Segars, A., and Purvis, R. "Exploring Alternative Models for the Adoption of Innovative Telecommunications Technologies," Americas Conference of Information Systems, Orlando, Florida, 2003, pp. 1-3. is a brief conference publication summarizing the unpublished work in Grover, V., Segars, A., and Purvis, R. "Exploring Ambidextrous Innovation Tendencies in the Adoption of Telecommunications Technologies," *Working paper*) 2004.. Both are used in this analysis but only the published version, albeit short, is included in this count.

"organizational" and "external" variables in the second column). Each of the ten constructs has been found to be statistically significant predictors of radical innovation as shown by the list of references in the right-most column. The eleventh row in Table 1 deals with the eleventh factor, innovation age, which is argued by Attewell (1990) and Fichman and Kemerer (1997) to be inversely related to radical innovation adoption.

CONSTRUCT / # OF INSTRUMENT ITEMS	**CONSTRUCT TYPE**	**DESCRIPTION**	**SOURCES (those adopted for instrument are in bold)**
Depth of Knowledge Resources (2-item measure)	Organizational	# of full-time technologists actively building services	**"Learning Related Scale" (Fichman, 1997);** "Depth of Knowledge Resources" (Dewar, 1986); "IS Size" (Grover, 1997); "Organization Size" (Ettlie, 1987; Damanpour, 1996; Germain, 1996)
Structural Complexity (2-item measure)	Organizational	# of units below CEO level & # of job titles	**"Structural Complexity" (Damanpour, 1996);** "Specialists" (Grover, 2003;Grover, 2004);
Diversity of Knowledge (3-item measure)	Organizational	# of languages, platforms, or architectures previously used for developed services	**"Diversity of Knowledge" (Fichman, 1997)**
Related Assets (3-item measure)	Organizational	Amount of knowledge or infrastructure already in place related to radical innovation adopted	**"Complimentary Assets" (Srinivasan, 2002)**; "Related Knowledge" (Fichman, 1997)
Intra-firm Structural Linkages (8-item measure)	Organizational	Extent development project teams share knowledge	**"Intra-firm Structural Linkages" (Koberg, 2003)**
Experimentation (6-item measure)	Organizational	Extent of experimentation and pilot projects and slack resources to do so. Includes "future focus"	**"Experimentation" (Koberg, 2003);** "IS Slack" (Grover, 1997)
Technological Opportunism (8-item measure)	Organizational	Extent of BOTH technology-sensing (exploration) and technology-response (exploitation) capabilities COMBINED	**"Technological Opportunism" (Srinivasan, 2002);** "Professionalism" (Grover, 1997); "Vendor Interaction" (Grover, 2003;Grover, 2004)
Environmental Pressures (8-item measure)	External	Demands from significant change in: (1) client needs, (2) competition, and (3) base technology	**"Institutional Pressures" (Srinivasan, 2002);** "Environmental Dynamism" (Koberg, 2003)**;** "Environmental Uncertainty" (Germain, 1996);
Unit Autonomy (3-item measure)	External	Freedom of client to make decisions independent of other functional areas in their organization	**"Integrative mechanisms" (reverse scale) in (Germain, 1996)**
Adopters' IT Strategic Congruence (4-item measure)	External	Extent to which IT is a strategic part of client organization	**"Corporate Congruence" (Grover, 2003;Grover, 2004)**
Age of Innovation (1-item measure)	Moderating	Year innovation was first adopted in target population	**"Year First Adopted" (Grover, 1997)**
Radicalness of Innovation (5-item measure)	Outcome	How radical was the innovation adopted (for Type 0, 1 and 2 innovations per Lyytinen and Rose, 2003a)	**Radicalness (Gatignon, 2002)**

Table 1. Predictors of Radical Innovation Adoption

As can be seen from the diversity of predictors in Table 1, as well as the lack of overlap in the sources in the right-hand column, to date there has been little integration of the disparate findings of these limited works on radical innovation adoption and creation. The model proposed here is an attempt to find this comprehensive view of radical innovation and specifically apply it to ISD organizations. Next we shall outline the logic and justification for each identified factor in the model.

Factors Explaining Radical Innovation

Internal (organizational) factors

We observe overall seven (internal) organizational factors. Out of these seven, four characterize a configuration of capabilities that promote radical innovation within the firm. These four are: 1) Depth of Knowledge Resources; 2) Specialists; 3) Diversity of Knowledge; 4) Related Assets. The remaining three relate to features of processes where these capabilities are mobilized in ways that promote radical innovation. These three are: 5) Intra-firm Structural Linkages; 6) Experimentation; and 7) Technological Opportunism. Theoretical support for each of these organizational factors is detailed below.[6]

Organizational Configuration Factors

Firms that are likely to adopt radical innovations have built a specific configuration of capabilities at their disposal. In other words they have resources in place that are either dedicated to absorb the inevitable costs of radical change, or to lower the barriers of early adoption, or both. As such they thus predict an organization's effectiveness in "technology sensing". As noted above (Lyytinen and Rose 2003a), ISD organizations must adopt both radical Type 0 and radical Type I innovations in order to exhibit radical transformative capacity. Subsequently, adoption of both types of radical IT innovation should be seen in innovative ISD firms.

Depth of Knowledge Resources. The most often mentioned predictor of radical innovation adoption in the literature is the number of employees. While there is some evidence to the contrary (see e.g., Damanpour 1996 for a summary of those arguments), a majority of research suggests that larger firms are better equipped to deal with the burden of radical change and associated risk. Size is often measured in terms of the total number of employees (Damanpour 1996; Ettlie et al. 1987; Germain 1996). Other studies have measured organizational size only in terms of the number of "relevant" employees and pointed out that this is the appropriate predictor (Dewar, 1986; Fichman, 1997; Grover, 1997). In the case of ISD organizations, the measure should accordingly reflect the number of IT technologists, and exclude other employee groups such as the clerical or janitorial staff. Lacking a theoretical reason from the literature why either of the radical innovations adopted by ISD firms (Type 0 or I) should be excluded from these relationships, overall we propose:

[6] Grover et al. (2003), Grover et al. (1997), and Swanson (1994) provide evidence that different antecedents predict three innovation types recognized in Figure 2. While some predictors are antecedents across the whole spectrum of IS innovations, others have been shown to only predict a subset (Grover et al. 2003, Grover et al. 1997). Accordingly, we suggest that the adoption and creation of radical IT innovations is predicted by a different set of antecedents for different innovation types. Hence, not all antecedents found to predict adoption of one IT innovation type necessarily predict innovations in other types. In the following when theoretical support exists for differentiating among or excluding certain of the three innovation types in our hypotheses concerning radical innovation antecedents, it will be specified.

H_{1a}: Adoption of radical *Type 0 IT Innovations by the ISD Organization is positively* related to the total number of technologists employed by the ISD organization.

H_{1b}: Adoption of radical *Type I IT Innovations by the ISD Organization is positively* related to the total number of technologists employed by the ISD organization.

Structural Complexity. Another common measure is the degree of specialization (diversification) among employees. The number of varying job specialties represents an ISD organization's ability and commitment to seek out and absorb radical innovations (Grover, 2003; Grover, 2004; Damanpour, 1996). Basically, an organization more prone to take the burden of a radical innovation is likely to posses a larger set of specialized skills to adopt and exploit all subcomponents of that innovation. Damanpour (1996) identifies two mechanisms (number of functional units and the greater the number of job titles) to capture this characteristic, which he terms "structural complexity." Again, there is no evidence why either Type 0 or I innovation adoption would differ in this regard based on the existing literature.

H_{2a}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to the degree of technical job specialization in the ISD organization.

H_{2b}: Adoption of radical *Type I Innovations by the ISD Organization is positively* related to the degree of technical job specialization in the ISD organization.

Diversity of Knowledge. While "specialization" is a measure of pertinent job specialization, diversity of knowledge is a measure of necessary skills and their volatility needed to innovate. In Fichman and Kemerer (1997) ISD organizations that had more experience in adopting radical Type 0 innovations were claimed to more easily adopt other radical innovations. Specifically, early adoptions of radical programming technologies were predicted by the number of programming languages, architectures, and platforms known (by at least 5% of the current staff), or previously exploited by the organizations (5% or more of their services in the prior 3 years).[7] These findings suggest that a threshold to adopting a radical innovation was significantly lowered by previous learning experiences. We propose accordingly:

H_{3a}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to the number of preceding Type 0 innovations (programming languages, architectures, and platforms) adopted and exploited by an ISD organization.

Fichman and Kemerer (1997) specifically measure the adoption of radical Type 0 innovations in ISD organizations. Adoption of Radical Type 0 innovations in ISD groups has been shown in Lyytinen and Rose (2003a) to be a condition that predicts subsequent radical innovation (both creation and adoption) in Type I by ISD organizations. Accordingly we suggest:

[7] It is unclear if the items used meant to exclude grafted knowledge via confederations of groups such as business partners or outsourcers, and could be interpreted either way. Therefore, use of this construct will require attention to be paid to both internal IT staff as well as external sources that lead to exploitation of knowledge in services created by the firm.

H_{3b}: Adoption of radical *Type I Innovations by the ISD Organization is positively* related to the number of preceding Type 0 and Type I innovations (programming languages, architectures, and platforms; methods, tools, and guidelines) adopted and exploited by an ISD organization.

Related Assets. Related assets refer to those assets (in the form of infrastructure or knowledge) that ease the burden of adopting a radical innovation. Whereas the diversity of knowledge is a general measure of the ability of a firm to adopt radical innovations, related assets measure how much of the complexity of the innovation has been already absorbed by the organization. While not totally eliminating the radicalness of the innovation, complementary assets (Srinivasan et al. 2002) or related knowledge (Fichman et al. 1997) render a radical innovation less radical for the adopting organization. These assets lower the threshold of a firm to commit itself to adopting the innovation and decrease the amount of resources it needs to mobilize to do so. By doing so, organizations possessing related assets can obtain a head start over their competitors in deploying radical technological innovations.

H_{4a}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to the number of related technology assets already in use by that organization.

Again, since Fichman and Kemerer (1997) measured only the adoption of radical Type 0 innovations in ISD organizations, we likewise assume that a similar condition prevails that predicts Type I radical innovation in the same organizations (Lyytinen and Rose 2003a):

H_{4b}: Adoption of radical *Type I Innovations by the ISD Organization is positively* related to the number of related technology assets already in use by that organization.

Organizational Process Factors

In addition to configuration attributes, we also observe three organizational processes that will increase the likelihood of radical innovation. In particular, these factors help explain how deep and diverse obtained technological capability is transformed into radical Type II innovations in client organizations. Hence we assume that ISD organizations that radically innovate in all three IS innovation types (either adopting, creating or producing) must possess both structural and organizational process capabilities. Lack of process capabilities results in unused technological excellence that produce useful applications.

Intra-firm Structural Linkages. Koberg *et al.* (2003) define intra-firm structural linkages as "cross-functional and coordination mechanisms, designed to increase integration" (p. 33) among teams that innovate. These linkages connect ideas and collaboration across a variety of people working on different but related subsets of a given problem domain. Accordingly, the absence of "interplay of ideas among individuals can impede all types of innovation" (p.27). While not limited to radical innovations, these linkages have been found to predict radical innovation (Koberg et al. 2003). Koberg *et al*. (2003) indicate that these linkages promote radical innovation activity as such, and *not simply the adoption of innovation*. Hence, this factor may not directly indicate adoption of Type 0 innovations in ISD organizations. It can, however, predict the creation of radical Type I and II innovations

by the ISD organizations. Since these groups internally produce (and subsequently adopt) radical Type I innovations, as well as produce radical Type II innovations (for the adoption by their clients), the following hypotheses are proposed.

H_{5a}: Creation and adoption of radical *Type I Innovations by the ISD Organization is positively* related to the Intra-firm structural linkages in the organization.

H_{5b}: Production of radical *Type II Innovations by the ISD Organizations is positively* related to the Intra-firm structural linkages in the firm.

Experimentation. Experimentation allows managers to "proactively pursue and recognize new opportunities early" (Koberg et al. 2003, p. 28) and subsequently these firms are more prone to radically innovate (again, the act of radical innovation itself). As noted, since ISD organizations create Type I and produce Type II innovations, the following hypotheses are suggested:

H_{6a}: Creation and adoption of radical *Type I Innovations by the ISD Organization is positively* related to the level of experimentation in the organization.

H_{6b}: Production of radical *Type II Innovations by the ISD Organization is positively* related to the level of experimentation in the organization.

Similarly, IS Slack (Grover et al. 1997), as measured by the relative profitability of the firm, "allows units to experiment and pilot projects in advance of an actual need" (p. 276) and it has been shown to predict adoption of Type 0 innovations specifically by ISD organizations. Accordingly we propose:

H_{6c}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to the level of experimentation in the firm.

Technological Opportunism. The final organizational process factor is technological opportunism (Srinivasan et al. 2002). Firms that are predisposed to "sense and respond to new technology opportunity developments" (p.48), are better able to identify and exploit radical innovations. Technology sensing is essentially the same construct as professionalism (Grover et al. 1997); and Vendor Interaction (Grover et al. 2003; Grover et al. 2004), although these construct do not specify the main cause of the effect. Regardless of whether a firm senses technology, because it is seeking it out to peers, (aka professionalism) or because of its strong relationships with external vendors (aka vendor interaction), technology sensing measures whether a firm has successfully identified radical innovations. All studies on radical innovation indicate that technology sensing is an important determinant in acquiring external radical innovations. In addition, (Srinivasan et al. 2002) indicates that it is only half the equation, and that also a history of effectively exploiting these new technologies contributes to the ability of a firm adopting radical innovations. Accordingly we suggest:

H_{7a}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to the technological opportunism in an ISD organization.

Since (Grover et al. 1997) measured this effect in ISD departments, using the rationale noted above (Lyytinen and Rose 2003) we propose:

H_{7b}: Adoption/Creation of radical *Type I Innovations by the ISD Organization is positively* related to the technological opportunism of that organization.

Environmental Factors

In addition to the seven organizational factors, three additional environmental factors will predict radical innovation within ISD organizations: 8) Environmental Dynamism; 9) Unit Autonomy; and 10) Adopters' IT Strategic Congruence.

Environmental Pressures. The radical innovation adoption literature indicates that pressures in the environment lead to radical innovations in organizational populations. Referred to as "environmental dynamism" (Koberg et al. 2003) "environmental uncertainty" (Germain 1996); and "institutional pressures" (Srinivasan et al. 2002), literature shows that uncertainties in and demands from providers, competitors, stakeholders, and customers lead organizations to adopt radical innovations to meet these demands or adjust to new uncertainties. Since both the Koberg et al. (2003) study of radical innovation as well as the Germain (1996) and Srinivasan et al. (2002) studies of radical innovation *adoption* share a variant of this construct, radical innovation and adoption of radical innovations are suggested by the literature. Accordingly, the following hypotheses are suggested.

H_{8a}: Adoption of radical *Type 0 Innovations by the ISD Organization is positively* related to Environmental Pressures of an ISD organization.

H_{8b}: Adoption/Creation of radical of radical *Type I Innovations by the ISD Organization is positively* related to Environmental Pressures of an ISD organization.

H_{8c}: Production of radical *Type II Innovations by the ISD Organization is positively* related to Environmental Pressures of an ISD organization.

Similar to the relationship of environmental pressures on radical adoption, the remaining two variables, *"unit autonomy"* and *"adopters' IT strategic congruence,"* are environmental conditions that predict radical innovation adoption in an ISD organization. What is different, however, is that the effect is indirect in that these variables both predict adoption of radical innovation by the ISD group's clients, which in turn predicts production of radical innovations in the ISD organizations. As proposed in Swanson (1994), and empirically supported Lyytinen and Rose (2003a), ISD innovations are often responses to external demands, or pressures. Specifically, radical innovation by vendors (Type 0) or by clients (Type II) lead ISD organizations to adopt radical Type 0 innovations and create/ adopt radical Type I innovations in order to subsequently produce Type II radical innovations. In particular, if we are dealing with a radical innovation of Type II, radical innovations in Type 0 and I are many times necessary (albeit not sufficient) precursors for it (Lyytinen and Rose 2003). As a result, if clients demand radical innovations of Type II, radical Type 0 adoptions and Type I adoptions may have to be put in place in the ISD organization providing that innovation. Likewise, ISD organizations with clients receptive to adoption of Type II radical innovations will be in a position to successfully adopt the required radical tools and processes (Type 0 and I innovations). With that in mind, two variables have been identified that enable the prediction of adoption of radical Type II innovations by ISD organizations' clients[8] and the subsequent adoption of radical Types 0 and I.

[8] Technically, any of the previous factors that predict radical innovation, if true for the client firm, would predict radical Type II innovation adoption by the client firm. They are excluded from the study for three reasons: 1)

Unit Autonomy. The first attribute of client firms involves the relative autonomy of the business unit which the ISD organization is serving. Noted as "integration" (a reverse scale) in (Germain 1996), the idea is that a business unit that has more autonomy to is more prone to adopt radical innovation due to the lack of interference from unrelated business areas. Therefore, if an ISD firm has noted its customers to be more autonomous, they are more likely to adopt radical Type II innovations. Using the logic stated above, the following hypotheses are suggested:

H_{9a}: Adoption of radical *Type II Innovations* in IS deploying organizations (client firms) is positively related to Unit Autonomy in those organizations.
H_{9b}: Adoption of radical *Type 0 Innovations* in ISD organizations is positively related to Unit Autonomy of their client firms.
H_{9c}: Adoption of radical *Type I Innovations* in the ISD organizations is positively related to the Unit Autonomy of their client firms.

Internal unit autonomy of the ISD functional area of the ISD organization itself has not been included in our model because the unit itself is the strategic purpose of the firm. It would not be logical for the functional areas (e.g., marketing) outside of the development function to have their goals be inconsistent with the goals of the development group and take precedent.

Adopters' IT Strategic Congruence. Similar in effects with client unit autonomy is the client's IT strategic congruence. Called "corporate congruence" (Grover et al. 2003; Grover et al. 2004), a firm that has aligned its IT as a strategic part of its business is more likely to adopt radical IT innovations. Using the same logic as for H_{9a-c}, the following hypotheses are suggested:

H_{10a}: Adoption of radical *Type II Innovations* in client firms is positively related to IT Strategic Congruence in those firms.
H_{10b}: Adoption of radical *Type 0 Innovations* in the ISD organizations is positively related to IT Strategic Congruence by their client firms.
H_{10c}: Adoption of radical *Type I Innovations* in the ISD groups is positively related to IT Strategic Congruence by their client firms.

As was the case with unit autonomy, IT strategic congruence is not included as an internal construct of study for ISD organizations. IT strategic congruence is assumed for ISD organizations since they are all dependent on IT for their *modus operandi*.

Moderating Factor: Innovation Age

Time. Time must be included into the model as a predictor because it acts as a confounding variable (Attewell (1992): the same innovation becomes over time less difficult for firms to adopt as a result of continued refinements in the innovation and resulting hiding of its complexity and in later stages of diffusion curve the adoption can no longer be regarded

many if not all of those other variables are difficult for the ISD organization to know about their clients but the studied variables should be known as part of the normal sales process; 2) the variables have shown predictive ability for radical adoption but do not apply to ISD organizations because of their nature as strategic exploiters of IT with missions toward building IT services; and 3) there are limits to questionnaire length for a fear of participant fatigue and these two factors seem to compliment Environmental Pressures.

as radical (Rogers 1995). Therefore it is expected that for later adopters the same innovation as measured in the preceding hypotheses will be deemed less radical. Accordingly they need less expertise, diversified knowledge, induce investments that are less risky, do not involve experimentation or tight cross-organizational linkages. They have also become commodities and do not involve strategic intent,
Accordingly we propose:

H_{11a}: Innovation radicalness will be lower for those ISD organizations that adopt the same innovation later.
H_{11b}: The significance of innovation radicalness predictors will be lower for those ISD organizations that adopt the same innovation later.

A summary of the suggested model of radical IS innovation within IS development organizations is shown in Figure 3 and it offers an explanatory model to address the three research questions posed in section 2 above.

Methodology and Instrument Development

For the identified eleven predictors existing validated measures as noted in Table 1 will be adopted and modified. The outcome measure of radical IS innovation adoption will be a combination of five items. We suggest that adopted innovations will need to represent each of the three innovation types (Lyytinen and Rose 2003a; 2003b) and we will use Internet computing innovations as an example of radical innovation. As shown in Lyytinen and Rose (2003a; 2003b) innovations in each type at some point were radical and we expect that by 2004 in some areas they have become less so (moderating factor of time). Yet the change is so recent that it is possible to tap into a population, which covers both early and later adopters. Therefore, Internet computing innovations in each type will be used to capture the extent and scope of radical IS innovation adoption by studied ISD organizations.

Each of the three innovation types will be defined using a variation of Srinivasan *et al's* (2002) measure where they define a Type II innovation construct as follows: "we define e-business (Type II) as the use of Internet-based systems to share business information, maintain business relationships, and/or conduct business transactions." Similar descriptions will be developed to represent Types 0 and I innovations described in Lyytinen and Rose (2003a). For each of these innovation types, the degree of radicalness (perception) and time of adoption (objective measure) will be captured. A measure of radicalness will be adopted from Gatignon, *et al*. (2002) who developed an instrument for measuring a wide array of innovation characteristics. Time will be measured by asking the year when a specific innovation Type (0, I, II) was adopted. This is consistent with Grover, et al. (1997) when they measured early vs. later innovation adoption.

The final instrument will be modified based on pilot tests in using multiple field interviews. In line with the studies in Table 1, the validated instrument will be mailed to either the CEO or CTO of a representative sample of ISD organizations. A wide array of organizations will be included so as to have a diversity of predictor and outcome values. The hope is to have preliminary data to present at ICIS in December.

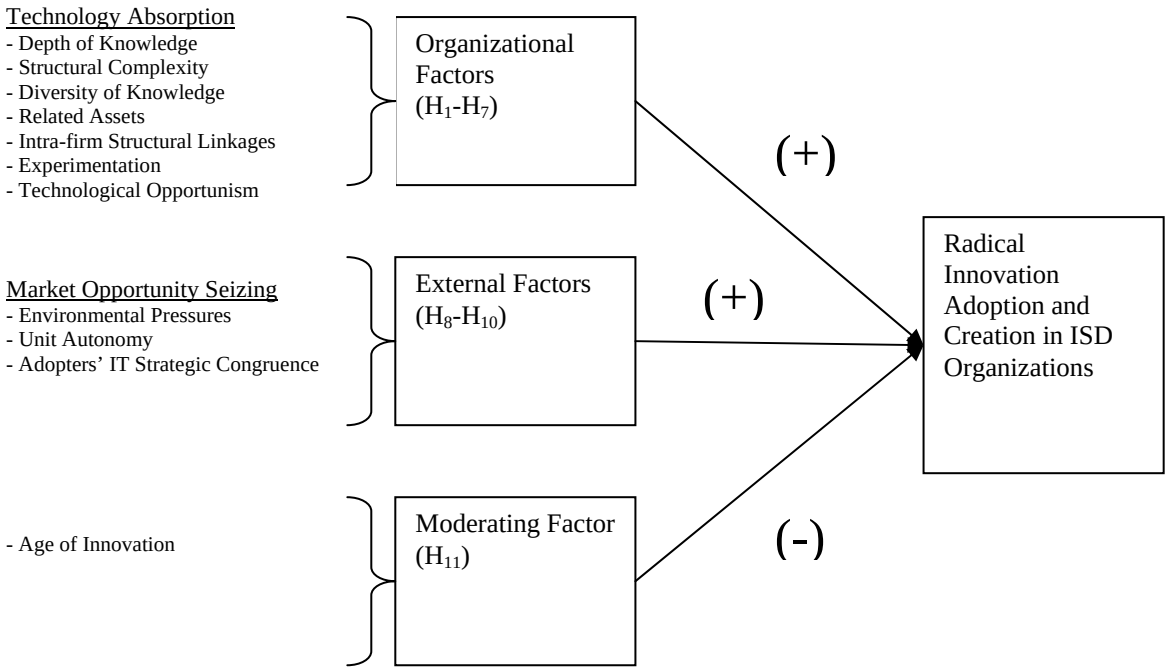

Figure 3. Model of radical innovation by IS development organizations

Conclusions

In this paper we have developed a predictive model to explain the level of innovation radicalness in IS development organizations. It is a first proposed model to explain propensity to radically innovate in ISD organizations. It draws upon and integrates recent findings in radical innovation theory and organizes them into a set of propositions that recognize the complex dynamics of IS innovation in the IT value chain and is thus a theoretical generalization of the existing body of research. The model is also faithful to and integrates over five years of fieldwork in leading edge software development organizations and has good analytical generalizability. In this regard it recognizes that radical innovation capability is an effective combination of technological sensing and market opportunity seizing capabilities. The suggested model and developed instrument will be used specifically in the next phase in a large survey to predict the adoption and deployment of Internet computing as a disruptive IS innovation. In doing so we seek to improve statistical generalizability thereby extending findings from a multi-site case study by Lyytinen and Rose (2003a). In terms of external validity, we feel that the model can be used in the future to understand radical innovation drivers in any IT innovation type, or their combinations. At the practical level the model can be used to better organize and manage radical innovation activities in ISD organizations. Specifically, it can prescribe attributes for ISD organizations that wish to be involved in exploiting radical innovations or being at the forefront of the next disruptive innovation cycle.

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