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Introduction

In today's rapidly changing environment, organizations are increasingly faced with the need to adapt in order to survive, resulting in the adoption of a plethora of innovations. One such innovation which has been gaining popularity is *telework*. Telework has been enabled by the recent advances in communications and computing technologies and this is reflected in an overemphasis of the technological and implementation aspects of telework in research studies. However, telework remains, *essentially*, an administrative innovation. In this paper we distinguish between technological vs. administrative innovations to help understand the diffusion of a complex innovation like telework. We analyze the process of diffusion of telework and build a conceptual model drawing from the vast body of work in the area of diffusion of technological innovations (Rogers, 1983*) that has been extended to administrative innovations (Mahajan et al., 1988; Teece, 1980).

Diffusion of Innovations

An *innovation* is usually an idea, practice, or object that is perceived as new by an individual or any other unit of adoption and *diffusion* is the process by which an innovation is communicated through certain channels over time among the members of the social system.

Diffusion Models **:** Over the years, a number of mathematical models have been proposed to represent the adoption of an innovation over time (Mahajan, et al., 1988). The purpose of these models has been to depict the successive increase in the number of adopters or adopting units over time. By doing so, these diffusion models permit the prediction of the continued development of the diffusion process over

time as well as facilitate a theoretical explanation of the dynamics of the diffusion process in terms of certain general characteristics (Mahajan and Peterson, 1985). The most popular diffusion models have been the aggregate diffusion models - the three basic ones being **:** the *internal - influence* model; the *external-*

influence model and the *mixed-influence* model.

While the *internal-influence* model is based on the assumption that diffusion occurs only through interpersonal contact and is widely used in technological forecasting, the *external-influence* model (Coleman et al., 1966) does not consider interaction between prior adopters and potential adopters, and thus does not recognize the imitation process (Venkatraman et al.,1994). However the *mixed-influence* model is the most widely used of the three fundamental models (Mahajan and Peterson, 1985). The *mixed-influence diffusion model* subsumes both the internal and the external-influence models (Bass, 1969). The mixed-influence model can be represented by the following equation:

$$dN(t) / dt = [\, p + qN(t) \,][\, m - N(t) \,]$$

where, $N(t)$ is the cumulative number of adopters at time t; m is the total number of potential adopters in the social systems at time t; *'p'* is the *coefficient of innovation* and '*q*', the *coefficient of imitation*.

Bass's model assumes that *innovators* adopt new products independently of the influence of others in the social system while *imitators* are influenced by those who have already adopted and that, these two classes

interact with each other and among themselves (Bass, 1969). The Bass model implicitly assumes that all individuals in the population are homogenous with respect to their behavior regarding adoption decision. Although these fundamental diffusion models have several simplifying assumptions such as a binary diffusion process, constant number of potential adopters, one adoption per unit, fixed geographical bounds, a complete mixing of social system members etc., we specify these models as they are consistent with our conceptual level of analysis pertaining to the phenomenon under consideration.

Technological vs. Administrative innovations

Two main types of organizational innovations are *technological innovations* and *administrative innovations*. *Technological innovations* are those that bring change to the organization by introducing changes in the technology i.e. a tool, technique, physical equipment or system (Dalton et al.,1968) while *administrative innovations* are those that change the organization's structure or its administrative processes and may pertain to the recruitment of personnel, the allocation of resources, the structuring of tasks or authority and rewards (Damanpour, 1987). Administrative innovations tend to occur when an organization is poised to adapt to changes in goals, policies, strategies, structure, control systems and personnel, all of which are in the administrative domain while technological innovations are more due to changes of importance in technology (Daft, 1978). Most of the earlier studies in the diffusion of innovations have primarily focused on "technological innovations" to the extent that "innovation" and "technology" have been used as synonyms. An interesting issue is whether the diffusion of administrative and technological innovations can be treated in an analogous fashion. If the diffusion of administrative innovations is governed by the same kinds of considerations as the diffusion of technological innovations, then it may be possible to predict the adoption patterns and the speed of diffusion in a reasonably exact fashion (Teece, 1980). One criticism of innovation research concerns the assumption that a universalistic theory of the innovation process can be developed that applies to all types of innovations (Dewar et al., 1986). The search for an universalistic theory may be inappropriate given the fundamental differences that exist across innovation types (Downs and Mohr, 1976). Technological and administrative innovations have been combined in unknown ways, so that the explanatory power of innovation types and the importance of two separate innovations centers has been obscured (Daft, 1978). Although technological innovations cannot be separated from their cultural and social settings and their use is often conditioned by norms and values, social roles and practices, technological innovations differ from administrative innovations.

Even though administrative innovations are difficult to protect by patent, administrative innovations involve significant "set-up" costs (Teece, 1980) unlike the introduction of a technological innovation. Such administrative innovations usually require a major overhaul of task, responsibilities, power structures etc. Besides, while technological innovations can be adopted on a partial basis, incremental approach to administrative innovations may not be feasible. Though some administrative innovations, such as telework, can be adopted on a partial basis the benefits from such implementation can rarely be established. Thus, administrative innovations exhibit characteristics different from those of technological innovations and the existence of two empirically distinguishable categories of innovations calls for different models which take into account different variables or the different interrelationships among them.

Telework - A complex innovation

The adoption of telework represents a fundamental

shift away from the established traditional mode of working. According to Gray et al. (1993), "*Telework is a flexible way of working which covers a wide range of work activities, all of which entails working remotely from an employer, or from a traditional place of work, for a significant portion of work time*". As can be seen from its very definition, *telework* involves the use of information technology and a change in place and/or time of the task and the people in an organization. The adoption of telework (we exclude experimental schemes) involves substantial changes in routine and procedures of organization and management, that might be associated with substantial "set-up" costs and organizational disruptions and changes in internal and external alignments, besides the adoption of enabling technologies. The adoption of

telework by an organization, therefore, involves adoption of both technological innovations as well as administrative innovations and its diffusion is a function of the diffusion of both these innovations. Adoption and diffusion of the technological components are relatively straight forward, while the diffusion of the administrative component of telework is more complex. While it is useful to recognize the existence of the two distinct components of telework, it should, nevertheless, be understood that both these components of telework influence each other and a tight coupling is required to ensure success.

Diffusion of Telework **:** Research shows that telework can be implemented successfully with relatively simple technology like telephones, facsimiles and networked computers. Diffusion of these technological innovations lend themselves to the process of imitation due to their inherent simplicity and low cost. Besides, the diffusion of these enabling technologies is in a relatively advanced stage and as the diffusion process progresses the population of potential adopters mostly comprises of *imitators* (Mahajan et al., 1990). Rogers and Shoemaker (1971) identify five main characteristics of innovations that have helped explain the differences in their rates of adoption viz. their *Relative Advantage*, *Compatability*, *Complexity*, *Triability*, *Observability*. Administrative innovations for telework relate more to people in an organization and the nature of the tasks performed. We contend that these administrative innovations are clearly *more complex*, *less triable* and *less observable* as compared to the technological components of telework thereby making such administrative innovations less amenable to imitation and more so, due to their idiosyncratic nature and characteristics. Mahajan et al. (1988) suggest that the uncertainity associated with the performance advantages, the unique nature of the innovation and the nature of the organizational momentum may also cause the diffusion of administrative innovations not to follow the imitation process. Venkatraman et al. (1994) identify three major sources that make imitation of such innovations difficult, namely, unique historical conditions, causal ambiguity and social complexity. Administrative innovations relating to telework exhibit these very characteristics, leading us to hypothesize that they are not likely to diffuse by the process of imitation, unlike technological innovations.

A Model for Telework Diffusion

Telework, as discussed above, can said to be composed of two components viz. technological and administrative, with the administrative core being the central dominant one and of prime importance, and the enabling technology being peripheral. Drawing from the Bass' mixed-influence model, we propose a modified generalized model for telework diffusion which can be represented as follows:

$$d\,\boldsymbol{N_1}/d\,t = \mathbf{[}\,p_1 + q_1\,.\boldsymbol{N_1}\,\mathbf{][}\,M_1 - \boldsymbol{N_1}\,\mathbf{]}\,.\ (\mathbf{1})$$

where, $\boldsymbol{N_1}$ is the cumulative number of adopters of the *administrative innovation* at time *t*; M_1 is the total number of potential adopters in the social systems at time *t*; 'p_1' is the *coefficient* that reflects the *intensity of adoption* due to "*innovation*" and 'q_1', the *coefficient* that reflects the *intensity of adoption* due to interaction between potential adopters and prior adopters (*imitation)*, and " is coefficient that represents that influence of the diffusion of enabling technologies, the rate of diffusion of enabling technologies being represented by equation (**2**).

We use the mixed-influence model rather than the external-influence model for the following reason. While in the initial stages of diffusion, as discussed above, the diffusion of administrative innovations related to telework do not follow the process of imitation, in the later stages of the diffusion process, with a higher degree of standardization of the processes related to telework, *imitation* is likely to play a greater role in the diffusion process. Thus in equation (**1**), '*p*' would be very high, while '*q*' would be very small and relatively unimportant.

While the Bass model assumes the existence of two dichotomous classess of individuals, namely *innovators* and *imitators*, with inherently different response characteristics, our point of departure is to contend that every adopting unit exhibits these characteristics of *imitation* and *innovation*, and thus "*imitate*" or "*innovate*" depending on various factors for eg., the characteristics of the innovation. As

mentioned earlier and consistent with the exisiting literature on technological innovations, we suggest the use of the internal influence model (**2**) to determine the diffusion of enabling technolgies.

$$dN_2 / dt = q_2 . N_2 [M_2 - N_2] . x_2(t) \quad \textbf{(2)}$$

where, N_2 is the cumulative number of adopters of the *enabling technologies* at time *t*; M_2 is the total number of potential adopters in the social systems at time *t*; 'q_2' is the *coefficient* that reflects the *intensity of adoption* due to interaction between potential adopters and prior adopters (*imitation)*, and '$x_2(t)$' is a non-negative function that reflects the effect of *marketing variables* on the conditional probability of adoption at time *t*. Through a mapping function (Bass et al., 1994) as shown in equation **(3)**, we can map decision varibles such as price *Pr*(*t*) and performance *Pf* (*t*) to the function '$x_2(t)$'.

$$x_2(t) = 1 + b_1 (dPr / dt) + b_2 (dPf / dt) \quad \textbf{(3)}$$

The expected sign of 'b_1' is negative and the expected sign of 'b_2' is positive. Such mapping function can be extended to include more decision variables.

In addition to the existence of two main influences on the process of diffusion viz. the *internal* and *external*, the model recognizes the influence of the adoption of enabling technologies by the members of the social system. It is pertinent to mention that the actual behavior of organizations, however, may be influenced by the idiosynchracies of their decision-making processes and their specific cost-benefit equations regarding specific technologies (Grover and Goslar, 1993) and administrative innovations. Therefore the model presented is not fully explanatory of any particular technology or organization. On the other hand, it represents certain contexts and associates them with collective implementation of telework

Conclusion

Research (Wolfe, 1994) suggests that innovations processes, rates and patterns of diffusion are influenced by innovation attributes. As shown earlier, the model, based on the differences between technological and administrative innovations, helps integrate the factors that influence the diffusion of both these components that form the basis of telework. An important consideration for future research is that telework diffusion involves both a technical component and an administrative component with different factors influencing the diffusion rate of each of them. The focus of this paper has been on providing a basis for modeling the diffusion of a complex innovation like telework. Empirical studies are needed for validation and refinement of the structural, estimation and conceptual assumptions underlying the model.