PACIS 1995 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 1995

Diffusion of Information Technology: An Exploration of the Stage Models and Facilitating the User's Choice by Systems Approach

Mohammed Quaddus
Curtin University of Technology

DIFFUSION OF INFORMATION TECHNOLOGY: AN EXPLORATION OF THE STAGE MODELS AND FACILITATING THE USER'S CHOICE BY SYSTEMS APPROACH

M A Quaddus
School of Information Systems
Curtin University of Technology
GPO Box U 1987
Perth, W.A. 6001
AUSTRALIA

There is an abundance of models to study the diffusion process of information technology (IT). These models can be categorized as implicit (stage) or explicit time dependent (dynamic) models. In this paper we explore the stage models and their applications with a view to facilitating the users to choose the appropriate model for specific applications. The paper first reviews the models. A number of IT diffusion studies are then reported to show how these models are put into practice. It then takes a systems approach to analyze the adoption and diffusion process and thus facilitates the user to choose (or develop) an appropriate model. It is observed that the stage models are interrelated. The user can therefore narrow down his/her choices for the models in an IT diffusion study.

1 Introduction

In the last three decades diffusions of innovations has been widely researched by economists, social scientists, engineers and the like. As Rogers [1983] pointed, during 1962 to 1983 the diffusion literature has grown almost eight folds. Diffusion is a natural process in any society. People learn from people, exchange ideas, copy habits and adopt a technology [Nakicenovic and Grubler 1991]. Technology (idea, product, art etc) thus diffuses in a society. Diffusion (spread in usage) analysis has many applications. Nakicenovic and Grubler[1991] summarizes the usefulness of diffusion analysis in a number of ways:

- to explain the process of social and economic change and restructuring
- to integrate technological change into economic theory
- to aid strategic business decisions and planning activities
- to use as a policy tool.

In a related study Quaddus [1986] mentions that diffusion of technologies is needed:

- to understand the dynamics of technology
- to understand the substitution phenomenon of one technology by another
- to allocate resources in technology management.
- to understand the impact of technology on society.

Literature on diffusion analysis is plentiful, for example see Mahajan and Peterson 1985; Mahajan and Wind 1986; Nakicenovic and Grubler 1991; Quaddus 1986; and Rogers 1983; among many others. Applications range from administrative innovation (soft-tech) diffusion [Teece 1980] to the diffusion of high-tech products (ICs) [Norton and Bass 1987]. This paper is concerned with the diffusion of information technology (IT) to individuals and organizations. IT is defined here as a collection of hardware and software engaged in the generation, communication, usage and management of information. OECD report [OECD 1988] classifies IT as one of the most important new technologies of the 90's (others are: bio-technology, materials technology, space technology and nuclear technology). The report also portrays IT as the most pervasive technology having the most economical effects and substantial employment implications. In a range of six economical and social criteria IT averaged a score of 9.5 (in a scale of 1 (lowest) to 10 (highest)) [OECD 1988]. The second best was materials technology with an average score of 4.83 . Table 1 summarizes these criteria which the OECD also portrays as the main characteristics of large scale IT diffusion.

The above discussions highlight the importance of IT. Careful planning is necessary for successful adoption and diffusion of IT in organizations. While IT can provide a competitive edge, if not planned properly, it can also end up being under utilized, wrongly utilized, or even a total failure. Diffusion analysis studies an IT in detail. The intricacies of the technology are known fully which is helpful in any forward planning.

This paper explores a number of IT diffusion models and their applications in order to facilitate the user to choose the most appropriate model for a specific application. In the next several sections basic models of diffusion are presented first. The models are categorized as implicit time dependent (stage) and explicit time dependent (dynamic) types. The stage models are then further explored, and a number of relevant IT diffusion studies are reported. A systems approach is then suggested to analyze

Currently on leave at: Nanyang Business School, Nanyang Technological University, Nanyang Avenue, Singapore 2263 the adoption/diffusion process in order to facilitate the potential users to choose or develop an appropriate model. Finally, conclusions are presented with a brief remark on future directions.

Table 1: Main Characteristics of IT Diffusion (Adapted from [OECD 1988])

Criteria	Evidenced By
Range of new products and services	Large varieties of IT products and services used by individuals and organizations
Improvements in costs or technical attributes of existing processes, services and products	Technical advances in the computer industry at an exponential rate of 57% per year [Sahal 1984]. IT price reduction of 30% per year [OECD 1988].
Social acceptance	Widespread adoption, favourable regulatory framework for IT, minimal opposition [OECD 1988]
Strength of private industrial interest	Competitive advantage [McFarlan 1984, Scott Morton 1991], profitability, efficiency, and effectiveness.
Sectors of applications	Widespread adoption in all sectors of economy [OECD 1988].
Probable employment impact in 1990s	Perceived productivity growth and its positive impact on employment

2 Basic Models

Diffusion is defined as a process by which an innovation is communicated through certain channels over time among the members of a social system [Rogers 1983]. Four key elements of the diffusion process is: the innovation, channels of communication, time, and the social system [Mahajan and Peterson 1985, Rogers 1983]. Table 2 describes the key elements in the context of IT diffusion.

It has been observed that diffusion of technology over time can be modelled by a logistic or S-shaped curve. The literature suggests that new technology is not adopted all at once. Some early adopters adopt new technology. If they are successful a bandwagon effect takes place and the potential adopters then imitate [Martino 1983, Mahajan and Peterson 1985, Rogers 1983]. This imitation process grows in the same way as the growth of organisms or population which is S-shaped [Pearl 1925].

Table 2: Key Elements in IT Diffusion

Generic Elements	IT Context
Innovation	IT software and/or hardware having significant impact on the adopting organizations and individuals within the organization.
Channels of communication	Horizontal channel (e.g. direct interpersonal contacts, indirect observations within the IT user community) and vertical channel (e.g. interaction with outside agents, promotional efforts by the IT vendors etc) [Loh and Venkatraman 1992].
Time	The time period of IT adoption under study
Social system	Set of organizations (and individuals within an organization) leveraging IT to achieve their mission [Loh and Venkatraman 1992]

The basic differential equation which governs the diffusion process can be presented as follows [Mahajan and Peterson 1985, Martino 1983]:

$$\frac{df(t)}{dt} = b(t)f(t)[F - f(t)] \qquad (1)$$

where b(t) is the coefficient of imitation and F is the upper limit of f(t). In actual application f(t) can either be cumulative adoption at time t (expressed as % of upper limit F) or % market share at time t [Quaddus 1986]. The former is used to study pure diffusion of IT over time while the later is used to study the bi-level substitution of an old IT by a new one. It is noted that the substitution model is even more applicable in the context of IT as new generations of IT are constantly replacing the old ones [Norton and Bass 1987]. Equation (1) provides the basic structure of explicit time dependent dynamic IT diffusion model. It deals with diffusion process over time. A lot of information about the dynamics of IT (ie behaviour of adopter population over time) is obtained using dynamic model.

In a number of other studies [for example, Brancheau and Wetherbe 1990; Cooper and Zmud 1990; Gerwin 1988; Huff and Munro 1985; Kwon and Zmud 1987; Manross and Rice 1986; Nilakanta and Scamell 1990; and Wynekoop et al 1992; among many others] behaviour and characteristics of adopter population have been investigated at a specific point in time to study different stages of diffusion process. Conceptual models have first been developed for IT diffusion process and different hypotheses have been tested. These models are implicitly dependent on time and can, therefore, be classified as stage (or phase) models of IT diffusion. Broadly, IT diffusion models can then be classified as shown in Figure 1.

In our review we shall explore the stage models in detail. It will be observed that the models in this category are interrelated thus the user can narrow down his/her choice to use an appropriate model.

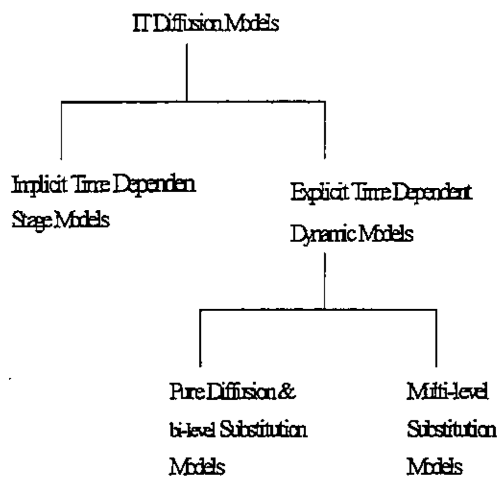

Figure 1: Classification of IT Diffusion Models

3 Implicit Time Dependent Stage Models

Applegate [1992] recently presented a collection of six stage models. Starting from Applegate and after a comprehensive literature search we have identified thirteen stage models of innovation diffusion which are presented in figure 2. To show how these models are related we have chosen the framework of Rogers [1983] in presenting them in figure 2. According to Rogers, technology diffusion follows the broad stages of *Initiation*, *Decision to adopt*, and *Implementation*. This *initiation* may come from internal or external forces. Internally the organization may feel a need for a technology, and externally various agents (vendors etc) may persuade the organization to adopt a technology. In a field survey Huff & Munro [1985] identified two major driving forces of technology adoption and diffusion as *issues* and *technology*. The authors concluded that some organizations identify issues first then find a technology to deal with the issues, while others identify an interesting technology first then identify some organizational issues which can be addressed by this technology. *Decision to adopt* is an important step, which is normally performed by a group championing the technology in collaboration with the end users. Finally, the technology is *implemented* in the organization which by then may go through several adaptations.

In figure 2 we present thirteen stage models in terms of their finer stages. However, we argue that the finer stages can be roughly grouped under the more broader stages of *Initiation*, *Decision to adopt*, and *Implementation*. For example, Rogers [1983] has grouped *agenda setting* and *matching* under *initiation*, and *redefining/restructuring*, *clarifying* and *routinizing* under *implementation*. Two of the most widely used stage models are due to Rogers [1983] and Nolan [1973]. Nolan's model has been widely used in IS/IT area. It is considered to be the best known model of the growth of IS in organization [King and Kraemer, 1984]. A number of studies have used Rogers' model or a variation of Rogers' model in IT diffusion study [Brancheau and Wetherbe 1990, Gerwin 1988, Huff and Munro 1985, Nilakanta and Scamell 1990, among many others]. We discuss below the stages of Rogers' model. Others will then also be quite clear to understand.

Agenda-Setting involves the identification of an important problem (issue) in the organization by one or more individuals, then searching (environmental scanning) for an innovation to cope with the problem. Where problems may be identified by any individual (or group of individuals) in the organizational hierarchy, the environmental scanning is typically performed by a decision making unit or focus group in collaboration with the technological gatekeepers.

Matching consists of the steps involved to test the feasibility of the innovation to solve the organization's problem. A perfect match or fit is sought at this phase at the end of which a decision is made (by a decision making unit) either to adopt or reject the technology.

Redefining/Restructuring is perhaps the most important phase of innovation diffusion in organization and it is more so for IT diffusion. At this stage the imported technology is adapted to use successfully in the organization. A number of re-inventions may be carried out at this stage to fit the technology to perfect use. The organizational structure may also be adapted to use the technology effectively.

Clarifying phase identifies the practical problems and prospects of the technology after wider use. Corrective actions are taken to overcome the problems. On the other hand arrangements are also made for further innovative use of the technology.

In *Routinizing* phase the technology becomes an integral part of the organization. Members of the organization use it on a regular basis. In some situations the technology may be discontinued or substituted if it can not be integrated into the organization.

It is important to note that the stage models of diffusion of figure 2 have inherent time sequence [Rogers 1983]. For

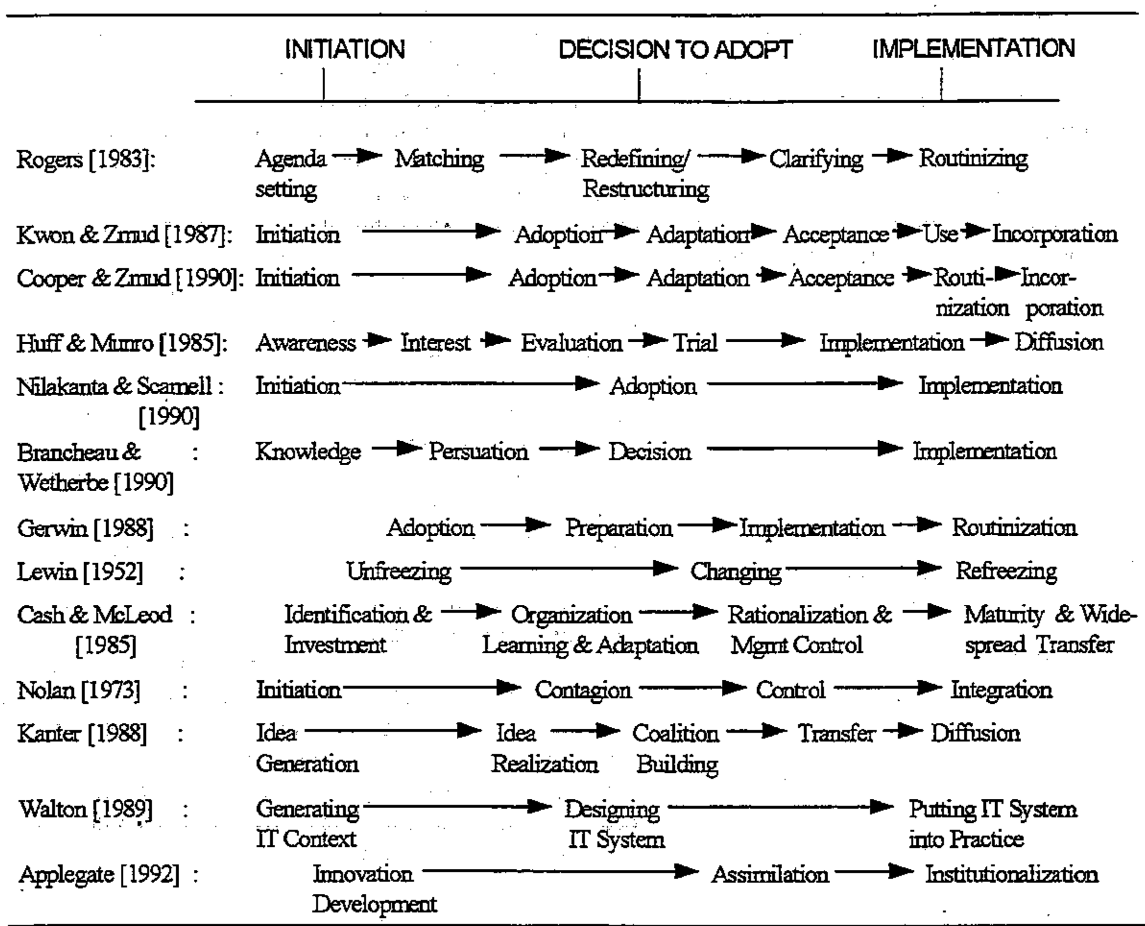

Figure 2: Stage Models of Innovation Diffusion

example, the problem of *matching* will only come after some time has been spent in the *agenda setting* to find an organizational issue and the corresponding innovation to cope with the issue. However, it must be realized that instead of moving forward from the *matching* stage the diffusion process might come back to the *agenda setting* if a perfect match is not found at this stage. In the overall sense, therefore, the process will move forward but there will be a number of feedback loops among and between the various stages.

Most of the IT diffusion research based on the stage models have been conducted at a specific point in time in order to study the characteristics of the key elements of IT diffusion (Table 2) and the effect of various factors (individual, organizational, environmental etc.) on different stages of the diffusion process (Figure 2). Kwon and Zmud [1987] did a comprehensive review to identify various factors contributing towards IT diffusion in organizations. They came up with five broad categories (entities) as "Individual Factors", "Structural Factors", "Technological Factors", "Task-Related Factors" and "Environmental Factors", which favour or retard different phases of diffusion of IT in organizations. Table 3 presents further breakdown of these factors. The attributes of Table 3 will not be discussed here which are comprehensively discussed in Kwon and Zmud [1987].

4 Review of Applications

We now review some representative applications of stage models in IT diffusion study. Our main objective here is to explore how different stage models of figure 2 have been used in order to study the impact of various factors (Table 3).

In a recent study Cooper and Zmud [1990] used a variation of Kwon and Zmud's [1987] original model (Figure 2) in the diffusion of MRP technology. The authors identified the organizational tasks to be performed by the specific technology (MRP) and studied the effect of task and technology characteristics on the adoption and infusion (i.e., "incorporation and more" of Figure 2) of MRP. The authors conclude that while rational decision models are useful in explaining IT adoption, political and learning models are more useful when examining infusion. Huff and

Table 3: List of Factors Favouring or Retarding Stages of IT Diffusion [Kwon & Zmud 1987]

Entity	Attribute
Individual Factors	Job Tenure, Cosmopolitanism, Education, Attitude toward change
Structural Factors	Specialization, Centralization, Formalization, Informal network
Technological Factors	Compatibility, Relative advantage , Complexity
Task-related Factors	Task uncertainty, Autonomy, Responsibility, Variety, Identity, Feedback
Environmental Factors	Heterogeneity, Uncertainty, Competition, Concentration/Dispersion, Inter-Organizational Dependence

Munro [1985] observed six phases of IT diffusion as: *Awareness, Interest, Evaluation, Trial, Implementation* and *Diffusion*. The authors studied the assessment and adoption (i.e. roughly first four stages of their model) of IT and found that issue (task) and technology are the major factors. In the diffusion of intelligent telephone Manross and Rice [1986] studied a number of individual and organizational variables (Table 3). The authors used a five-stage diffusion model very similar to that of Rogers' [1983] and primarily dealt with the implementation stage. Nilakanta and Scamell [1990] examined the impact of information sources, communication channels (Table 2), organizational size and availability of technical support (Table 3) on the diffusion of requirements analysis and logical data base design tools and methods. The authors used a simplified stage model as shown in Figure 2 and studied the impact of above mentioned factors on all the three stages of the model, i.e. *Initiation, Adoption* and *Implementation*. They observed that the factors had mixed influence on the diffusion process. Wynekoop et al. [1992] examined the implementation of CASE tools as an innovation diffusion process. The authors, however, did not use any diffusion phase model and only studied the impact of technical and organizational factors (management commitment, communication amount) on the "*acceptance*" (i.e. *Implementation*) of CASE tools. The study found that management commitment and increased communication can successfully diffuse CASE tool. However information regarding the benefits of the CASE tool should be accurate and should not be raised to unrealistically optimistic levels. Brancheau and Wetherbe [1990] used a four-stage individual diffusion process as shown in Figure 2 to study the diffusion of spreadsheet software. The authors studied several hypotheses regarding the characteristics of adopter population (age, education, mass media exposure, social participation, interpersonal communication, opinion, leadership etc.) and examined the impacts of communication channel type (mass media, interpersonal) and source (external vs internal) on different stages (Knowledge, Persuasion, and Decision) of the diffusion process. The authors concluded that early adopters of spreadsheet software were younger, more highly educated, more attuned to mass media, more involved in interpersonal communication and more likely to be opinion leaders. They also found significant impact of interpersonal channels of communication in all phases of the diffusion process. In a theoretical study Gerwin [1988] proposed a four-stage diffusion process of computer aided manufacturing (see Figure 2). The author did not do any field study to support his various propositions but developed a comprehensive model of each stage of the diffusion process from the perspective of uncertainty minimization.

5 A Systems Approach To Choose (or Develop) A Stage Model for Specific Application

One of the major problems in any IT diffusion study is to choose an appropriate stage model for a specific application. As shown in Figure 2 various models have been used in different applications. Literature, however, does not say how these models have been developed. In this section, we propose a systems approach to analyze the specific situation and then choose or develop an appropriate model.

Table 4 summarizes the representative applications of IT diffusion study presented earlier. Although various researchers have adopted different stage models, the overall objectives of the studies are the same, i.e. identify the significant factors which will affect the selected stages of the diffusion process. It is therefore observed that choosing a stage model and finding the appropriate factors are two of the most important considerations in an IT diffusion study. Our proposed systems approach analyzes the adoption and diffusion process for the specific case, which will then hopefully guide a user to select (or develop) an appropriate stage model.

It has been observed that the stage models can be broadly grouped under *initiation*, *decision to adopt*, and *implementation*. At a higher level these three stages will suffice for almost any application. It shows two clear phases of the diffusion process, that of *initiation to adoption* and *adoption to implementation*. As observed previously a number of studies have only considered these two phases. However care must be taken to fine tune these broader stages in order to find more detailed stages.

While various systems approaches are available in the literature [Rosenhead 1992], we have taken the approach as advocated by Forrester [1968]. Forrester's systems dynamics approach clearly shows how various feedback loops interact in a complex situation and thus help to identify the major issues of the process. Figure 3 shows a construct of feedback loop in IT initiation to adoption process. This diagram has been developed by our own understanding of the initiation to adoption process after a comprehensive literature review.

Table 4: Summary of Applications

Author(s)	Factors Studied	Diffusion Stages Studied
Cooper & Zmud [1990]	Task and Technological Factors	Adoption & Infusion
Huff & Munro [1985]	Issue (task) and Technological Factors	Assessment & Adoption
Manross & Rice [1986]	Individual & Organizational Factors	Implementation
Nilakanta & Scamell [1990]	Information Sources, Communication Channels, Organization size, and Technical support	Initiation, Adoption, and Implementation
Wynekoop et al [1992]	Technical & Organizational Factors	Implementation
Brancheau & Wetherbe [1990]	Individual Factors, Communication Channels, and Communication Sources	Knowledge, Persuasion, and Decision

Organization's search for new appropriate IT is influenced by three major forces: external persuasion, backlog of organization's issues (problems), and IT status of the organization. However the type of influence is different for different forces. For example, if organization's IT status is not so healthy there will be more searches for new appropriate ITs. How much more will, of course, depend on the effect of the other two forces. This more search will lead to more of new ITs under consideration, which in turn will increase the backlog of problems of IT choice making. This will eventually have a dampening (negative) effect on the appropriate IT selection and adoption and will ultimately negatively affect the already not so healthy status of the organization's IT. We, therefore, observe the existence of a positive feedback loop in this initiation to adoption process, i.e. organization's unhealthy status of IT will eventually leave the organization even unhealthier in ITs (or vice versa).

Discovery of this positive feedback loop has many implications. It clearly infers that continuous searches for new and top end ITs may not be a good idea for an organization with existing unhealthy IT status. There has to be a critical mass of ITs before new searches can be initiated for a technology push adoption [Huff and Munro 1985]. This notion has also been observed by Madu and Jacob [1989] in the context of technology transfer. A carefully planned search for an IT, however, may be initiated for an issue based adoption [Huff & Munro 1985]. Depending on the specific organization's IT status, finer stages can now be developed (or selected from Figure 2) which adequately addresses the notion of the feedback loop. Different variables (as presented in Tables 2 and 3) can then be studied to find various effects .

The second phase of the diffusion process (adoption to implementation) has been adapted from Saeed [1990] and is shown in Figure 4. As new IT is practised in organization, a backlog of associated problems begins to build up (even if the IT has been adequately evaluated in the initiation to adoption process). These problems discourage further adoption of IT and, in fact, encourage its abandonment. We, therefore, observe two negative feedback loops in figure 4 both of which has negative impacts on the practice of IT. While IT abandonment is one of the major problems in reality [Bayer and Melone 1989], it is noted that none of the reported stage models of figure 3 addresses this problem explicitly. For a specific IT diffusion study a figure similar to figure 4 can be developed, analyzed, and then finer stages can be developed to address the process of adoption to implementation.

It must be emphasized that Figures 3 and 4 present a generic approach to IT adoption and diffusion analysis. For a specific application organization's present IT status, the push or pull type forces for IT adoption and various other factors must be considered explicitly. We believe that a formal systematic analysis of this type will help understand the IT diffusion process better.

5 Conclusions

This paper reviewed a number of stage models of IT diffusion. The stage models deal with different phases of the diffusion process and study the impacts of various personal, organizational and technological factors. To fully understand the diffusion of IT a user can select one of the models discussed in the paper. Systems approach has been suggested to this end. Different causal relationships can then be hypothesized and tested in any specific application. Factors influencing the diffusion process can then be managed properly.

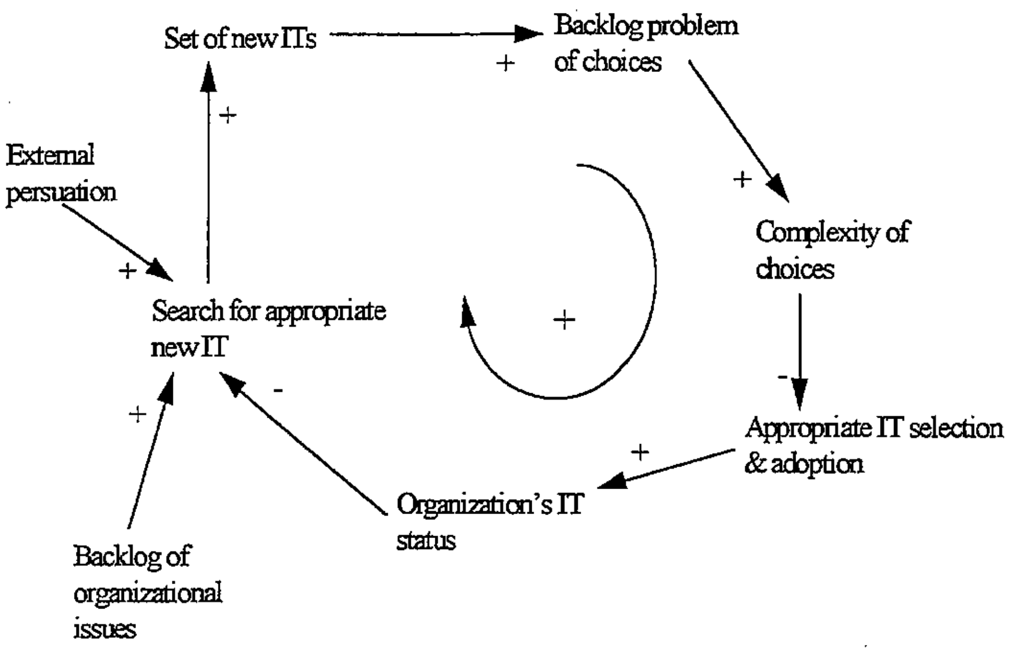

Figure 3: Feedback Loop in IT Initiation to Adoption Process

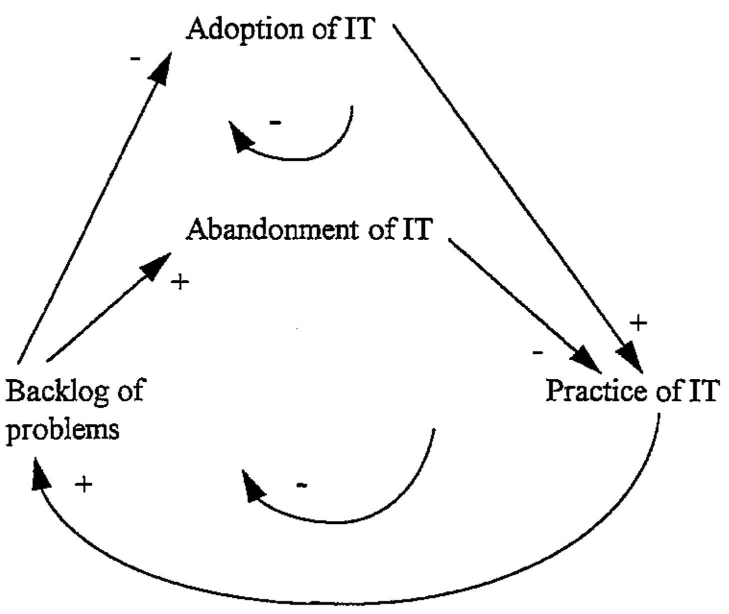

Figure 4: Feedback Loops in IT Adoption to Implementation Process (Adapted from Saeed [1990])

The author advocates the use of system dynamics modelling for exploring and selecting (or developing) a stage model. The major advantage of system dynamics approach is that various exogenous factors can be easily incorporated in the model and thus their impacts studied directly. We are currently working in this direction.

References

Applegate, L. M. (1992), A Case Study in the Assimilation of Technology Support for Teams, In R. P. Bostrom, R. T. Watson and S. T. Kinney (eds), *Computer Augmented Teamwork: A Guided Tour*, Van Nostrand Reinhold, New York, pp. 34-62.

Bayer, J. and Melone, N. (1989), A Critique of Diffusion Theory as a Managerial Framework for Understanding Adoption of Software Engineering Innovations, *The Journal of Systems and Software*, Vol 9, pp. 161-166.

Brancheau, J.C. and Wetherbe, J.C. (1990), The Adoption of Spreadsheet Software: Testing Innovation Diffusion Theory in the Context of End-User Computing, *Information Systems Research*, Vol.1, No.2, pp.115-143.

Cash, J. and McLeod, P. (1985), Managing the Introduction of Information Systems in Strategically Dependent Companies, *Journal of Management Information Systems*, Vol 1, No 4, pp. 5-23.

Cooper, R.B. and Zmud, R.W. (1990), Information Technology Implementation Research: A Technology Diffusion Approach, *Management Science*, Vol.36, No.2, pp.123-139.

Forrester, J.W. (1968), *Principles of Systems*, Wright Allen Press, Mass.

Gerwin, D. (1988), A Theory of Innovation Process for Computer-Aided Manufacturing Technology, *IEEE Transactions on Engineering Management*, Vol.35, No.2, pp.90-100.

Huff, S.L. and Munro, M.C. (1985), Information Technology Assessment and Adoption: A Field Study, *MIS Quarterly*, Vol. 9, pp.327-339.

Kanter, R. (1988), When a Thousand Flowers Bloom: Structural, Collective and Social Conditions for Innovation in Organizations, In B. M Staw and L. L. Cummings (eds), *Research in Organizational Behavior*, JAI Press, Greenwich, CT, pp. 169-211.

King, J. L. and Kraemer, K. L. (1984), Evolution and Organizational Information Systems: An Assessment of Nolan's Stage Model, *Communications of the ACM*, Vol 27, No 5, pp. 466-475.

Kwon, T.H., & Zmud, R.W. (1987), Unifying the Fragmented Models of Information Systems Implementation, R.J. Boland & R.A. Hirschheim (eds.), *Critical Issues in Information Systems Research*, Wiley, pp.227-251.

Lewin, K. (1952), Group Decision and Social Change, Newcombe and Hartley (eds.), *Readings in Social Psychology*, Henry Holt, New York, pp.459-473.

Loh, L and Venkatraman, N. (1992), Diffusion of Information Technology Outsourcing: Influence Sources and the Kodak Effect, *Information Systems Research*, Vol.3, No.4, pp.334-358.

Madu, C.N. and Jacob, R. (1989), Strategic Planning in Technology Transfer: A Dialectic Approach, *Technological Forecasting & Social Change*, Vol 35, pp. 327-338.

Mahajan, V. and Peterson, R.A. (1985), *Models of Innovation Diffusion*, Sage Publications, Beverly Hills.

Mahajan, V. and Wind, Y. (eds) (1986), *Innovation Diffusion Models of New Product Acceptance*, Ballinger Publishing Co., Cambridge.

Manross, G.G. and Rice, R.E. (1986), Don't Hang Up: Organizational Diffusion of the Intelligent Telephone, *Information and Management*, Vol.10, pp.161-175.

Martino, J.P. (1983), *Technological Forecasting for Decision Making*, American Elsevier, New York.

McFarlan, F.W. (1984), Information Technology Changes the Way You Compete, *Harvard Business Review*, Vol.62, No.3, pp.98-103.

Nakicenovic, N. and Grubler, A.P. (eds) (1991), *Diffusion of Technologies and Social Behaviour*, Springer-Verlag, Berlin.

Nilakanta, S., and Scamell, R.W. (1990), The Effect of Information Sources and Communication Channels on the Diffusion of Innovation in a Data Base Development Environment, *Management Science*, Vol.36, No.1, pp.24-40.

Nolan, R. L. (1973), Managing the Computer Resource: A stage Hypothesis, *Communications of the ACM*, Vol 16, No 7, pp. 399-405.

Norton, J.A. and Bass, F.M. (1987), A Diffusion Theory Model of Adoption and Substitution for Successive Generations of High-Technology Products, *Management Science*, Vol.33, No.9, pp.1069-1086.

OECD (1988) *New Technologies in the 1990s: A Socio-Economic Strategy*, Special Report, France.

Pearl, R. (1925), *The Biology of Population Growth*, Alfred A. Knopf, New York.

Quaddus, M.A. (1986), On Applying Logistic Models in Technological Forecasting, *Socio-Economic Planning Sciences*, Vol.20, No.4, pp.201-206.

Richmond, B. (1987), *Systems Thinking: Four Key Questions*, High Performance Systems, Hanover, N.H.

Rosenhead J. (ed) (1992), *Rational Analysis for a Problematic World*, John Wiley & Sons, Chichestor

Rogers, E.M. (1983), *Diffusion of Innovations*, The Free Press, New York.

Saeed, K. (1990), Managing Technology for Development: A Systems Perspective, *Socio Economic Planning Sciences*, Vol 24, No 3, pp. 217-228.

Sahal, D. (1984), The Innovation Dynamics and Technology Cycles in the Computer Industry, *Omega*, Vol.12, No.2, pp.153-163.

Scott Morton, M.S. (ed.) (1991), *The Corporation of the 1990s*, Oxford University Press, New York.

Teece, D.J. (1980), The Diffusion of an Administrative Innovation, *Management Science*, Vol.26, pp.464-470.

Walton, R. (1989), *Up and Running: Integrating Information Technology and the Organization*, Harvard Business School Press, Boston.

Wynekoop, J.L., Senn, J.A., and Conger, S.A. (1992), The Implementation of CASE Tools: An Innovation Diffusion Approach, K.E. Kendall et al. (eds.), *The Impact of Computer Supported Technologies on Information Systems Development*, Elsevier (North-Holland), p.25-41

A SURVEY OF THE STATUS OF TELEWORKING IN SINGAPORE

Lam Soi Hoi
Nanyang Technological University

Lim Ghee Soon
National University of Singapore

Loh Chee Meng
National Computer Board

This paper presents the main findings from the survey of the status of Teleworking in Singapore, which was jointly conducted by National Computer Board, National University of Singapore and Nanyang Technological University. Covering 868 establishments employing 10 or more employees, this teleworking survey is the first of its kind in terms of scale and coverage. The results show that 12% of the responding organisations practise some form of teleworking with some having more than one teleworking arrangements. Increased productivity and reduced office space are viewed as the main benefits of teleworking, while main perceived problems include data security, provision of adequate supervision. The results of the second phase survey with selected companies which are currently practising teleworking in Singapore are also presented in this paper.

1 Introduction

"Telecommuting" was coined by Jack Nilles in 1976 to refer to "the substitution of computer and telecommunication technologies for physical travel to a central work location." (Nilles, 1992) This concept was later expanded to include "any form of substitution of information technologies (telecommunications and computers) for work-related travel" (Nilles, 1992) and telecommuting was redefined as "that portion of teleworking that applies to the daily commute to and from work - the primary source of traffic congestion, air pollution and loss of productivity in urban areas." Teleworking is a work option that aims at reducing dependence on transportation by exploiting information and telecommunication technologies.[1]

Teleworking is a relatively new concept in Singapore and most of the existing teleworking research and development are conducted in overseas. As pointed out by Yap (1993) and DOT (1993), the adoption of teleworking is mainly affected by the following reasons:

1) the advances in telecommunications and information technology,

2) the changes in demographics, the nature of work, and the workplace,

3) urban traffic congestion and

4) environmental legistlation.

[1] In our study, telecommuting and teleworking are interchangeable terms although we prefer the later by choice.

Some countries, like USA, have laws that require companies to set up trip-reduction programmes for cutting down urban traffic congestion and air pollution (Smart Valley, 1994). Many consider teleworking as a viable option to achieve such goals and these have prompted a new wave of research activities in the area of teleworking. At present the number of teleworkers in USA is estimated at 2 to 6.6 million from various sources. This figure is projected to grow to about 7.5 to 10 million, or 5 to 10% of the labour force by the year 2002 (DOT, 1993).

Worldwide, teleworking programmes may be found in both the public and private sectors. Many companies have tried or currently process teleworking programmes. Selected examples in the public sectors include the California Telecommuting project, Federal Flexiplace project, and Los Angeles County Telecommuting project (DOT, 1993). In the telecommuting programme in the LA County, more than 1000 participants, from low level clerical staff to upper manager, took part in the study. Some of the telecommuting programmes in the private sectors include Pacific Bell (Niles, 1992), Bell Atlantic (Bell Atlantic, 1992) and Smart Valley Corp. (Smart Valley, 1994). With close to 1000 professional staff and managers participating as formal or informal telecommuters, Pacific Bell and Atlantic Bell projects are among the largest scale experiments. It was reported that Bell Atlantic has offered teleworking as an option of work arrangement available to its 16,000 managers (Bell Atlantic, 1992). The Smart Valley telecommuting project, implemented in Silicon Valley and the Bay Area, has ISDN as the backbone of the communication link for some telecommuters, and other technologies such as shared-whiteboard and video-conferencing. Most of these studies concluded that teleworking must be voluntary, and benefits such as higher job satisfaction and productivity for the employees, lower office space cost and easier to recruit and retain employees, were observed. Important experience and practical procedures for the implementation of telecommuting programmes are also reported in these studies (Bell Atlantic, 1992, Niles, 1992, and Smart Valley, 1994).

In Singapore, the IT2000 plan calls for the construction of a National Information Infrastructure (NII) to transform the nation into an "Intelligent Island" by the year 2000. Part of this plan envisions the development of a concept called "Anywhere Workplace" which aims at the wide-spread use of information technology so that people can obtain or send information anywhere anytime (NCB 1993). This lays the backbone of infrastructure for teleworking. Demographically, the percentage of information workers in