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ICIS 2001 Proceedings

International Conference on Information Systems (ICIS)

December 2001

# The Quad-Core Model of Information Systems Innovation: Identifying and Confirming the Role of Novel Technological Frames as a Supra-Innovation Core--The Case of Internet Induced IT Innovation

Gregory Rose
*California State University*

Kalle Lyytinen
*Case Western Reserve University*

# THE QUAD-CORE MODEL OF INFORMATION SYSTEMS INNOVATION: IDENTIFYING AND CONFIRMING THE ROLE OF NOVEL TECHNOLOGICAL FRAMES AS A SUPRA-INNOVATION CORE— THE CASE OF INTERNET INDUCED IT INNOVATION

**Gregory Rose**
Department of Accounting and Management Information Systems
California State University, Chico
grose@csuchico.edu

**Kalle Lyytinen**
Department of Information Systems
Case Western Reserve University
kjll3@po.cwru.edu

## Abstract

*The paper extends Swanson's three core model of IT innovation in order to account for observed radical changes in systems development and IS service due to Internet induced innovations. A new supra-core called the base IT innovation core is suggested that accounts for IS innovations in the new world of development which cannot be categorized in the existing tri-core model. The impact and role of this core is supported by findings from a field study, which examined eight leading edge software firms and changes in their development practices. Concurrently, the study confirms the 20 propositions put forward in Lyytinen et al. (1998) that predicted the Internet and its associated tools would represent a new technological frame that would radically change systems development and services.*

**Keywords:** Internet, innovation theory and models, IS innovation, system development, software management, IS applications.

## INTRODUCTION

Information systems development (ISD) has entered an era of rapid innovation. Specifically, Internet technologies are invigorating the creation and adoption tools, techniques, and practices that collectively represent a new technological frame (Bijker 1987) for ISD (Lyytinen et al. 1998). This frame consists of a "new aggregate of concepts and techniques used by a community of IT service providers in its problem solving" (Lyytinen et al. 1998, pg. 242) that will have a profound impact on both methodologies and services. The basic elements of the frame can be seen as a series of IS innovations that will move into the mainstream over time. Consequently, investigations concerning these elements need to be grounded using a comprehensive IS innovation model.

This paper confirms predicted innovations in ISD delivery mechanisms and services induced by the Internet and classifies them with an encompassing model of IT innovation. Our study is motivated by recognition that we don't know enough about complex ISD innovations and their adoption (Bayer and Melone 1989). Essentially, current models lack in consistency and explanatory

ability when base IT technologies change (especially rapid change). Following Swanson's (1994) IT specific innovation model, we seek to understand how Internet induced innovation in IS services is taking place.

## AN OVERVIEW OF INTERNET INDUCED TECHNOLOGY FRAME

In Lyytinen et al. (1998), 20 propositions are suggested for the new Internet technology frame (Table 1). Proposition TF1 suggests that this is, indeed, a new technological frame based on the Internet infrastructure. Propositions FC1 through FC9 develop its main characteristics. Propositions ISS1 through ISS5 predict changes in IS services, while propositions ISD1 through ISD5 discuss changes that would occur to ISD.

Collectively, Table 1 predicts a radical change for ISD and resulting computing services. To understand the above chorus of IS innovations and their dependencies in context, we need to align these propositions within a model of IT based innovation. The tri-core model of IS innovations (Swanson 1994) was selected as a basis for such analysis because of its IT specificity and empirical support (Grover et al. 1997).

**Table 1. Internet Induced Innovation Characteristics in IS**

| | |
|---|---|
| TF1: | New Technology Frame – the Internet induced Technological Frame |
| FC1: | Uniform clients (browser) with multimedia and platform independence (Java, Java Scripts, Java Beans) |
| FC2: | Clients will have the same look and feel as traditional clients. |
| FC3: | Readable scripts and metadata in HMTL /XML code complement traditional compiled code |
| FC4: | Importance of the middleware to glue components, new services, and legacy systems together. Uniform service interfaces allow single-user, workflow, and group-level services configured into the same client interface |
| FC5: | Highly functional telecommunication services, including wireless become widely available and part of the design space. |
| FC6: | Component-based capability allows for granular, configurable, market driven software and cross platform distribution and wrapping |
| FC7: | Data of any kind can reside anywhere on the network and be posted dynamically with a Web interface |
| FC8: | Borderlines between structured and unstructured data will become blurred at interface and database levels |
| FC9: | Separation of User Interface and Application Logic |
| ISS1: | Ubiquitous services available anytime and anywhere. |
| ISS2: | New technologies and skills for development needed and many made obsolete at record pace |
| ISS3: | New services provided for end users at a record pace |
| ISS4: | Mainstreaming will create software component market |
| ISS5: | IS service will change from computation-oriented to media-oriented. |
| ISD1: | Telecommunication skills to become more critical |
| ISD2: | User interface design skills are broadened |
| ISD3: | Organizational design and change management skills are broadened |
| ISD4: | ISD complexity profoundly increased |
| ISD5: | ISD managerial skills need to be broadened to incorporate and manage new services and their heterogeneity |

## TRI-CORE MODEL OF IS INNOVATIONS

The tri-core model distinguishes three distinct areas of IS innovation. The innermost core involves IS development (types Ia and Ib). The second core represents innovations to the administrative function of the organization. The third core deals with those innovations that impact primary business functions. Table 2 summarizes each core and its sub-core (Swanson 1994).

**Table 2. IS Innovation Types and Examples**

| Innovation Types | Description | Examples |
|---|---|---|
| Type Ia | IS Administrative Process Innovation | Maintenance departmentalization, CIO |
| Type Ib | IS Technological Process Innovation | Systems programming, data administration, prototyping |
| Type II | IS Product and Business Administrative Process Innovation | Accounting systems, EIS |
| Type IIIa | IS Product and Business Technological Process Innovation | MRP, computer integrated manufacturing |
| Type IIIb | IS Product and Business Technological Product Innovation | Remote customer order entry and follow-on customer service systems |
| Type IIIc | IS Product and Business Technological Integration Innovation | Interorganizational information systems, EDI |

## IDENTIFICATION OF THREE CORES IN THE INTERNET INDUCED TECHNOLOGY FRAME

Classification of the propositions in Table 1 with the core types in Table 2 produces Table 3. Table 3 thereby recognizes those application services within the Internet technological frame that fall into Type I categories. We have also added typical applications (innovations) that fit into Type II and Type III cores being built with the new technology frame. It is generally recognized that Internet infrastructure and tools are being used to build services that span an organizations' internal services (intranets), external and public (B2C and C2C services), and external and private services (B2B extranets).

Unfortunately, the three cores do not exhaust the innovations in Table 1. In particular, technological frame, frame characteristic, and IS service innovations cannot be classified. This is worrisome because these are clearly IS innovations. Hence, while Swanson's model organizes propositions regarding applications and ways to develop applications, it is insufficient to recognize base technology innovations including Internet induced innovation predicted in Table 1.

**Table 3. Classification of Innovations in Table 1 within Swanson's Tri-Core Model**

| Innovation Types | Classification of Propositions |
|---|---|
| Type Ia | ISD1, ISD2, ISD3, ISD5 |
| Type Ib | ISD4 |
| Type II | Non-strategic intranets, routine data and information delivery, document management |
| Type IIIa | Strategic intranets, R&D related knowledge management, business intelligence |
| Type IIIb | B2C order entry applications |
| Type IIIc | Extranet service applications, electronic market places |

This limitation is indicated by Swanson when he discusses how IS administrative process and technological process innovations are preceded by innovations in antecedent technological systems. For example, a Database Administrator function innovation

(Type Ib) is preceded by database management systems. Hence, he observes that the model insufficiently explains technological innovation antecedents of the three cores. Despite this, the fourth antecedent innovation layer is neither codified nor explained in any level of detail. Likewise, Grover et al. empirically confirm the three cores, but at the same time suggest that the model has to be extended. Specifically, they argue that innovations in the basic IT (e.g., TCP/IP based networks, and IT tools) "might be worthy of future study, perhaps as a fourth category of IS innovation types" (Grover et al. 1997, pg. 285).[1] Therefore, we need to integrate base technology antecedents into IT innovation model in order to identify necessary conditions that make innovations in other three core areas possible.

## THE QUAD-CORE MODEL

We thus need a way to codify core IT innovations that establish necessary (but not sufficient) antecedents to the other three cores of innovation if we want to provide an account of how diffusion and adoption of IT innovations in organizations takes place. To address the remaining propositions, a fourth level was developed. This level includes: (IVa) fundamental changes to the base technology capability in terms of functionality, speed, reliability, or architectural principles; (IVb) IS development modality innovations, i.e., innovations dealing with generic features of ISD; and (IVc) IS service modality innovation i.e. innovations dealing with generic features of IS services. We will refer to this core level with its three subsets as the **base IT innovation core**. Table 4 shows how these categories classify the unaccounted set of innovations in Table 1.

**Table 4. Classification of Internet Technology Frame Innovations within the Base IT Innovation Core**

| Base IT Innovation Types | Classification of Propositions |
|---|---|
| Type IVa | TF1, FC1, FC2, FC3, FC4, FC5, FC6, FC7, FC8, FC9 |
| Type IVb | ISS2, ISS4 |
| Type IVc | ISS1, ISS3, ISS5 |

## DIRECTION OF CHANGE IN THE BASE IT INNOVATION CORE

Swanson's model is a directional model in that level III innovations have strong order effects on Level II innovations, which have subsequent strong order effects on Level I. Accepting that base IT should be included in the model, it appears that it should do so as an outermost core. Swanson suggests that changes to DBMS lead to changes in lower innovations. Likewise, all innovations in IT can be seen to be dependent on the base IT directly or indirectly. Hence, the fourth innovation core forms a supra-innovation core, or a Level IV innovation (as indicated in Table 4), which has strong order effects on all of the subordinate levels.

In order to validate the quad-core model in the context of Internet induced IT innovations, we examined in a field study to what extent Internet induced innovations predicted in Lyytinen et al. were taking place and how they related to different cores of the quad-core model. Thereby the study sought to understand the logic of the innovations and their dependencies in the Internet innovation frame.

### Research Design and Goals

The research goals of the field study were the following:

(1) To what extent is ISD utilizing the features of the IT base innovation core?

[1]Ironically, Grover et al.'s proposed fourth core dimension can be used to remedy their apparent misclassifications of some constructs. While emulating Swanson's study, they include CASE, OOPS, and DBMS as representatives of IS technological ***process*** innovations. This is a misinterpretation of Swanson's original concept, because in Swanson, DBMS are observed possibly to have *led* to a Type Ib innovation, but not to have been a Type Ib innovation.

(2) What factors explain the adoption of those features?
(3) Do changes in the IT base innovation induce innovations in other core areas?

Likewise, Table 1 propositions were tested.

In order to study these questions, we carried out a multi-site case study. The case study followed analytical sampling by selecting organizations that were already known to experiment with the Internet technology frame. Thereby, we interviewed representatives of eight leading edge software firms that, between June and December 2000, were observed to have changes in ISD and IS services. All of these firms develop Web-based systems using some of the most advanced technologies available. By Web-based we mean that the resulting browser-based systems had an "n-tier architecture" and they embedded new "middleware" components.

Each interview lasted from one hour to three hours and followed a semi-structured interview format focusing on innovation propositions and their relationships. The number of interviewees ranged from one to four and they were technical managers and business managers. The interviews were tape recorded and transcribed. The transcriptions were sent to companies for correction and validation. The transcripts and other notes and information obtained during our study were analyzed by content analysis using the above categories. The results below are based on preliminary analyses (which is why this paper is submitted as a research in progress).

## Preliminary Results

**Question 1: To what extent is leading edge ISD utilizing the features of the IT base innovation core?**

Each firm affirmed that they had entered a new era in ISD due to changes in the IT technology base. This observation confirms the proposition (TF1) that the Internet forms a fundamental innovation in base IT. The universal characteristics of this base were also ascertained. Each studied company had a working knowledge of the nine frame characteristics proposed in FC1 through FC9, and most firms were exploiting most, if not all, of these features to some extent in their software products (confirming FC1 through FC9).

That each firm was found to be working with these innovations supported that these characteristic changes in the frame did exist in the IS development world and had been adopted at least by some leading-edge firms.

**Question 2: What factors explain the adoption of those features?**

When we asked what factors had lead them to examine and exploit those features, all firms affirmed that the changes were required mostly by their customers. This finding is interesting as it contradicts some of the findings by Swanson, who argues that IT innovations are slow to be adopted by business units, and this process is largely driven by technological push from the IS departments. Instead, here we saw the IT induced innovation to take place through "pull" forces, i.e., by primary customers or by management that wanted to position the company in a new emerging market niche. What we observed is a market driven nature of the innovation cycle which is quite different from internal diffusion dynamics discussed by Swanson: potential adopters recognized features in the IT innovation base and sought competent providers in the market instead of soliciting and garnering complicated technological knowledge by themselves. This finding supports our claim that the technological frame aspect of the fourth core (Type IVa) is indeed a supra-core that impacts Types III, II, and I, and is a necessary element in IT induced innovation. Likewise, Type IVa was attributed with causing ISS1 through ISS5 innovations.

**Question 3: Do changes in the IT base innovation induce innovations in other core areas as outlined in the Internet technology frame?**

The remaining 10 proposed innovations (ISS1 through ISS5 and ISD1 through ISD5) were confirmed in seven of eight firms, thus corroborating the relationship between changes in the IT innovation base (Types IVb and IVc) and predicted changes in the inner core. Likewise, initial analysis indicates that most firms attribute Type IVb and IVc innovations as leading to Type I, II, and III changes. It is also important to observe that companies regarded many features as necessary for service or delivery processes in the new "era" and pointed out that these features were a result of changes in the IT base technology core. Again, this supports the directional change of the supra-core.

Data will be further analyzed to refine this relationship and attempt to more fully validate the directional impact of Type IVb and IVc innovations on lower core innovations. These results will be presented at ICIS.

## CONCLUSIONS

We have extended Swanson's model of IT innovation to a quad-core model to account for changes in ISD and IS services due to Internet induced innovation. A new core called IT base core was suggested as the supra-core. The impact of this core for IT innovation is supported by preliminary findings from a field study. It also shows that the organizational mechanism mediating innovation patterns are changing. Last, it confirms the propositions of Lyytinen et al. with regard to changes in ISD from the technological frame. Future work will focus on outlining relationships between different innovations and examining organizational strategies for coping with the speed and scope of change required in more detail.

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