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Diffusion of selected concepts in information systems and management: 1973-2004

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Abstract

Purpose – The purpose of the study is to explore the extent to which the diffusion of concepts related to information systems and management approximates the rate and the cumulative frequency distribution patterns assumed to reflect the diffusion of innovations.

Design/methodology/approach – The diffusion of those concepts was measured via citation analysis of 4,014 publications (journal articles, books, and dissertations) for the period 1973-2004.

Findings – Two key findings emerged from the study. First, the cumulative frequency distribution approximates the S-curve of adoption. Second, the rate of adoption is exponential and corroborates an epidemiological model of the rate of adoption recently reported in the literature.

Research limitations/implications – Further research is needed to identify and examine topics or concepts that have run their course and subsequently offer an excellent opportunity to perform *ex-post-facto* studies on the life cycle of innovative concepts or topics. From these studies will be baseline data and easily identifiable "actors" in the diffusion process (authors, editors, reviewers, and dissertation committees) that will provide the impetus for continued, progressively complex research models.

Practical implications – The practical implications of a deeper understanding of the diffusion of innovations are immense. It will enhance understanding of how to better promote research and development and technology transfer. It will enhance understanding of how better to market the fruits of those endeavors.

Originality/value – This paper's findings bring to the scholarly community in the digital era the importance of understanding how new concepts and theories are brought to light and evaluated.

Keywords Information systems, Innovation

Paper type Research paper

Introduction

Four decades after the publication of the now classic treatise *Diffusion of Innovations* by Rogers (1962), scholarly interest in the diffusion of innovations remains at a relatively high level. Rogers' (2003) book is now in its fifth edition. It reflects enduring interest in the topic and scholars' general acceptance of the "S-curve" that depicts the diffusion of innovations and scholars' general acceptance of Rogers' typology of "adopter categories," e.g. "innovators" vs "laggards" (Dubin, 1983 and Torraco, 1997 as cited in Lundblad, 2003). A simple search of ProQuest Database using the search string "diffusion of innovations" yields nearly 1,400 titles with over 1,000 titles accounted for by scholarly publications.

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Lundblad (2003) presented an extensive critique of Rogers' theory and concluded that its four basic components or constructs remain virtually unchanged after four decades. Those components included:

(1) the innovation itself,

(2) the communication of the innovation,

(3) the time span or duration of time passed between the introduction of an innovation and its widespread acceptance, and

(4) the social system into which the innovation is introduced (Lundblad, 2003, p. 63).

Wejnert (2002) offered additional insights by providing an overview of various models of innovation spawned by Rogers' theory and tracing the intellectual heritage of Rogers' theory to Tarde's (1903) seminal book *The Laws of Imitation*. Hivner *et al.* (2003) offered an interesting example of the application of Rogers' theory by presenting an epidemiological model of the diffusion of innovations. Maienhofer and Finholt (2002) offered another interesting example of the application of Rogers' theory by presenting a computer simulation of diffusion innovation.

Diffusion theory is rooted in studies of mass media communications and advertising (Rogers and Shoemaker, 1971). Rogers believed that the mass media genre of diffusion research would remain robust even as scholars in an increasingly wide array of other fields apply Rogers' theory (McGrath and Zell, 2001).

Given the tradition of research on the adoption of innovations, it is surprising that there is a relative dearth of studies on scholarly communications via scholarly publications. Scholars interested in the diffusion of innovations among the academic community have focused upon publication processes and outlets that mediate or control the flow of scholarly discourse (Elton, 2003; Kamhawi and Weaver, 2003; Orlans, 1998; White *et al.*, 2004). Journal articles, books, and doctoral dissertations offer a set of data to understand how new or innovative theories or concepts are diffused among scholars (Borgman, 1990; Findlay and Sparks, 2002; Hildreth and Kimble, 2004). It is reasonable to suggest that this also applies to the diffusion of theories and concepts germane to field such as information systems and management.

The slope of the S-curve model infers that at some point the rate of adoption will increase. Scholars have confirmed this concept. Ravichandran (2003) studied the adoption of TQM and organizational factors that impact it and reported that rates of adoption increase over time. Hsu and Mesak (2001) followed up on an earlier study by Olshavsky (1980) who reported that the rate of adoption of innovations was generally increasing but with substantial differences depending upon the innovation. Hsu and Mesak (2001) confirmed the findings reported by Olshavsky (1980) who confirmed findings reported by Mansfield (1961). Bayus (1992) offered additional confirmation.

Those studies have been primarily focused upon the rate of adoption of products as measured by purchases of tangible products. There is a dearth in the literature regarding the rate of adoption of ideas or concepts as measured by scholarly publications about them. The present study addresses that gap in the literature.

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Purpose and organization

The purpose of this paper was to present exploratory data that would shed light on the extent to which the frequency or volume of scholarly publications on fields such as information systems and management resembles the "S-curve" distribution articulated in diffusion research. Specifically, this study focused upon scholarly publications (journal articles, books, and doctoral dissertations) covering nine selected topics germane to the field of information systems and management.

The paper is organized in a manner consistent with its purpose. Introductory remarks include the rationale and theoretical framework for the present study, the purpose and organization of the paper, and the definition of key terms. The introductory remarks are followed by a discussion of the study procedure, i.e. method. Discussion of the study procedure is followed by a presentation of the study findings. Concluding remarks follow the study findings and include the implications of the study findings and the need for further research. References round out the discussion.

Definition of key terms

For the purposes of this study the term "innovation diffusion" or "diffusion of innovation" refers to the adoption or implementation of new ideas, processes, products, or services (Lundblad, 2003, p. 50). A major assumption underlying this definition is that the acceptance of or the acknowledgement of a new idea is demonstrated by authors' willingness to address a topic and further demonstrated by dissertation advisors' editors' or reviewers' recommendations that a manuscript be approved for publication or a dissertation topic be approved as a topic worthy of study.

Another key term is "S-curve" or "adoption curve." The normal curve describing the pattern of adoption can be converted to an S-shaped curve representing cumulative adoption of the innovation over time (Bass, 1969; Bass *et al.*, 1994; Basu *et al.*, 2000; Rogers, 1962, 2003). For the purposes of this study, the term "S-curve" or "adoption curve" refers to an S-shaped curve representing cumulative adoption of the innovation over time.

"Bitnet" (BN) is a worldwide communications network. It stands for *Because It's Time NETwork* or *Because It's Their NETwork*. BN was created in 1981 to serve higher education and research. BN's was known for its LISTSERV and had the capacity to manage large electronic mailing lists eventually replaced by the internet in 1994.

Common Business Oriented Language or "COBOL" is a programming language that was developed in the late 1950s and early 1960s. COBOL programming language was used primarily for business applications. It is closer to English than many other high-level languages. Although COBOL is still being used, it popularity is lessening.

"Gopher" (GPHR), a client-server program was invented in 1993 at the University of Minnesota. GPHR used text-based interface to make information available on the internet. Although GPHR has been succeeded by hypertext or world wide web, there are still many GPHR servers available on the internet.

The term "information architecture" (IARCH) was coined by Richard Saul Wurman in the 1970s (Wurman, 1996). IARCH is an emerging discipline. IARCH is an aspect of information systems development within the context of web site design that deals with the analysis, organization, and implementation of information (Rosenfeld and Morville, 1998).

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The term "knowledge management" (KM) is defined by Holsapple and Joshi (2004, p 596) define KM as:

> … [A]n entity's systematic and deliberate efforts to expand, cultivate and apply available knowledge in ways that add value to the entity, in the sense of positive results in accomplishing its objectives or fulfilling its purpose.

Gupta *et al.* (2000) defined KM as a process within organizations. The authors further stated that the process:

> … deals with the development, storage, retrieval, and dissemination of information and expertise within an organization to support and improve its business performance.

"Open source" (OSRCE) means that the software's source code is freely available to anyone who wants to use, extend, modify, and/or improve the code. Linux (www.linux.org), Apache (www.apache.org), Mozilla (www.mozilla.org), and OpenOffice (www.openoffice.org) are several examples of OSRCE projects.

The term "Reengineering" (REENG) was popularized by Hammer and Champy (1990). REENG is the analysis and redesign of workflow within and between enterprises to lower costs and increase quality (Zhang and Cao, 2002; Zhao, 2004).

"Videotext" (VTXT), an information service, was popularized in the early 1980s. It allowed displaying of the data on a television or computer monitor via telephone lines or cables.

"Y2K" (Y2K) – Year 2000, also referred to as "millennium bug" was a defect in the computer program code. When "00" was read it would identify as 1900 instead of 2000 producing incorrect calculation in date. Koh *et al.* (2000) postulated that the Y2K crisis would not go away even after the year 2000.

Research questions and hypotheses

The present study is exploratory because it examines the rate and pattern of the diffusion of concepts among the scholarly community. Exploratory studies are not normally framed via research questions and hypotheses (Burns, 2000). However, the S-curve of the adoption of innovations is generally assumed to depict the frequency with which innovations are adopted over time and to infer the rate with which innovations are adopted over time.

Cumulative frequency distribution

Scholarly consensus on the shape of the S-curve (cumulative frequency of the adoption of an innovation over time) provides a basis to state two straightforward research questions and hypotheses, one which is intuitive or qualitative (*RQ1*) and one which is analytical (*RQ2*).

RQ1. Does the cumulative, annual frequency distribution of titles graphically approximate (visually resemble) the "S-curve" of adoption?

H01. The annual, cumulative frequency distribution of titles graphically approximates (visually resembles) the "S-curve" of adoption.

$H01_{alt}$. The annual, cumulative frequency distribution of titles does not graphically approximate (does not visually resemble) the "S-curve" of adoption.

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RQ2. Which trend line model has the largest r^2 (coefficient of determination – COD) in terms of the variance between time and the cumulative frequency of publications?

H02. The polynomial trend line model has the largest r^2 (COD) in terms of the variance between time and the cumulative frequency of publications.

$H02_{alt}$. The polynomial trend line model does not have the largest r^2 (COD) in terms of the variance between time and the cumulative frequency of publications.

Rate of adoption

Framing a research question and corresponding hypothesis as regards the rate of adoption is not a straightforward process. The linear model developed and tested by Mansfield (1961) and corroborated by later studies (Hsu and Mesak, 2001; Olshavsky, 1980; Ravichandran, 2003) involved adoption of an innovation as measured by purchases of tangible products as opposed to the adoption of a concept or idea as measured by the process of scholarly communication in journal articles, books, and dissertations. Additionally, the present study uses a bivariate design whereas earlier studies used a multivariate design. This is a significant factor to consider, especially when trend or time-series data are involved and the level of measurement for the dependent variable is nominal (Cameron and Trivedi, 1998). So, the following research question was framed:

RQ3. Which trend line model has the largest r^2 (COD) in terms of the variance between time and the rate of growth in the annual number of publications, as measured by the harmonic mean?

Methodology

Sampling

The sample for the present study included 4,014 publications (books listed at Amazon.com and doctoral dissertations and journal articles archived in ProQuest Database). The search for books was conducted during February 2005 and a simple search string, e.g. "BN" was used in each search, per topic. Each book title served as the unit of analysis. The search for journal articles and dissertation titles was conducted during March 2005 and a simple search string was used in each search, per topic. Each journal article title and each dissertation title served as the unit of analysis.

The authors of the present study understand that archives and web sites for entities such as Ebrary, the US Library of Congress, and Barnes & Noble.com provide extensive coverage of titles. But Amazon.com offered the highest count total and to avoid duplication of titles the sampling of book titles was limited to Amazon.com.

Likewise the authors of the present study are aware that Worldcat offers an extensive collection of dissertation titles. But ProQuest had the highest count total and to avoid duplication of titles the sampling of doctoral dissertations was limited to ProQuest. Search strings included "Bitnet" (BN), "COBOL" (COBOL), "Gopher" (GPHR), "information architecture" (IARCH), "knowledge management" (KM), "open source" (OSRCE), "reengineering" (REENG), "Videotext" (VTXT), and "Y2K" (Y2K).

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Topics were selected heuristically in order to identify sets of topics that matched some stage of a "life cycle." Innovations are considered to have a definitive life cycle, as inferred by the shape of the S-curve and by conceptual linkages to theories on the life cycle of products (Mansfield, 1961; McGrath and Zell, 2001; Wejnert, 2002; Rogers, 2003).

"Information architecture" (IARCH) was deemed to be representative of a topic in its "infancy." The topics "knowledge management" (KM) and "open source" (OSRCE) were deemed to be topics representative of those in "early maturity" or "maturity." The topics "Gopher" (GPHR), "Bitnet" (BN), "COBOL" (COBOL), and "reengineering" (REENG) were deemed to be topics representative of those in "late maturity." The topics "Videotext" (VTXT), and "Y2K" (Y2K) were deemed to be topics representative of those in "decline."

The authors of this study recognize that it would be possible to devise a plan to select topics on a random basis from ProQuest Database and from the database for Amazon.com. However, as noted earlier, the present study is exploratory in nature.

It would be inaccurate to characterize the sample as a sample of convenience. Historical records explicitly germane to the topics, i.e. artifacts/relics (titles of publications) are used and randomization is not a strict requirement (Burns, 2000, pp. 483-9). Additionally, the authors of this study are university professors who:

- teach and research in the areas of information systems and management;
- possess a sufficient grasp of the relative "age" of the topics, i.e. where they would fit on a "life cycle" continuum; and
- subsequently constitute an "expert panel" (Fries, 1995; Louwerese and van Peer, 2002).

Coding

Once publications were identified for a given topic via their title, they were arranged by year (1973 through 2004). They were also coded by type of publication (journal article, book, or doctoral dissertation).

Data analysis

Preliminary data analysis included tabulation of frequency counts of document titles. Tabulations were made on an annual basis per type of publication and per topic. Annual totals were computed per topic for each period (1973 through 2004).

Harmonic means were computed for each annual period, 1973-1974 through 2003-2004. In the present study, the harmonic mean was used to obtain the most accurate picture of the manner in which the rate (frequency) of publications changed on an annual basis, i.e. rate proportional to time. The harmonic mean is also appropriate when data are expected to fit a nonlinear model, e.g. the "S-curve" and they are in serial (time-series) fashion. Additionally, the harmonic mean, like the geometric mean is not sensitive to outliers so it is appropriate when data are expected to be distributed lognormal or heavily skewed and when data are drawn from unequal samples.

A detailed discussion of the harmonic mean and its applications is beyond the scope of this paper. Readers desiring more in-depth discussion may consult Eviritt (2002), Glanzel (1992), Kantz and Schreiber (1997), Lane (2005), Otto and Whitlock (1997) and McEntire (1984).

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The harmonic means were calculated using HARMEAN function for MS Excel© software. A detailed discussion of the software program is beyond the scope of this discussion. Those who seek to learn more are encouraged to consult Walkenbach (2003) and Microsoft Corporation (2005).

Ms Excel© "Standard Types Area Chart" was used to create a cumulative frequency chart. MS Excel© "Standard Types Line Chart" was used to plot harmonic means for 1973-1974 through 2003-2004. Five other charts were created by superimposing trend lines (exponential, polynomial, power, linear, and logarithmic) via MS Excel© functions on the cumulative frequency chart and harmonic means chart.

The authors of the present study were concerned primarily with the actual nature (shape) of the distribution of titles over time vs the expectation that they would approximate the "S-curve" that typifies the adoption of innovations (Demetriou, 2004; Friesen, 2004; Foxall *et al.*, 1992; Milne, 1984). The lack of scholarly consensus on the rate with which innovations are adopted precluded any expectations or preconceived ideas by the authors of the present study.

Analysis was not limited to visual inspection. When the trend lines were superimposed the authors of the present study used the MS Excel© option that displays the trend line equation and the r^2 value (COD). Because the present study was essentially an *ex-post-facto* analysis of time series data, the trend line equations were not used to develop forecasts. Rather, the focus was upon the r^2 value because the r^2 value indicates the proportion of the total variation in the dependent variable (Y) that is explained by or accounted for by the variation in the independent variable (X). For the present study, the dependent variable was the frequency of titles published and the independent variable was time (annual periods, 1973-1974 through 2003-2004).

The COD value is relatively straightforward. Because the COD indicates the proportion of the total variation in the dependent variable (Y) that is explained by or accounted for by the variation in the independent variable (X), then by inference the COD indicates the proportion of the total variation in the dependent variable (Y) that is not explained by or accounted for by the variation in the independent variable (X).

A detailed discussion of the COD is beyond the scope of this paper. Readers desiring an in-depth discussion of the COD and its applications and interpretation are encouraged to consult Lind *et al.* (2005), Witte and Witte (2004) and McClave and Sincich (2003).

Findings

Annual frequencies

Table I presents the frequencies per topic (title) for the period 1973-2004. Table I provides a sense of the "life cycle" stage for each topic by indicating the highest frequency per topic during the period, 1973-2004. Table I generally confirms the present authors' speculations regarding the maturation or "life cycle stage" for each management and information systems topic that was included in the study.

The highest number of VTXT publications occurred in 1986 and rapidly declined thereafter. It is reasonable to suggest that it is in the "decline" stage. Likewise, Y2K publications peaked in 1999 and have declined on an exponential basis since 1999.

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	VTXT	BN	COBOL	REENG	GPHR	Y2K	IARCH	KM	OSRCE	Sum
1973	0	0	6	0	0	0	0	0	0	6
1974	0	0	7	0	0	0	0	0	0	7
1975	0	0	8	0	0	0	0	0	0	8
1976	0	0	7	0	0	0	0	0	0	7
1977	0	0	15	0	0	0	0	0	0	*15*
1978	0	0	10	0	0	0	0	0	0	10
1979	0	0	14	0	0	0	0	0	0	14
1980	2	0	17	0	0	0	0	0	0	19
1981	1	0	25	0	0	0	0	0	0	26
1982	3	0	32	0	0	0	0	0	1	36
1983	1	0	25	1	0	0	0	12	0	39
1984	1	0	27	0	0	0	0	1	2	31
1985	3	1	47	0	0	0	1	0	1	53
1986	*10*	1	44	1	0	0	1	1	3	61
1987	5	1	38	0	0	0	0	0	5	49
1988	3	1	41	0	0	0	0	0	6	51
1989	5	1	35	2	0	0	0	1	2	46
1990	1	4	37	6	0	0	0	0	1	49
1991	1	1	33	5	1	1	2	0	0	44
1992	4	*8*	26	7	1	0	2	8	3	59
1993	8	2	16	49	6	0	1	2	1	85
1994	1	7	*51*	100	24	0	0	6	1	*190*
1995	4	3	20	*121*	*43*	0	0	5	1	197
1996	0	0	21	87	17	2	16	13	2	158
1997	1	1	28	70	11	33	2	17	1	164
1998	1	1	37	69	2	127	1	56	6	300
1999	0	0	39	51	2	*382*	9	114	17	*614*
2000	1	0	46	47	1	72	7	157	40	371
2001	0	0	16	29	0	25	10	166	43	289
2002	0	0	16	32	1	8	*18*	*239*	68	382
2003	1	0	10	32	0	4	14	214	97	372
2004	0	0	17	13	1	5	9	107	*110*	262
Total	57	32	811	722	110	659	93	1119	411	4,014

Notes: "BN" Bitnet; "COBOL" COBOL; "GPHR" Gopher; "IARCH" information architecture; "KM" knowledge management; "OSRCE" open source; "REENG" reengineering; "VTXT" videotext; and "Y2K" = Y2K

Table I.
Frequency of titles, by topic: 1973-2004

Although the authors of the present study speculated that IARCH was in its "infancy" the data in Table I indicate otherwise. IARCH publications have a cyclical pattern and are trending downward.

Table I sheds light on the "life cycle" stage of KM publications. The frequency of KM publications peaked in 2002 and has rapidly declined. It is reasonable to suggest that KM publications have reached a "maturity" stage.

OSRCE publications are in either an "early maturity" stage or a "maturity" stage. Publications have increased steadily since 1999 (Table I).

BN, GPHR, COBOL, and REENG represent topics in "late maturity." The frequency of publications for those topics peaked in the mid-1990s and has been declining since then (Table I).

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Table I also provides a glimpse at the growth of all publications. In 1977, the total for all publications reached double-digits. The total for all publications reached triple-digits in 1994 and the highest frequency for all publications occurred in 1999 (primarily due to the large number of publications on Y2K).

Y2K publication frequencies indicated that it has run its course, i.e. it has been through each stage of a life cycle. The authors of the present study considered excluding Y2K publications data because they represent outliers, i.e. a special case situation. But it would be difficult to argue that the Y2K issue did not have a positive, synergetic impact on publication frequency in general. Likewise it would be difficult to argue that the Y2K issue did not have a negative, synergistic impact. Assuming that "truth" resided somewhere between those extreme arguments, the authors of the present study chose not to treat Y2K publication data as outliers. Also the present study is concerned with the frequency distribution for all topics and the rate of change for all topics versus the S-curve.

Further, if one accepts arguments that innovations such as KM, OSRCE and IARCH represent "fads" then those data too would have to be excluded as outliers. Logically, any innovation could be deemed a "fad" so the issue of outliers is a conceptual issue that poses no simple answers to scholars. So as noted earlier, the use of the harmonic mean to chart central tendency over time and to chart the change in the rate of adoption over time addresses the statistical issues related to outliers.

Cumulative frequencies

Table II sets forth the cumulative frequency for all publications for the period 1973-2004. The cumulative frequency of publications has increased steadily; as Table II shows although Table I indicates that annual frequency totals have followed a cyclical trend since 2000. The first year when cumulative frequencies reached double- and triple-digit totals are indicated. So too is the first year that cumulative frequencies totaled 1,000 or higher. Cumulative frequencies reached a double-digit level in 1974. By 1981 cumulative frequencies had reached the triple-digit level. Cumulative frequencies equaled or exceed 1,000 by 1995. This indicated that cumulative frequencies roughly grew at an exponential rate an average of every seven years (1974-1995) although it took 14 years for cumulative frequencies to grow from triple-to quadruple-digit levels.

Figure 1 presents a cumulative frequency polygon for total publications for the period 1973-2004. The distribution is negatively skewed. This would be expected if frequencies generally follow the pattern of the S-curve which assumes a negatively skewed distribution that begins to slope downward once the innovation has become widespread (Rogers, 1962, 2003; Rogers and Shoemaker, 1971; Fredrickson *et al.*, 2004; Senhadjj, 1998; Smith, 2003).

Table III presents the results of testing the cumulative frequency distribution of publications vs an exponential, linear, logarithmic, polynomial, and power trend line. The derived r^2 values are presented in rank order starting with the highest value. As Table III indicates, the polynomial trend line explained or accounted for the highest amount of variation. With the exception of a logarithmic model, the models accounted for a high amount of variation (Table III).

The data in Table III also infer the proportion of variance that is not accounted for or explained. In the case of the polynomial model, less than one percent of variation is not accounted for or explained.

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Table II.
Cumulative frequency of titles: 1973-2004

Year	Cumulative frequency
1973	6
1974	*13*
1975	21
1976	28
1977	43
1978	53
1979	67
1980	86
1981	*112*
1982	148
1983	187
1984	218
1985	271
1986	332
1987	381
1988	432
1989	478
1990	527
1991	571
1992	630
1993	715
1994	905
1995	*1,102*
1996	1,260
1997	1,424
1998	1,724
1999	2,338
2000	2,709
2001	2,998
2002	3,380
2003	3,752
2004	4,014

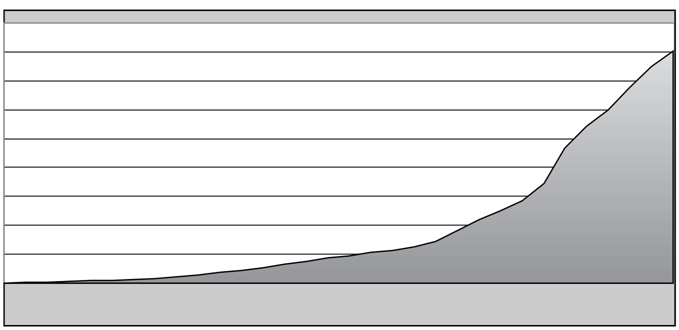

Figure 1.
Cumulative frequency of titles: 1973-2004

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It is important to note that r^2 does not describe or predict individual values and is not an unqualified measure of causation. At a minimum, it provides a straightforward measure of the efficacy of using a least squares method, i.e. data model. Witte and Witte (2004, pp. 186-96) set forth a concise discussion of the use of r^2 and related issues including relative size of r^2 (COD or coefficient of determination).

The polynomial trend line model used in MS Excel© has a striking resemblance to the S-curve. Readers who wish to verify this may easily do so by selecting that option in MS Excel©. Figure 2 presents a graphic representation of the polynomial trend line superimposed on the cumulative frequency distribution.

Annual harmonic means and rate of adoption

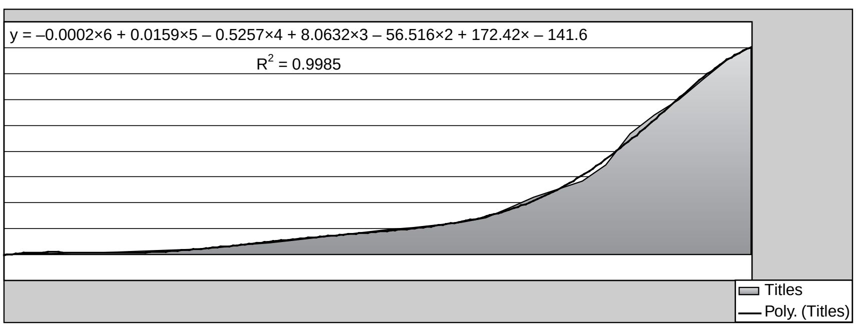
Table IV presents the annual harmonic means, 1973-1974 through 2003-2004. In 1977-1978 the harmonic mean reached a double- and a triple-digit level in 1993-1994 (Table IV). The exponential growth of the harmonic mean over that 16-year period (1977-1978 to 1993-1994) roughly parallels the growth pattern in cumulative frequencies from a double- to a triple-digit level between 1981 and 1995 (Table II). Since, 1999-2000 the harmonic mean has exhibited a cyclical pattern (Table IV) that parallels the cyclical pattern in cumulative frequencies (Table II).

Figure 3 presents a frequency polygon of the harmonic means for the annual intervals, 1973-1974 through 2003-2004. The distribution is negatively skewed and thus follows the pattern of the S-curve which assumes a negatively skewed distribution that slopes downward over time.

Model/trend line	r^2 value (coefficient of determination)	Rank
Polynomial	0.9985	1
Power	0.9497	2
Exponential	0.9349	3
Linear	0.7591	4
Logarithmic	0.4488	5

Note: Ms Excel© uses R^2 to represent COD rather than the conventional symbol, r^2

Table III. Trend lines vs cumulative frequency of titles: 1973-2004



Note: Ms Excel © uses R2 to represent Coefficient of Determination (COD) rather than the conventional symbol, r^2.

Figure 2. Polynomial trend line fitted to cumulative frequency, all titles: 1973-2004

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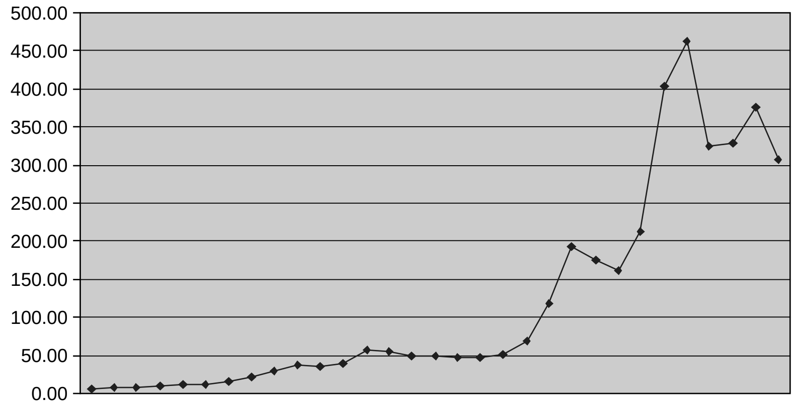
Year	Mean
1973-1974	6.46
1974-1975	7.47
1975-1976	7.47
1976-1977	9.55
1977-1978	*12.00*
1978-1979	11.67
1979-1980	16.12
1980-1981	21.96
1981-1982	30.19
1982-1983	37.44
1983-1984	34.54
1984-1985	39.12
1985-1986	56.72
1986-1987	54.35
1987-1988	49.98
1988-1989	48.37
1989-1990	47.45
1990-1991	46.37
1991-1992	50.41
1992-1993	69.65
1993-1994	*117.45*
1994-1995	193.44
1995-1996	175.36
1996-1997	160.94
1997-1998	212.07
1998-1999	403.06
1999-2000	462.53
2000-2001	324.91
2001-2002	329.06
2002-2003	376.93
2003-2004	307.46

Table IV.
Annual harmonic means, all titles: 1973-1974 through 2003-2004



Note: Ms Excel © uses R^2 to represent Coefficient of Determination (COD) rather than the conventional symbol, r^2.

Figure 3.
Harmonic means: all titles: 1973-1974 through 2003-2004

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Table V presents the results of testing the annual harmonic means vs an exponential, linear, logarithmic, polynomial, and power trend line. The derived r^2 values are presented in rank order starting with the highest value. As Table V indicates, the exponential trend line explained or accounted for the highest amount of variation. With the exception of a logarithmic model, the models accounted for a high amount of variation (Table V).

Figure 4 shows a graphic representation of the exponential trend line superimposed on the distribution of annual harmonic means for the period 1973-1974 through 2003-2004. The exponential trend line model used in MS Excel© does not visually resemble the S-curve. But it does graphically depict a distribution that is negatively skewed, albeit with a much steeper slope than the slope one sees when examining the visual model of the polynomial model in MS Excel©. Readers who wish to verify this may easily do so by selecting that option in MS Excel© and making a visual comparison between the polynomial and the exponential model.

Conclusions

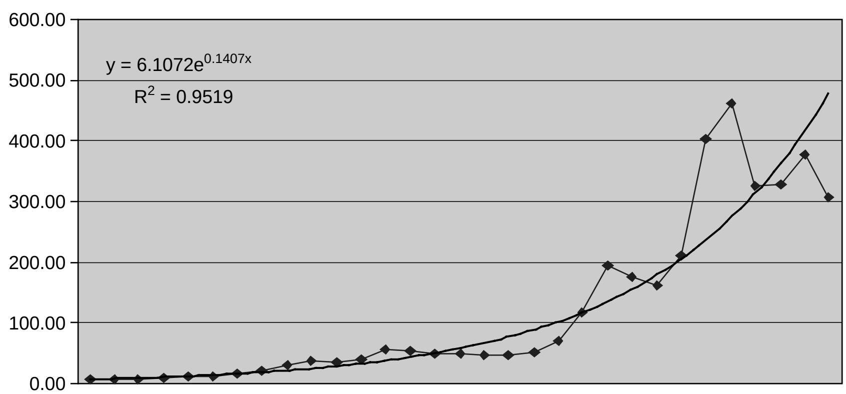
RQ1 (research question one) and HO1 (hypothesis one)

The study findings tend to confirm hypothesis one (*H01*): the annual, cumulative frequency distribution of publications graphically approximates (visually resembles)

Model/trend line	r^2 value (coefficient of determination)	Rank
Exponential	0.9519	1
Polynomial	0.9328	2
Power	0.8303	3
Linear	0.7274	4
Logarithmic	0.4511	5

Note: Ms Excel© uses R^2 to represent coefficient of determination (COD) rather than the conventional symbol, r^2

Table V. Trend lines vs annual harmonic means: 1973-1974 through 2003-2004



Note: Ms Excel © uses R^2 to represent Coefficient of Determination (COD) rather than the conventional symbol, r^2.

Figure 4. Exponential trend line fitted to annual harmonic means, all titles: 1973-1974 through 2003-2004

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the “S-curve” of adoption. Visual inspection indicated that the cumulative frequency distribution is strikingly similar to the polynomial trend line. This confirms scholars’ consensus on the S-curve.

RQ2 (research question two) and HO2 (hypothesis two)

The visual inspection is confirmed by the trend line data. The polynomial trend line had a COD that explained 99 percent of the variance between time (*X* or predictor variable) and annual cumulative titles/publications (*Y* or dependent variable). The study findings confirm hypothesis two (*H02*): The polynomial trend line model has the largest r^2 (COD) in terms of the variance between time and the cumulative frequency of publications. Recall that COD is a straightforward measure so a COD of 0.50 is twice as large as a COD of 0.25 so using the value of COD as a decision criterion was appropriate because a COD of 0.99 explains 5 percent more variance than a COD of 0.94 and over twice as much variance as a COD of 0.44 (Witte and Witte, 2004, pp. 188-9). Again, the study findings confirm scholars’ consensus as regards the S-curve.

RQ3 (research question three)

Recall that the present study had no model applicable to examine the issue of the rate of adoption. The findings are counter-intuitive because the exponential trend line did not visually resemble the S-curve (as does the polynomial tend line). The trend line data, however, indicated that the exponential trend line accounts for the highest amount of variance (95 percent). So as regards *RQ3*, the authors of the present study concluded that the rate of adoption follows an exponential growth pattern.

This finding does (quite tentatively) confirm the findings of Hivner *et al.* (2003) who argued that the diffusion process exhibits a growth pattern that resembles patterns found in the spread of a disease during an epidemic, i.e. the epidemiological model. This is important if one ascribes to the concept of the diffusion of innovations as basically a series of binary events, i.e. “adopt innovation vs do not adopt innovation,” “purchase product or service versus do not purchase product or service.” Epidemiological modeling is ultimately based upon a binary event, e.g. one becomes infected or one does not become infected. Likewise, a scholarly work (journal article, book, or dissertation) on a given topic is either approved or not approved by an editor, a set of journal reviewers, or a dissertation committee. Indeed, the process is set in motion when an author submits or does not submit a scholarly work (a binary event).

Recommendations

The present study is clearly an exploratory study but the findings indicate that this is a potentially fruitful path to follow. Further research is needed to identify and examine topics or concepts that have run their course and subsequently offer an excellent opportunity to perform *ex-post-facto* studies on the life cycle of innovative concepts or topics. Scholarly publications offer an especially excellent “ecology” because they are unobtrusive measures of the “actors” involved in scholarly communication.

There is a need for research on emerging topics to understand how they are diffused. And there will be topics that may never complete a “life cycle.”

From these studies will be baseline data and easily identifiable “actors” in the diffusion process (authors, editors, reviewers, and dissertation committees) that will provide the impetus for continued, progressively complex research models. Given that

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scholarly publishing reflects deeply-held traditions of consensus and resistance to change juxtaposed with a norm of divergent thinking, innovation and progress, studies of scholarly publishing offer an opportunity to enhance understanding of diffusion and prototypical "actors" in the process.

The practical implications of a deeper understanding of the diffusion of innovations are immense. It will enhance understanding of how to better promote research and development and technology transfer. It will enhance understanding of how better to market the fruits of those endeavors. For the scholarly community in the digital era it has never been more important to understand how new concepts and theories are brought to light and evaluated.

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