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Editors

Finding the "Radicalness" in Radical Innovation Adoption

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Abstract

Prior conceptualizations of radicalness have been useful but are incomplete and have often assumed that term "radicalness of an innovation" is clearly understood and means the same for all researchers and managers. This however is far from truth. Different people characterize the same innovation as radical for very different underlying reasons and in some cases even as incremental. This lack of definitional clarity belies understanding the inherent attributes of radicalness for effectively understanding radical technologies and innovations. Researchers often face ambiguity in understanding and explaining the effects of radicalness on adoption and implementation decisions and outcome due to this lack of clarity, even though they may agree that something is special about "radicalness." This study addresses a conceptual gap and synthesizes existing research to define the perception of an innovation as radical by its adopters. By identifying the attributes that make an emerging technology innovation radical from the adopter's perspective, this study contributes a grounded construct for adoption research and attempts to clarify the current ambiguity concerning the application of the term "radicalness" regarding technology and innovation adoption. Using the context of Radio Frequency Identification (RFID) adoption by organizations, data from field interviews indicate technology radicalness in adoption is better understood and measured as a perceived and formative construct with five critical sub dimensions 1) embedded knowledge in the technology or product knowledge; 2) knowledge and prior experience in the application of technology or application knowledge; 3) changes in fundamental concepts of the activities to which it is applied or extent of concept change; 4) changes in the resources needed for the activities to which it is applied or extent of component change and 5) changes in the processes of the activities to which it is applied or extent of linkage change, each of which contribute to the degree of perceived radicalness of a technology.

Keywords: radical innovation, adoption, perceived radicalness, RFID, disruptive technology

1. INTRODUCTION

Multiple labels such as disruptive, breakthrough, revolutionary, discontinuous and radical have been used in prior literature, to represent innovations that may provide significantly new offerings and are perceived as providing significantly large benefits and rewards that alter the competitive position of the innovating firms (O' Connor & McDermott, 2004). Besides potential rewards these innovations are also associated with high degree of risk and uncertainty in their potential outcomes. These labels have been used interchangeably in many cases, but may mean very different things. Most labels such as breakthrough or disruptive are based on the perceived outcomes of the innovation and hence give rise to circular arguments which are true by definition (Sood & Tellis, 2005). For example, disruptive innovations have been characterized as those innovations which fundamentally alter the competitive landscape of a firm or disrupt the existing positions of the key market players. As Henderson and Clark (1990) rightly point out "the distinction between radical and incremental innovations has produced important insights but is fundamentally incomplete." There is ambiguity in their definitions and their operationalization are more categorical rather than on a continuous scale.

We address this literature gap and argue that the radicalness of a technology innovation is inherently related to technology adoption and will be understood more completely when we conceptualize it as a multi-dimensional formative construct including user perceptions and their application context along with the inherent technology attributes. The conceptualization of radicalness in technology adoption we present herein extends work by Sood and Tellis (2005); Chandy and Tellis (2000); Henderson and Clark (1990) on innovation attributes by incorporating technology-organization-context focused dimensions which, we argue, will enable radicalness to better explain when and why a technology will experience adoption resistance or success. We begin by discussing the role of technology radicalness in new technology adoption and making a case for its relevance in adoption studies. We follow it with a discussion on prior conceptualizations of technology radicalness in the innovation literature. We define perceived radicalness of a technology as a second order formative construct and present its five critical dimensions based on our data collected through semi-structured interviews. We conclude with a discussion of implications for research and practice.

2. TECHNOLOGY RADICALNESS AND ADOPTION LITERATURE

All technologies are not created equal and hence should not be treated the same. Differences in their adoption patterns exist based on their attributes and their perceived impact. This issue needs to be addressed by Information Systems (IS) researchers (Lyytinen & Rose, 2003).

Hage (1980) identified radicalness as one of the "most critical dimensions" along which an innovation may differ, however it remains to be thoroughly explored in innovation adoption literature and even more so in the interorganizational system adoption context. Radical technologies are very different from incremental technologies. Radical technologies are less frequently adopted than incremental innovations (Damanpour, 1996) and pose a greater challenge to the existing structure of political influence, causing more resistance during their implementation (Frost & Egri, 1991). Radical technologies are also more likely to fail than incremental technologies (Pennings, 1988). Radical technologies appear more complex to adopters and generate uncertainty about the resources required to use them effectively and hence have lower adoption likelihood (Gopalakrishnan & Damanpour, 1994). The perceptions of radicalness of a technology may hence influence its adoption by individuals and organizations, and therefore needs to be investigated (Ciganek & Zahedi, 2004).

Prior Conceptualizations of Radicalness

Radical innovations are likely to be competence destroying often making existing skills and knowledge redundant (Tushman & Anderson, 1986). Radical innovations often require different management practices (O' Connor, 1998). Dewar and Dutton (1986) recognize radical innovations with high degree of new knowledge embedded in them. According to them, the labels radical and incremental represent differences in degrees of novel technological process content embodied in the innovation. Also these innovations have been suggested as usually originating from scientists and are market push innovations where new features of the technologies and possibility of grasping new opportunities trigger the interest in their adoption (O' Connor, 1998) compared to incremental innovations which are more pull innovations triggered by market need either from customers' demand or a perceived need to stay competitive. Radical innovations are also likely to

open opportunities for follow-on incremental innovations (Ettlie & Rubenstein, 1987). Additionally, radical innovations whether they are new-to-the-world or new–to-the-firm, represent risky departures from existing business practices (Hage, 1980). Another characterization of radical innovations is based on the changes in behavior resulting from using the innovation (Schiffman & Kanuk, 1997) or having a customer orientation of providing greater value or benefits over existing products or technologies (Chandy & Tellis, 1998). These conceptualizations while useful do not adequately address the question: what makes a technology/innovation radical?

Similarly prior literature characterizes innovations dichotomously (i.e. product-process, administrative-technological and/or incremental-radical (Hage, 1980)), but little operationalization of these characterizations on continuous scales or testing them for mediating/moderating effects has been done at individual, organizational or inter-organizational levels.

3. PERCIVED RADICALNESS BY ADOPTERS

Radicalness of a technology has been studied mainly from its development and creation standpoint in the new product development and marketing literature. These characterizations are from the developer's perspective and suggest that radicalness of the technology is an objective characteristic, inherent to the technology. However, we argue that in the adoption of an innovation what matters is the radicalness of the innovation as perceived by its adopter. The adopter could be an individual, a group, a business unit or an organization. In each case, it is the perception of radicalness of the innovation by those that make decisions related to its adoption. In case of an organization it could be the CIO's/managers that make decisions related to whether a new technology is suitable for their organization. We propose that radicalness of an innovation would be better understood by viewing it as a combination of technology-organization-context focused dimensions which not only includes inherent attributes of the technology but the relative newness of the technology based on prior experience of the adopter and the application context within which the innovation is adopted.

Perception based on relative newness
Radicalness also has been suggested more as a perceived or subjective construct rather than an objective measure of an innovation. The perceptions of radicalness would vary based on the "newness-to-the-organization" or

experiences and familiarity of the managers in adopting organizations with the innovation (Dewar & Dutton, 1986). The greater the prior experience with the innovation the more likely that knowledge embedded in the innovation would not be perceived as new and hence lower the perceived radicalness of the innovation. The degree of perceived radicalness would be related to prior experiences and existing skills and competencies in an organization that are relevant for the adoption of the innovation in question. For example, an innovation such as the Google search engine may have be considered as radical in the late 1990s for those who transitioned from library style sequential search using catalogs by one field to multiple field simultaneous search using an electronic search engine; however, the same innovation may have been considered less radical or more incremental for those who moved from a search engine such as AltaVista to an enhanced product such as Google. This difference in perceptions of radicalness of the same innovation comes from the fact that in the first case the new innovation may have required significant new conceptual knowledge in terms of how to use key words for search engines and the change that it mandates in established routines of library search. In the second case, the leap may be only slight in the perceived outcome of the result with minimal or limited new knowledge and changes in established routines. Hence, perceptions of radicalness of the same innovation may vary across organizations depending on its newness to the organization in question.

Perceptions based on Application Context
As discussed earlier, differences in perceptions of radicalness exist between development/creation of an innovation and its adoption and use. Certain innovations may be perceived as being highly radical in terms of creation but may not be perceived radical in their application and use. For example, replacement of vacuum tubes by transistors may have been perceived as a radical shift by radio manufacturers as it overturned existing concepts and components of the technology it was replacing but may or may not have been considered a radical change by its users as the only perceptible difference for them would be improved voice quality. Similarly, a certain innovation by itself may represent a new technological paradigm, but unless it is considered in its application context at the individual or business activity level and unless it requires drastic changes or alterations in the routines or replaces existing concepts underlying the individual or business activities it is likely to be perceived as being more incremental than radical. For example, a personal computer might

have been be a paradigm shifting invention for its creators because it overturned previously existing concepts of space and processing power. However, to a computer user it would have been a paradigm shift only if it overhauled the concepts of its application context, and redefined what could now be done with this machine as compared to what was done prior to its use. Hence, a user that considered a PC as a replacement of an electronic typewriter and used it for printing documents only may not have perceived it as being highly radical. On the other hand those users that made use of its high processing ability in tasks that were complex such as running computational models were using it in a context that required overhauling of what could and could not be done to accomplish the given task (i.e. the difference in terms of the changes that it may have mandated in their existing and established routines for modeling – computerized vs. hand executed) may have perceived it as being highly radical. This difference would reflect itself in the degree of new knowledge they needed to acquire and apply to accomplish the given activity and the changes that needed to be made at the concept, component and linkage level for the activities it was used for. Hence, there is in most cases an implicit comparison with the technology that is being replaced and with the context of its prior application. Same is true for the mobile smart phones replacing the traditional land line and even the voice based mobile phones earlier.

Similarly, a search engine such as Google based on new search principles, may have been a radical innovation for its developers because it overturned existing concepts about how the engine searches and requires different logic and but may not be radical for an adopter who already had been using other search engines because all they can perceive is the output which may not be very different from other search engines. Thus, we believe that an innovation idea in its development may be perceived as being radical but it may or may not be perceived as radical in terms of its adoption and use. This study focuses on adoption and use of innovations rather than their creation (inception and technological initial development)

4. PROPOSED CONCEPTUALIZATION OF PERCEIVED RADICALNESS

Ettlie et al. (1984) define an innovation as radical if it is new and introduces significant change. Consistent with Ellie et al and Lyytinen-Rose's (2003) work we go further and extend this definition to include embedded knowledge in the technology, prior experience of the adopting

individual or organization and the application context changes (in terms of concepts, components and linkage changes of the individual or business activity to which it is applied.

It is to be noted here that the term "business activity" is used as a high level description of the application context and includes the business processes that are required to accomplish that activity. For example marketing a product can be considered as a high level business activity which subsumes various processes such as research, promotions and sales. Hence activities have been suggested as subsuming the processes that are needed to accomplish them.

We define radical innovations as requiring high degree of new knowledge about the product and its application and mandating substantial change in concepts, components and linkages in the context of its application.

Based on the conceptualizations in prior literatures in IS, marketing, strategic management, innovation management and other related disciplines and findings from data gathered from semi-structured interviews we define and conceptualize perceived radicalness of a technology as a five dimensional construct which includes 1) embedded knowledge in the technology or product knowledge; 2) knowledge and prior experience in the application of technology or application knowledge; 3) changes in fundamental concepts of the activities to which it is applied or concept change; 4) changes in the resources needed for the activities to which it is applied or component change and 5) changes in the processes of the activities to which linkage change.

Following is the discussion on how each of the sub-dimensions is defined and measured.

The new knowledge to adopt an innovation could entail two types of knowledge: 1) product knowledge and 2) application knowledge.

1) Product knowledge: This dimension captures new knowledge about the description of the product and features and how it could be potentially used by the adopter.

2) Application knowledge: This knowledge refers to the knowledge about the settings and contexts in which the product could be applied to potentially benefit the adopter. Hence, new knowledge for adoption of an innovation would be a combination of product knowledge of how the

product works and what it can do and knowledge about what individual and business activities it can potentially impact.

These dimensions capture the extent of new knowledge that needs to be acquired to adopt and apply the innovation in an individual or business activity setting (Hall & Andriani, 2002). This dimension is measured along a continuum from low to high and is an important dimension in the perception of radicalness of an innovation along a continuum.

3) Extent of change in concepts: Engineering or fundamental scientific principles which determine the components that would be needed for a technology product have been defined as concepts by Henderson and Clark (1990). However, that definition of concepts was in context of product innovation creation. A product innovation when it is brought into a new setting for its adoption and use may mandate changes in concepts related to the individual or business activities where it is to be applied to derive benefits from it. These changes are more important from the adopter's perspective than the scientific principles behind the innovation. Hence, we extend that definition to an activity setting where the product is applied and define concepts as underlying principles which drive the routines and tasks of an individual or a business activity. For example, an RFID tag and reader enable the unique item-level identification, non-line of sight, real time and parallel processing of identification data. All of these scientific concepts are embedded in the technology. However, the use of RFID in business activities such as asset management would lead to a change in the concepts of how that activity is conducted and would mandate either change in components for the activity or the linkages between the components or both.

This dimension captures the extent of the change in the activity concepts in terms of whether the concept change is reinforcing existing routines or overturns them and requires unlearning of old routines and replacing them with new ones.
This change in concepts is measured as the degree of substitution of conceptual knowledge and varies from low to high on a continuum where low signifies reinforcement of existing concepts and high signifies overturning of existing concepts. Please note that there could be many concepts or principles involved in a business activity at different levels of the activity, however our focus is on the changes in fundamental principles that govern the activity.

4) Extent of change in components: Components have been defined as physical manifestation of scientific concepts embedded in the technology by Henderson and Clark (1990). This definition when extended to an individual or business activity setting in which the technology would be used, means components are resources which are mandated or required for the application of the concepts. Any improvements, replacements, additions or removals of existing resources would mean a change in components for the activities. Hence, in the context of RFID use, the readers and tags, other hardware, software, systems and sub-systems and people would be components associated with the RFID innovation required to execute a business activity. The level of change in components will be high when RFID technology is to be used to accomplish business tasks that were earlier manually performed because the innovation adoption may involve all of the above mentioned changes. Please note that changes in components may or may not involve a change in the fundamental concept but would involve a change in linkages at some level.

The extent of change in components dimension would measure the overall degree of improvement or alteration in the resources of the individual or business activity that the new innovation requires on a low to high continuous scale where low signifies similar resources with no improvements and high signifies new and improved resources with high level of improvements contributing towards higher perceptions of radicalness.

5) Extent of change in linkages: Linkages have been defined as the links (or connections) between the components that have been embedded in a technology according to Henderson and Clark (1990). We extend the definition of linkages from technology creation context to the activity context where a technology is applied and used. We define linkages as the connections or relationships between components or resources associated with the innovation for the individual or business activities. Hence, in context of RFID, it would mean how the tags, readers, other hardware, software, middle-ware, other systems and people are inter-connected to accomplish the business activity. Any change in the way components or resources are connected and interact with each other for accomplishing an individual or business activity would mean a change in linkages. When RFID is introduced, as discussed earlier it is likely to be compared to the technology it replaces in the business activity context and because it would require improvements or changes in components it would

also change the linkages between them and hence is likely to be perceived as radical. Please note that any change in components would reflect as a change in linkage at some level but any change in linkages may or may not require a change in components. Any change in linkages however would be a change in concepts at some level.

The extent of change in linkages dimension would measure the degree of restructuring in the existing linkages of the business activity that the new innovation requires on a low to high continuous scale where low signifies no or minimal change in the basic architecture of business activity and high signifies major restructuring of the business activity by changing the existing links. Hence, high levels of restructuring of linkages would contribute towards higher perceptions of radicalness.

5. DATA AND METHODOLOGY

We wished to open the radicalness "Blackbox" and explore the meaning of radicalness of an innovation from the adopter's perspective. For this purpose we utilized the context of RFID adoption by organizations to understand, why organizations perceive some innovations as more radical than others, and how radicalness may impact their decision to adopt and integrate a technology-based innovation. Prior literature showed inconsistent definitions and incoherence across fields in understanding radicalness in innovation adoption. In such a case, interpretive research focusing on exploring the unknown phenomenon best serves to initiate a valid and accurate line of inquiry (Yin, 1989), (Lee, 1991) precisely our underlying research goal. To accomplish the above-mentioned goals and to develop a better understanding of the adoption process, we conducted in-depth, semi-structured interviews using a convenience sample. The interviewees were executives and RFID program managers and supply chain managers across 10 organizations (12 interviews) involved in RFID initiatives at some level. We sampled from three perspectives in order to triangulate and, thereby, strengthen our understanding of radicalness of RFID adoptions. These perspectives were the adopter perspective (7 firms and 8 interviews in three industries: manufacturing, retailing, and logistics), the implementer perspective (1 top IT consulting firms and 2 interviews), and the vendor perspective (2 firms and 2 interviews).

The interviews were conducted over a period of three months (May-July, 2005) and were either face to face or over the phone, lasting between one and two hours. The questions for the interviews were a mix of open-ended questions and closed questions to allow both the flexibility of exploring new contexts but also to help maintain focus on some of the previously identified relevant themes. At the time of the interviews, we were not exploring radicalness as perceived or context dependent. These themes emerged from the data and were later developed conceptually, because of what we found from practice.

The interviews were recorded and later transcribed. The authors coded the interview data in an effort to extract key ideas underlying the concept of innovation radicalness for managers evaluating emerging technologies such as RFID. This coding process involved the first author identifying patterns and underlying themes that emerged from quotations in the raw text, excerpting them and bringing them to the other two authors for joint discussion and refinement over a period of 7 months and more than 20 hours of discussion.

6. RESULTS AND DISCUSSION

During the analysis phase of our study we became aware that all three perspectives were unified in seeing adoption radicalness for RFID as a continuous, context-dependent phenomenon with multiple dimensions. Prior conceptualization of radicalness as dyadic or non-perceptual does not fit these data from practice. The context dependency fits well if we expect radicalness would be perceptual for innovation adoptions.

Some of the key quotes of managers that were interviewed are presented in Table 1 (Appendix) as a representative sample that supports our multi-dimensional conceptualization of radicalness as perceived and depending upon relative newness/prior experience and application context. Table 1 also shows the major patterns and underlying themes found as a result of the coding and analysis process.

As can be seen from the interview data Organizations A, G and C made repeated mentions of "need for learning" in terms of features of the technology and of how the technology can be applied in their current processes. This related to the theme of Product and Business Application Knowledge. Organizations A, J and C mention the "need for high level of changes in business processes and infrastructure that could prove disruptive" which support the dimensions of product knowledge, business application knowledge, change in business linkages and business components.

Another important theme that emerged from the interviews and was mentioned by organization J was about paradigm shift in the way a particular business activity or process is conducted. This idea is also reflected in our proposed dimension of change in activity concepts.

This study addresses an important question i.e., why an innovation might be perceived as radical by its adopters? In doing so it also discusses what radicalness means and how perceptions of radicalness may influence adoption decisions.

The conceptualization of radicalness as a multi-dimensional construct has implications for both theory and practice. For the practitioners our conceptualization addresses the issue of "lack of definitional clarity" and enables managers to understand the inherent attributes of innovation radicalness. This will allow managers to effectively develop or respond to radical innovations. From the theoretical and academic perspective, our conceptualization opens the "black box" of radicalness by proposing a multi-dimensional construct. This will enable researchers to reconcile seemingly disparate results and aggregate their understanding of role of radicalness in innovation adoption.

7. CONCLUSION

In this paper, we defined technology radicalness as a second-order perceived construct formed of five dimensions. We presented prior literature showing that radicalness by itself is popular and exciting but confounding concept, often discussed without clear conceptualization and difficult to measure directly. By identifying the attributes that make an emerging technology innovation radical from the adopter's perspective, this study contributes a grounded construct for adoption research and attempts to clarify the current ambiguity concerning the application of the term "radicalness" regarding technology and innovation adoption.

Technology radicalness has objective characteristics inherent to the technology being adopted and the specific business processes to be changed, but these are only instantiated as radicalness in the perceptions of the individuals who must change within an organization. Thus, radicalness depends on prior experiences and competences of individuals, groups, and the adopting organization. If a technology-enabled radical innovation will be implemented in two different business units involving the same business processes, we could expect differential effects from radicalness of the technology

because of its perceptual nature and how it can be applied differently across units and across time.

We presented the five dimensions of perceived radicalness that will enable future examinations of radicalness to examine it on a continuum rather than as dichotomous as in prior research. The ability to understand radicalness on a continuum contributes to current literature, better capturing the theoretical nature of radicalness while also encompassing what we know about radicalness in its five dimensions as one construct:

1) Product Knowledge to be acquired
2) Business application knowledge to be acquired
3) Extent of changes required in the activity concepts (concept change)
4) Extent of changes required in the activity components (component change)
5) Extent of change required in the activity linkages (linkage change).

Technology adoption provides a seductive and powerful means for accelerating and enabling business process change, which can lead to tremendous growth and competitive advantage (Collins, 2001). However, the radicalness of a technology –enabled innovation leads to uncertainty as to how to adopt a new technology and get the benefits from it. We believe the conceptualization of perceived radicalness construct from the adopter's perspective in this study helps understand and explain its role in the area of radical technology adoption and will forward research in this area.

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APPENDIX

Table 1. Key Quotes from Managers

#	**Key Quotes**	**Organi zation**	**Underlying Themes**
1	We find benefits but RFID is not on our priority list and we don't think we are ready as we *don't have the infrastructure and expertise to process huge amount of data* that would be generated by it and make sense out of it. Lack of standards and cost of tags and readers is prohibitive. Also RFID will be *a major change for our company in over hauling our business processes.*	A	Business Application Knowledge, Product Knowledge, Business Component Change, Business Linkage change
2	For RFID we could easily identify which tag would work and what device would work for our products, that didn't take very long, less than six months but now we are facing a *major issue as far as its application. How much changes you have to do to all the existing ERP systems and front end business applications required in its application, we are not clear as there may be a lot.*	G	Business Application Knowledge
3	Smaller organizations see RFID as an opportunity to make two leaps at once and hence displace some of the existing organizations. Also I believe that it is *more perceptual and determined by the business context* in which it is applied. For us, in terms of retail checkout at this point it is not a major change, as it does not fundamentally change the business process. But going into the future, when there is item level tagging, and automated checkouts. It may be a paradigm shift because it *Eliminates the basis of our business. We may have to kiss our scanning and retail business goodbye.*	J	Business Concept Change, Product and Business Application knowledge, Business Component, Business Linkage Change
4	RFID would require *altering our existing optical scanners infrastructure and processes currently* in place. A lot of *learning, major changes in infrastructure may be required.* This would be *disruptive* for the organization.	C	Product Knowledge, Business Application Knowledge, Business Component Change, Business Linkage Change