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A VALIDATION OF THE DIFFUSION OF INNOVATION MODELS IN MOBILE DEVICES: AN ASSESSMENT OF CELLULAR PHONES

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Abstract

Plenty of wireless commercial services provide the potential for organizations and users to perform various commerce-related tasks without regard to time and location. Mobile commerce needs to be conducted with wireless (or mobile) devices. Therefore, tracking the diffusion of mobile devices is an increasingly important task, especially for mobile commerce planners. In this study, we investigate the adoption and diffusion pattern of the cellular phones which is the most popular wireless devices. The generalized mathematical model of the diffusion of an innovation as developed by Mahajan and Peterson (1985) will be explored. The available statistics on number of the cellular phone subscribers will be examined. The extent to which the process of adoption of the cellular phones can be more appropriately described by an Internal-Influence, External-Influence or Mixed-Influence diffusion model will be also discussed.

Keywords: Mobile commerce, cellular phone, innovation of diffusion

Introduction

Explosive growth of the mobile devices over the past years has greatly increased interest in its potential use of mobile commerce, especially as a vehicle for transactions. To provide consumers wireless commercial services, more and more businesses are aggressively pursuing wireless channels. Evidence of growing consumer reliance on wireless connectivity and mobile commerce is undeniable. Gartner Dataquest research shows that more than 1 million cellular phones will be sold worldwide in 2002 and consumers worldwide will spend more than \$300 billion for wireless telecommunications services. A Gartner survey of retail banks indicates that about 3% medium-to-large U.S. banks offered any kind of wireless services, that figure grows to 9% by the end of 2001, and 16% by the end of 2002. A much cited Ovum-report also points out that the number of mobile commerce users is expected to be more than 500 million in 2005, and the corresponding value of mobile commerce transactions is expected to be more than 200 billion (Davidson et al. 2000).

Plenty of wireless commercial services provide the potential for organizations and users to perform various commerce-related tasks without regard to time and location. Mobile commerce needs to be conducted using wireless (or mobile) devices. Therefore, tracking the diffusion of mobile devices is an increasingly important task, especially for mobile commerce planners. With the understanding of the diffusion pattern of mobile devices, the businesses can evaluate the number of mobile devices that can be supported has to account for the mobile commerce's future use. Developing and analyzing the diffusion models that explain the mobile device adoption process is critical for wireless capacity planning, mobile commercial strategy formulation, designing more sophisticated wireless hardware and software, and launching new wireless services. Adoption pattern informs the wireless commercial services providers about the potential consumer base. Other businesses, including mobile devices suppliers and latent entry, also need to rethink and reorient their strategic plans to account for mobile devices diffusion.

Although current wireless devices include cellular phones, PDAs, and personal message pager devices, the cellular phones are most commonly used and currently play the most important role in mobile commerce. Therefore, the objective of our research will focus on the cellular phones. Hence, the purpose of this study is to investigate the diffusion pattern of cellular phone adoption. The generalized mathematical models of the diffusion of an innovation, including Internal-influence model, External-influence model, and Mixed-Influence model, will be applied to examine the adoption pattern of cellular phones. The research results will allow us to have better understanding of cellular phones growth and impact on mobile commerce.

The rest of the paper is organized as follows: Firstly, we would like to briefly outline the literature on diffusion of innovation theory. Secondly, we would like to discuss the traditional mathematical models of the diffusion of an innovation as developed by Mahajan and Peterson (1985). At length, we will present current state of research and the expected results by the time of the conference.

Literature Review

Diffusion of Innovation Theory

Diffusion is the process by which an innovation is communicated through certain channels over a period of time among the numbers within a social system (Rogers 1995). Innovation, communication channels, time and social system are four critical elements during the diffusion process. The first element, innovation, often means a new object or idea that have not been previously explored or adopted. The second one is communication channel, by which messages pass from one individual to another. People can obtain the innovation information from the mass media channels, interpersonal channels or both. The third one is time, which means an adoption rate of an innovation within a social system. Eventually, five variables determine the rate of adoption. Those are perceived attributes of innovations, type of innovation-decision, communication channels, nature of the social system, and extent of change agents' promotion efforts. The last element is social system. A social system is defined as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal (Rogers 1995).

Traditionally, innovation diffusion research centers on these four areas discussed above and their interrelationships (Goodman et al. 1994; Press 1997). Since the time that the members of a social system adopted the innovation differs, the distribution of adopters over time is expected to be a bell-shaped curve (Bass 1969). We can categorize adopters into five categorizations by the different standard deviation from the mean: innovators, early adopters, early majority, late majority and laggards.

Cellular Phone is a Case of Innovation

The cellular phone is an innovation which has certain unique attributes. These raise interesting questions for models of its diffusion. We describe for attributes as below.

The first point of interest relates to the channels of communication by which an innovation is disseminated. In the case of the cellular phones, the innovation is itself a medium of communication. The cellular phone as an innovation is capable of acting as a medium for its own diffusion, including diffusion within a social system which has no direct access to it.

The second point is that the social system within which information about the cellular phone is being diffused is nationwide and almost unconstrained. Eventually, every individual and organization can access the information about this innovation. It is reasonable to assume that adoption of the innovation will be interest, eventually, of almost all members of the social system.

Thirdly, the cellular phone has been around for a considerable length of time and yet it is only recently, in the 2000s, which its potential s a vehicle for mobile commerce has been attended to. This has been partly ascribed to the development of the cellular phone as only the wireless environment realized by this mechanism permits the realization of one major facet of commerce, namely, access by a large population base of customers.

Finally, in the case of cellular phone, we have an innovation which is itself evolving. While studies of diffusion have acknowledged that an innovation may be customized locally through a process termed "reinvention," few have attended to the problem of studying how change in the feature of the innovation itself over time should be treated in studying its diffusion.

Diffusion Models

Diffusion models are mathematical models that can be applied to depict the successive increase in the number of adopters or adopting units over time (Mahajan and Peterson 1985; Mahajan et al. 1988). Equation (1) is the basic diffusion model. The equation (1) indicates that diffusion rate is a function of the difference between absolutely potential adopters and cumulative adopters. The diffusion rate decreases as the actual adopters increase. The coefficient of diffusion, $g(t)$, is the probability that potential adopters will adopt the innovation at time t . It is often affected by the nature of innovation, communication channel and others elements. Therefore, $g(t)[m - N(t)]$ is the number of adopters at a given time t , expressed as $n(t)$. In previous research, $g(t)$ has two kinds of definitions: one is the function of t ; the other one is the function of cumulative adopters, i.e. $g(t)=a+bN(t)+cN(t)^2+\dots$

$$\frac{dN(t)}{dt} = g(t)[m - N(t)]. \tag{1}$$

Where: $N(t)$ is the cumulative number of adopters, $N(t) = \int_{t_0}^t n(t)dt$;

$N(t=t_0) = m_0$, the initial number of adopters in a social system;

$\frac{dN(t)}{dt}$ = diffusion rate at time t ;

$g(t)$ is the coefficient of diffusion;

m = total number of potential adopters in a social system;

Mahajan and Peterson (1985) propose three general diffusion models: the Internal-Influence model, External-Influence model and the Mixed-Influence model. These three classic models are widely applicable in various topics. Internal-Influence model assumes that the interpersonal communication has major influence on the diffusion rate. Earlier adopters influenced the later adopters. The coefficient of diffusion $g(t)$ is a function of the cumulative number of adopters, and the diffusion model was expressed as the equation (2).

- $g(t)=qN(t), N(t) = \frac{m}{1 + \frac{m - m_0}{m_0} \exp(-qmt)}$ (2)

External-Influence model means the diffusion rate is primarily affected by the mass media. The coefficient of diffusion $g(t)$ is a constant, and the diffusion model becomes the equation (3).

- $g(t)=p, N(t) = m(1 - \exp(-pt))$ (3)

Mix-influence model combined the effect of external and internal influence. The model equation is described as the following:

- $g(t)=p+qN(t), N(t) = \frac{m - \frac{p(m - m_0)}{p + qm_0} \exp(-(p + qm)t)}{1 + \frac{q(m - m_0)}{p + qm_0} \exp(-(p + qm)t)}$ (4)

Since three general diffusion models are built under several hypotheses, it would appear to be some conflict between assumptions underlying the models and the context of the cellular phone adoption and diffusion phenomenon. For instance, the Internal-Influence model assumes that external factors do not affect the diffusion process; the population of the social system is constant and homogeneous, and so forth (Mahajan and Peterson 1985). These assumptions may restrict the validity of our study.

Current State of Research

At present, the statistic of cellular phone subscribers is being collected to estimate the parameters in diffusion models. We now employ nonlinear procedures in SAS to approximate all parameters. Diffusion models are built under the specific patterns rather than random process. Therefore, it is necessary to verify the distribution of diffusion patterns. Davidson and Mackinnon (1981) propose J-test to examine the specification of an econometric model. The testing results can evaluate the validity of diffusion model. Hence, we will employ J-test to assess influence models.

By the time of the conference, we expect the generalized mathematical model of the diffusion of an innovation will be fully explored. That is, we will have the available statistics on numbers of adoption of cellular phones numbers. The fitness of each diffusion models for cellular phones adoption will also be presented at the same time.

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