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# What makes an Innovation Radical?

## Finding the “radicalness” in radical innovation adoption

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### ABSTRACT

This study explores the factors that contribute towards the perception of an innovation as radical by its adopters. This paper addresses an important conceptual gap in the innovation literature by identifying the attributes which make an innovation radical. Prior conceptualizations of radicalness have been useful but incomplete and have often assumed that term “radicalness of an innovation” is clearly understood and means the same for all managers. This however may be far from truth. The same innovation may be characterized as radical by different managers for very different underlying reasons and it may even be characterized as incremental (very low on radicalness scale) by others. For the practitioner this lack of definitional clarity means not being able to understand the inherent attributes of radicalness and not being able to effectively develop or respond to radical innovations. More over from the theoretical and academic perspective, it becomes difficult to aggregate results from different studies which leads to ambiguity in understanding and explaining the effects of radicalness on adoption and implementation decisions and outcomes. We argue that technology radicalness is better understood and measured as a formative construct with four critical sub dimensions (Amount/extent of new knowledge, nature of concept change, nature of component change, nature of linkage change) each of which contribute to the degree of perceived radicalness of a technology.

### Keywords

Radical Innovations, Perceived Radicalness, Adoption

### 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 operationalizations 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 four critical dimensions. We conclude with a discussion of implications for research and practice.

## **TECHNOLOGY RADICALNESS IN INNOVATION ADOPTION**

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 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 (Etlie & 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.

## **RADICALNESS AS A PERCEIVED CONSTRUCT**

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.

### **Perceptions based on Relative Newness or Prior Experience**

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 be considered as radical for those who transition 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 be considered less radical or more incremental for those who move 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**

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 business activity level and unless it requires drastic changes or alterations in the routines or replaces existing concepts underlying the business activity it is likely to be perceived as being more incremental than radical. For example, a personal computer may 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 may be a paradigm shift only if it overhauls the concepts of its application context, activities or interfaces. Hence, a user that considers a PC as a replacement of an electronic typewriter and uses it for printing documents may not perceive it as being highly radical. On the other hand those users that make use of its high processing ability in tasks that are complex such as running computational models are using it in a context that requires overhauling of what can and cannot be done to accomplish the given task (i.e. the difference in terms of the changes that it may mandate in their existing and established routines for modeling – computerized vs. hand executed) may perceive it as being highly radical. This difference would reflect itself in the degree of new knowledge they need to acquire and apply to accomplish the given activity and the changes that need to be made at the concept, component and linkage level for that activity. Hence, there is in most cases an implicit comparison with the technology that is being replaced and with the context of its prior application. Similarly, a search engine such as Google based on new search principles, may be a radical innovation for its developers because it may overturn existing concepts about how the engine searches and requires different logic and but may not be radical for someone already 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).

## **DEFINITION AND CONCEPTUALIZATION OF PERCEIVED RADICALNESS AS A MULTIDIMENSIONAL CONSTRUCT**

### **Definition**

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 organization and the application context changes (in terms of concepts, components and linkage changes of the 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 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 preliminary data gathered from semi-structured interviews we define and conceptualize perceived radicalness of a technology as a four dimensional construct which includes 1) amount of new knowledge to be acquired and applied 2) nature of changes required in the business activity concepts 3) nature of changes required in the business activity components and 4) changes required in the business activity linkages

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

*1) Amount/Extent of New Knowledge to be acquired and applied:* The new knowledge to adopt an innovation could entail two types of knowledge: 1) product knowledge and 2) business application knowledge. Product knowledge or the new knowledge about the product is about the description of the product and features and how it could be potentially used. Business application knowledge refers to new 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 business knowledge about what business activities it can potentially impact.

This dimension captures the amount or extent of new knowledge that needs to be acquired to adopt and apply the innovation in a 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.

*2) Nature 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 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 a business activity setting where the product is applied and define concepts as underlying business principles which drive the routines and tasks of 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 nature of the change in the business activity concepts in terms of whether the concept change is reinforcing existing knowledge and 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.

*3) Nature 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 a business activity setting in which the technology would be used, means components are physical entities which are mandated or required for the application of the concepts. 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. Any improvements, replacements, additions or removals of existing components would mean a change in components for the business activities. 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 nature of change in components dimension would measure the overall degree of improvement or alteration in the components of the business activity that the new innovation requires on a low to high continuous scale where low signifies similar components with no improvements and high signifies new and improved components with high level of improvements contributing towards higher perceptions of radicalness.

*4) Nature 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 business activity context where a technology is applied and used. We define linkages as

the connections or relationships between components associated with the innovation for the 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 are connected for accomplishing a 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 nature 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.

The above discussion leads us to the following proposition:

Proposition 1: Degree of Perceived radicalness of a technology is a formative second order construct composed of four first order dimensions 1) Amount/extent of new knowledge to be acquired and applied 2) nature of change in business activity concepts 3) nature of change in business activity components 4) nature of change in business activity linkages

## DISCUSSION

### Effects of Perceived Radicalness on Adoption

Many in prior literature have argued that the adoption considerations for radical innovations would be different from adoption of incremental innovations (Damanpour, 1991, Swanson 1994). Radical innovations have been found to be less frequently adopted than incremental innovations (Damanpour, 1996). Radical technologies also experience more resistance to change (Frost & Egri, 1991). Innovations enabled by radical technologies are also more likely to fail than ones involving incremental technologies (Pennings, 1988). Prior research has suggested that the radicalness of a technology will moderate innovation relationships (Damanpour, 1991; 1996; Ziamou & Ratneshwar, 2003). There have also been arguments about their direct effects (Fichman, 2004). In these discussions about “radicalness”, “radical innovations”, and “radical technologies” terms have often been confusing, lacking a clear conceptualization in order to clearly relate them across studies. One key understanding that has often been overlooked is perceptions of radicalness versus objective radicalness in relation to technologies and innovations that they enable. We understand radical technologies as those that will require substantial amounts of change relative to incremental technologies when adopting them as part of making a business activity (one or more processes) innovation.

According to Dewar and Dutton (1986) and Attewell (1992), innovations are typically categorized as incremental and radical based upon the perceived level of new knowledge required to be learned. The related learning barriers must be hurdled in their adoption.

Lyttinen and Rose (2003) suggest that radical innovations can occur in individual value chain segments that may not affect other portions of the chain. These would be processes within larger business activities. Following this suggestion, we might expect that variance will occur on a cross-sectional basis (at any given moment in time) in organizations as they adopt innovations – leading individuals involved in different work processes with different perceptions of the radicalness of the innovation. Likewise, longitudinally (across time), there may be differences in the perceptions of radicalness of an innovation and the resulting impact on a technology’s adoption. At early adoption phases IT innovations are more radical because of the high level of organizational change required (Attewell 1992). Later adopters can capitalize on the changes in the organization to enable the earlier adoption if adoption occurs in phases and especially if the phases involve different identical business units so that latter adopters need only replicate many of the learned solutions of the early adopters.

The variance in perceptions of radicalness helps explain why adoption of new technologies to enable business innovations is so uncertain. Technology-enabled business process innovation “uncertainty arises both from the unpredictable evolution of the technologies themselves [conceptual/component knowledge] and from strategic path dependencies [architectural knowledge] they impose on a firm’s future IT trajectory. Irreversibility arises from high learning [amount of new knowledge] and adaptation costs during deployment [architectural knowledge], and high switching costs after deployment [conceptual/component knowledge].” (Fichman 2004)

Thus, we have taken a fresh look at perceived radicalness, gathering prior theory and resulting in a multi-dimensional construct that captures the essential elements of how radicalness impacts technology adoption. We believe our findings here will help forward research in this area. With this construct, we believe researchers will be able to better isolate and account for the uncertainty of radical technology adoption in business process innovations. The next step entails building a measurement plan for the construct and specifying how it would be indicated and aggregated into a continuous scale.

## CONCLUSION

In this paper, we defined technology radicalness as a second-order perceived construct formed of four 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.

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 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 differ across units and across time.

We presented the four 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 four dimensions as one construct:

- 1) amount of new technology knowledge to be acquired and applied (**technology knowledge**);
- 2) nature of changes required in the business activity concepts (**concept change**);
- 3) nature of changes required in the business activity components (**component change**);
- 4) changes required in the business 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 herein helps explain this effect and will forward research in this area.

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